# Energy for Gorno Badakhshan: Hydropower and the Cultivation of Firewood

## Analysis of the Energy Situation in the Tajik Pamirs and its Consequences for Land Use and Natural Resource Management

Joint Diploma Thesis Submitted to the Faculty
of Natural Sciences of the University of Berne
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Women with head load of *teresken* shrubs on the way home to the village of Savnob in the upper Bartang Valley (Photo: T. Hoeck, June 2003)

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*“We are like fish; during Soviet times the water was brought to us, today we have to find the way down to the river on our own!”*

Villager of Savnob

# Preface

The preliminary events leading up to this diploma thesis took place in the summer of 2001 when the Centre for Development and Environment (CDE) of the Department of Geography at the University of Berne implemented the so-called 'Pamir Strategy Project' (PSP) to focus on preparation of a sustainable development strategy for the Tajik Pamirs. R. Droux was a member of the PSP-research team, and was entrusted with the task of creating a documentary film to introduce the stunning beauty of the Pamir mountains, the dwellers' difficult living conditions and the progress of the PSP. As a result of the lasting impressions gained during visits to that region and the outcome of the Pamir strategy workshop in autumn 2002, it became clear that one of the largest and most urgent problems was the deplorable situation for energy supply, especially in the rural regions of the Pamirs. The authors therefore decided to write a joint diploma thesis that would provide the scientific groundwork for a better understanding of the energy situation in Gorno Badakhshan. In April 2003 the authors departed from Berne by train with the objective of conducting a field study in Gorno Badakhshan, arriving at the capital of Tajikistan after a one-week overland journey. The train trip made it possible to approach the region in a more gradual manner while adapting slowly to the new environment and traveling over vast sections of the former USSR. After waiting for three weeks for GBAO permission in Dushanbe, the authors were able to spend two months in the Pamirs collecting information and data, and investigating energy consumption patterns of the Pamiris in three different villages and at mini hydropower stations (MHPS). They also investigated different forms of degradation, attempting to gain an integral understanding of the energy situation in the Pamirs. A personal objective was writing a thesis that could be used as a practical guideline for further projects to improve the livelihood of the Pamiris. With this in mind, the authors listed concrete and viable recommendations at the end of their thesis for measures to mitigate the energy crisis in the Pamirs.

Nevertheless, such knowledge is of little or no worth if it cannot be transferred and made available to local organizations and inhabitants. With this in mind, an on-the-scene workshop is now planned for July 2004. The authors would like in this form to make their collected knowledge available while discussing results and recommendations with the different stakeholders involved in the field of energy. Since the authors consider the energy matter to be extremely urgent issue, the debate should focus on coming up with further steps and initiating concrete projects towards sustainable energy resource use in the Pamirs. In order that local organizations and people can profit even more from the findings reported on in this thesis, a section of it will be translated into Russian and the entire thesis will be posted on the Internet: www.nccr-north-south.unibe.ch

The authors feel confident that this diploma thesis can make a valuable contribution toward improving the living conditions of the Pamiris in rural regions.

*Berne in May 2004,*
*Tobias Hoeck and Roman Droux*

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We are greatly indebted to the Centre of Development and Environment (CDE) in Berne, to the National Centre of Competence in Research North-South (NCCR North-South), and especially to Prof. Dr. Hans Hurni, co-director of the CDE and director of the NCCR North-South, who gave us the opportunity for conducting the field survey in the Tajik Pamirs and allowed us to write our diploma thesis within the NCCR North-South. We also express our special thanks to Dr. Daniel Masselli, coordinator of the IP2 in the NCCR North-South, for his competent feedback and enriching inputs, and of course to Thomas Breu, who took us under his wings and who was at our permanent disposal for various administrative and organizational tasks, and not to mention his professional assistance in GIS work and map preparation. A special expression of thanks is sent to Äbu Liniger for his competent assistance in systematic and logical thinking and to Annlis von Steiger for her moral and linguistic support. Moreover, we are very grateful to Paul Shepherd for his professional proofreading and to Stefan Schaer of the Büro eigenart for giving this thesis a proper layout. In this regard, special thanks go to Madeleine and Robert Droux for their generous contributions, which allowed us to give the thesis's layout in the hands of a professional. Last but not least we would like to thank our parents for their irreplaceable support during our years of study.

# Executive Summary

The collapse of the Soviet Union not only brought independence to the Tajik Republic in 1991; it also caused a sudden power vacuum and the breakdown of the state-controlled subsidized provision system. The following years were characterized by the turmoil of a bloody civil war (1992-1997), the deterioration of infrastructures and a serious economic post-Soviet dip. Prior to independence, people in Gorno Badakhshan Autonomous Oblast (GBAO) were specialized in livestock farming, fodder and tobacco production, and enjoyed adequate external provision of foodstuffs, fossil fuels and other vital goods. This high dependence on external supplies had disastrous consequences for the Tajik Pamirs after the breakdown of the Soviet system. People had no choice other than to rely again on local natural resources to satisfy their demand for food and energy, as they had done 70 years before. But conditions had changed: Population had quadrupled, indigenous knowledge and traditional livelihood strategies for mixed mountain agriculture had disappeared, and the natural resource base had been transformed to fit the Soviet planned economy. At present, the majority of the population is heavily dependent on local biomass fuels to cover the demand for energy, thus severely overtaxing the local fuel wood resources. Large forests have been cleared and other biomass fuels, such as shrubs and manure, are accessed to compensate for the diminishing firewood resources. The present energy situation in GBAO is characterized by a huge gap between supply and demand, high domestic energy consumption, insufficient electricity supply, and expensive commercial fuels with a tendency towards increasing prices. This leads to extreme dependence on non-commercial fuels, high pressure on woody vegetation and thus often rapid environmental degradation.

The present study aims at providing an integral analysis of the energy situation and its consequences for land and energy resource use in rural areas of the Tajik Pamirs. For a detailed understanding of the energy situation and considering the principals of the sustainability concept, the authors focus on three main topics: (1) Energy consumption patterns at household and village levels, (2) use of micro and mini hydropower stations and their potential to relieve pressure on local biomass fuels, and (3) land degradation related to unsustainable energy resource use. An actor-oriented, trans-disciplinary, and multi-level stakeholder approach was chosen, and a set of different interview techniques and participatory methods were applied to fulfil the research objective (see Part I).

Not only the present biophysical and socio-economic conditions in the Tajik Pamirs, but also the development of these features during the past century determine the present energy situation and considerably influence the current energy resource use. There are namely two decisive events: The integration of GBAO into the Soviet Union in the early twenties and its disintegration in the early nineties (see Chapter 7).

The inherited infrastructures severely deteriorated and could no longer be maintained after the collapse of the Soviet system. Through international assistance the use of hydropower has been fostered in GBAO during the past decade, so that at present 94% of the population enjoys electricity supply from the grid and decentralized hydro schemes. The large number of micro and mini hydropower stations (MHPS) lack adequate equipment and maintenance, thus working insufficiently and only covering the demand for domestic lighting. Due to inadequate energy supply the rural population covers the bulk of the energy demand by local biomass fuels, such as firewood, shrubs and dung. Although the MHPS make only a small contribution to relieving pressure on fuel wood sources, they show a positive impact at socio-economic level, such as offering employment or reducing financial expenses for energy (see Chapter 8).

The difficult transition after independence resulting in the severe shortage of foodstuff and fuels already had an impact on the environment. Soil and woody vegetation suffer from increasing pressure and show signs of large-scale degradation (see Chapter 9).

The energy consumption patterns in rural areas of the Tajik Pamirs are characterized by generally high consumptions (up to 140GJ/hh/y), a share of biomass fuels between 82-97%, and high time expenditures (3-6h/day) for resource procurements. Especially women suffer from severe health problems resulting from carrying annually more than eight tons of shrubby fuel wood over large distances to cover the basic domestic demand for energy. The amount of consumed energy depends on the options of available resources, which is decisively determined by the biophysical setting of the region, people's financial means, availability of electricity and its capacity, accessibility to forestland, and the ratio of livestock to arable land (ALCDU). Electricity from the main grid in GBAO mostly provides an appropriate capacity making it possible to cover the bulk of domestic energy demand in summer and thus considerably replace firewood. Nevertheless, local biomass fuels are not used in a sustainable way in the Tajik Pamirs (see Chapters 10, 11, 12, and 13).

Generally it can be stated that GBOA is suffering from a severe energy crisis. Only the city of Khorog enjoys a satisfactory energy supply. The energy situation is particularly alarming in rural regions. Especially in areas where

forests are non-existent, people have to rely primarily on the inadequate shrubby fuel wood (*teresken*), resulting in the consumption of exorbitant quantities of biomass fuels and thus clearance of vast areas. This leads to a paradox situation: the more severe the energy situation, the higher the energy consumption (in GJ) at household level (see Chapters 14).

The origin of the energy crisis lies in the Soviet heritage and the unfavorable transition after independence: A large population, artificially settled in areas with scarce resources, generating a huge energy demand was suddenly forced to rely on the limited and heavily decimated natural resource base without alternatives. Even when aware of the unsustainable resource use, people do not feel able to adopt more sustainable strategies. Low income, scarce and low productive resource bases, high demand and the fact that women as the main energy resource procurer and user are usually not represented in decision-making authorities, are main obstacles to a sustainable use. The overuse of the local resource base not only has severe consequences at the ecological level (degradation), but also the socio-economic level. A series of energy source depletion, commercialization of biomass fuels and the tapping of new energy sources, determined to fulfill other functions in the livelihood system, leads the people into a vicious circle of increased poverty and health deterioration. Pressure on fuel wood resources considerably outweighs relief provided by electricity from the grid and the MHPS, by reforestation and tree cultivation. But these options have a large potential to mitigate the energy crisis and to form the groundwork for a sustainable energy resource use. Adequate electricity provision and the fostering of local renewable resources are the basic preconditions for a sufficient, affordable and sustainable energy supply in the Tajik Pamirs (see Part III).

# Zusammenfassung


Die vorliegende Arbeit untersucht die aktuelle Energiesituation im ländlichen Gebiet des tadschikischen Pamirs. Es wird auf drei Hauptpunkte fokussiert:

1) die Energiekonsummuster auf Haushalts- und Dorfebene,
2) den Einsatz von Kleinwasserkraftwerken und ihr Potenzial in Hinblick auf die Entlastung der lokalen Biomassenbrennstoffe und
3) die Degradation natürlicher Ressourcen, ausgelöst durch eine nichtnachhaltige Energieressourcennutzung (vgl. Part I).

Für die Datenerhebung im Feld wurde ein transdisziplinärer und partizipativer Ansatz mit verschiedenen Interviewtechniken gewählt. Es wurden Fallstudien in drei verschiedenen Dörfern mit unterschiedlichen Energieressourcengrundlagen durchgeführt. In den einzelnen Dörfern wurden je sechs Haushalte nach bestimmten Kriterien (Wohlstand, Haushaltsgrösse und räumliche Lage im Dorf) ausgewählt und mittels standarisierten und halbstandardisierten Leitfaden-Interviews untersucht. Zusätzlich wurden Gruppen- und Experteninterviews durchgeführt. Wichtige Infrastrukturen wurden mit dem GPS georeferenziert und im GIS zu Karten verarbeitet. Um den genauen Energieressourcenkonsum der Haushalte zu eruieren, wurde der Holz- und Dungverbrauch gewogen und hochgerechnet. Die Degradationsbeurteilung konnte durch die Feldbegehung mit den Landnutzern und mit einem Indikatorenkatalog eingestuft werden (vgl. Kapitel 5).

Der Zusammenbruch der Sowjetunion 1991 brachte Tadschikistan nicht nur die Unabhängigkeit, sondern auch ein politisches Machtvakuum und den Zusammenbruch des staatlichen Versorgungssystems. Die darauf folgenden Jahre waren geprägt von einem blutigen Bürgerkrieg (1992–1997), dem Abbau von Infrastrukturen und einem ökonomischen Rückschlag.

Vor der Unabhängigkeit lebten die Menschen in Gorno Badakhshan (GBAO) von der Viehzucht, Futter- und Tabakproduktion. Sie waren abhängig vom zentralistisch organisierten Versorgungssystem, das Nahrungsmittel und Brennstoffe lieferte. Diese Abhängigkeit wurde nach dem Zusammenbruch der Sowjetunion in höchstem Ausmass deutlich. Nach 70 Jahren Aussenversorgung waren die Menschen im gebirgigen Pamir wieder auf sich selbst gestellt, nun jedoch mit einem teils verlorengegangenen Wissen über Selbstversorgungs- und Überlebensstrategien, sowie einer vervierfachten Bevölkerungszahl, die ihren Energiebedarf mit dezimierten lokalen Ressourcen decken musste.

Gorno Badakhshan hatte daher nach der Unabhängigkeitserklärung 1991 mit einem enormen Versorgungsengpass zu kämpfen, der zu einer Hungersnot und einer grossen Energieknappheit führte. Da nur noch lokale Biomassenressourcen vorhanden waren, erhöhte sich der Druck auf die Holzressourcen markant. Die Folgen waren ein grossflächiges Verschwinden von Wäldern und damit gekoppelte Degradationserscheinungen (vgl. Kapitel 7).

Der heutige ländliche Energiebedarf im Pamir ist aufgrund ineffizienter Ressourcennutzung im Allgemeinen sehr hoch. Ein Energieverbrauch von 140GJ pro Haushalt und Jahr (versus 78GJ eines Schweizer Durchschnittshaushalts) ist keine Seltenheit.

Die Höhe des Energiekonsums wird im Wesentlichen durch folgende Parameter bestimmt: den biophysischen Gegebenheiten, dem Einkommen der Haushalte, der Art der erhältlichen Ressourcen, der Erreichbarkeit der Holzquellen, der Qualität der Elektrizitätsversorgung und der Dungnutzung, welche vom Verhältnis zwischen Viehbestand und Ackerland bestimmt wird (ALCDU).

Mit internationaler Hilfe wurde zwar im letzten Jahrzehnt der Bau von Wasserkraftwerken gefördert, wodurch heute 94% der Bevölkerung mit Strom versorgt sind. Die Kapazität des Hauptelektrizitätsnetzes ist vielerorts ausreichend, damit die Haushalte den Strom an Stelle des Brennholzes gebrauchen können. Jedoch funktionieren die Kleinwasserkraftwerke oft nicht, sind in einem schlechten Zustand oder produzieren nur sehr wenig Strom, der nur knapp für Innenbeleuchtung ausreicht. In vielen Orten ist die Stromlieferung nur im Sommer gewährleistet. Aufgrund dieser ungenügenden Energieversorgung deckt die ländliche Bevölkerung ihren Energiebedarf zu 90% durch lokale Brennstoffe wie Holz, kleine bodennahe Büsche (*Teresken*) und Dung ab. Diese lokalen Biomassenressourcen reichen jedoch nicht aus, um nachhaltig genutzt zu werden (vgl. Kapitel 10, 11, 12 und 13).

Für die körperlich sehr anstrengende Sammelarbeit wenden vor allem die Frauen und Kinder täglich 3 bis 4 Stunden auf, was zum Teil schwere gesundheitliche Konsequenzen bei ihnen nach sich zieht. Die Kleinwasserkraftwerke können demnach nur einen kleinen Beitrag zu Entlastung der Holzressourcen leisten. Sie haben jedoch einen positiven Einfluss auf andere sozioökonomische Verhältnisse, wie beispielsweise die Schaffung von Arbeitsplätzen oder die Reduzierung der finanziellen Ausgaben zur Deckung der Energieversorgung (vgl. Kapitel 8).

Im Pamir kann von einer ernsthaften Energiekrise gesprochen werden, unter der vor allem die ländliche Be-

völkerung leidet. Namentlich sind in den waldlosen Gebieten die mittellosen Bewohner gezwungen auf die dort letzte verfügbare und ineffiziente Ressource, die *Teresken*-Büsche, zurückzugreifen. Somit ist der Energiekonsum dort am höchsten, wo die Energiekrise und die damit verbundenen Degradations- und Desertifikationserscheinungen am drastischsten sind (vgl. Kapitel 14).

Obschon sich die Pamiris mehrheitlich bewusst sind, dass sie die lokalen Ressourcen im höchsten Masse übernutzen, sehen sie sich, aus Mangel an Alternativen, nicht in der Lage, diese Strategie zu ändern.

Die grössten Hindernisse für eine nachhaltige Ressourcennutzung sind vor allem das tiefe Einkommen, die spärliche und langsam regenerierende Ressourcengrundlage und der hohe Energiebedarf; jedoch auch die vorherrschende geschlechterspezifische Rollenteilung, welche der Frau als Hauptakteurin im Bereich der Energieversorgung wenig Entscheidungskompetenzen zuspricht. Dies wirkt sich negativ auf eine mögliche nachhaltige Entwicklung aus. Durch die zusätzliche Arbeitsbelastung der Frau, die immer länger werdende Sammeldistanz, durch die stattfindenden Degradations- und Desertifikationserscheinungen, sowie die Kommerzialisierung der Holzressourcen, gelangen die mittellosen Haushalte in einen Teufelskreis der Armut und Gesundheitsverschlechterung.

Ein grosses Potenzial, um die Energiekrise zu lindern, liegt in einer adäquaten und bezahlbaren Stromversorgung z.B. durch Kleinwasserkraftwerke, in grossflächigen Aufforstungsmassnahmen und in einer nachhaltig bewirtschafteten Feuerholznutzung (vgl. Part III).

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# Abbreviations

**ADB** Asian Development Bank
**ACTED** Agency for Technical Cooperation and Development
**AKDN** Aga Khan Development Network
**AKF** Aga Khan Foundation
**AKFED** Aga Khan Fund for Economic Development
**ALCDU** Arable Land per Cow Dung Unit
**ASSR** Autonomous Soviet Socialist Republic
**CDE** Centre for Development and Environment
**CIS** Commonwealth of Independent States
**CSD-9** Ninth Session of the Commission on Sustainable Development
**FAO** Food and Agriculture Organization of the United Nations
**FFW** Food for Work
**GBAO** Gorno Badakhshan Autonomous Oblast
**GDP** Gross Domestic Product
**GIS** Geographic Information System
**GJ** Gigajoule
**GNF** Global Nature Fund
**GoT** Government of Tajikistan
**GPS** Global Positioning System
**GWh** Gigawatt-hour
**h** hour
**hh** household
**HPP** Hydropower Plant
**HPS** Hydropower Station
**Hz** Hertz
**ICIMOD** International Centre for Integrated Mountain Development
**IDA** International Development Association
**IFC** International Finance Corporation
**IHTSSR** Institute of Hydropower of the Tajik SSR
**JACS** Joint Areas of Case Studies
**kg** Kilogram
**km** Kilometer
**km$^2$** Square kilometer
**kV** Kilovolt
**kW** Kilowatt
**kWh** Kilowatt-hour
**m** meter
**m$^2$** Square meter
**m$^3$** Cubic meter
**MHPS** Micro and Mini Hydropower Station
**MSDSP** Mountain Society Development and Support Programme
**MWh** Megawatt-hour
**NABU** Naturschutzbund Deutschland (German Society for Nature Conservation)
**NCCR** National Centre of Competence in Research
**NCCR North-South** National Centre of Competence in Research North-South
**NGO** Non-Governmental Organization
**PAT** Pump as turbine
**PEC** Pamir Energy Company
**PF** Plant Factor
**PPPP** Pamir Private Power Project
**PRDP** Pamir Relief Development Programme
**PSP** Pamir Strategy Project
**SCSRT** State Committee on Statistics of the Republic of Tajikistan
**SDC** Swiss Agency for Development and Cooperation
**Seco** Swiss State Secretariat for Economic Affairs
**SLM** Sustainable Land Management
**SNSF** Swiss National Science Foundation
**SSR** Soviet Socialist Republic
**TV** Television
**UCA** University of Central Asia
**UEC** Unit Energy Cost
**UNCED** United Nations Conference on Environment and Development
**USD** Dollars of the United States of America
**USSR** Union of the Socialist Soviet Republic
**VO** Village Organization
**WB** World Bank
**WCED** World Commission on Environment and Development
**WFP** World Food Programme
**WSSD** World Summit on Sustainable Development
**y** year

# Currency Equivalents

**Tajik Somoni**
Tajik national currency: somoni (1 somoni = 100 diram)

1996
1 somoni = USD 3.45
USD 1 = 0.29 somoni

1997
1 somoni = USD 1.79
USD 1 = 0.56 somoni

1998
1 somoni = USD 1.28
USD 1 = 0.78 somoni

1999
1 somoni = USD 0.81
USD 1 = 1.24 somoni

2000
1 somoni = USD 0.55
USD 1 = 1.83 somoni

June 2001
1 somoni = USD 0.43
USD 1 = 2.35 somoni

May 2002
1 somoni = USD 0.37
USD 1 = 2.7 somoni

October 2002
1 somoni = USD 0.34
USD 1 = 2.95 somoni

June 2003
1 somoni = USD 0.32
USD 1 =3.15 somoni

*Sources: SCSRT (2002: 147); www.asiaplus.tajnet.com; ADB (2002); Field study 2003*

**Soviet Rouble**
1989
1 Soviet Rouble = USD 1.02
USD 1 = 0.98 Soviet Rouble

*Source: Citizen of Khorog*

# Local Terminology

***Apparatchik*** A member of a Socialist or Communist Apparat
***Attalya*** A soup made of grasses, beans or peas with the addition of a handful of flour on rare occasions
***Barki Tojik*** The national energy company of Tajikistan
***Bazaar*** Market
***Beg*** Local Seigneur
***Hukumat*** Local administration office (hukumat is the Tajik word for government)
***Jamoat*** The smallest political entity, which is composed of 5 to 20 villages (Breu & Hurni 2003)
***Khan*** Important regional ruler
***Kishlok*** Village
***Kolkhoz*** Collective farm: Apart from the land, the capital and the productive assets belong to the workers (Herbers 2001b: 370)
***Leskhoz*** Governmental forestry office
***Oblast*** Province
***Somoni*** National currency of Tajikistan
***Sovkhoz*** State farm: The land and all other property belong to the state, the workers are employees of the state with fixed salaries and the state absorbs all the profits and losses of the *sovkhoz* (Herbers 2001b: 370).
***Tajikles*** Tajik Forestry Department
***Teresken*** Shrubby plant belonging to the family of *Chenopodiaceae*, There are several scientific names for *teresken*: as *Eurotia ceratoides*, *Ceratoides papposa* and *Krascheninikovia ceratoides*. In the Tajik Pamirs these shrubs grow at altitudes of 1800-4500 meters (Wennemann 2002: 68).
***Tugai*** Forests lining rivers and brooks, which consist of different species of willow (*Salix shugnanica* and *Salix turanica*), Russian olive, (*Elaeagnus augustifolia*), sallow thorn (*Hippophae rhamnoides*) and poplar (*Populus pamirica*) (Wennemann 2002: 85).

# Terminology Used in the Present Study

All village names are written as they are listed in the demographic statistics of the MSDSP (2003).

In the present study the following terms are used with the following meanings:
**Firewood:** Wood from trees used for burning.
**Fuel wood:** All types of woody vegetation (trees, bushes, shrubs) used for burning.
**Biomass fuels:** Fuel wood, dung and agricultural residues used for burning.
**The Tajik Pamirs:** Used interchangeably with Gorno Badakhshan, Gorno Badakhshan Autonomous Oblast, GBAO, the Pamirs.
**Pamiris:** Population of the Tajik Pamirs, used interchangeably with Badakhshani.

# Glossary

**Energy-poverty** Is the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development (Piana 2002).
**Land degradation** Is the reduction in the capability of the land to produce benefits from a particular land use under a specific form of land management (Hurni et al. 1996: 11).
**Land** Is defined as follows in terms of the functions of its resources:
Productive functions: To produce food, fodder, fuel, construction material, industrial goods, etc.
Physiological functions: To ensure human health by minimizing toxic substances in water, soil and plants, or hazards such as landslides, flash floods, etc.
Cultural functions: To preserve creation and the integrity of the landscape: the role(s) of water, land, forests and animals as an essential part of the cultural heritage, and to maintain the historical and aesthetic value of the landscape.
Ecological functions: To ensure maintenance of ecosystem functions and global life support functions, including source/sink capacity for greenhouse gases, filtering of water and pollutants, and maintenance of global geochemical (nutrient) cycles, etc (Herweg et al. 1998: 28).
**Stakeholders** Are interest groups or dependent groups, i.e. categories of people or institutions who share a common interest in a piece of land, be it an individual plot, the territory of a community, or a national conservation area (Hurni 1997: 212).
**Sustainable Development** Is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Definition of the WCED in Hurni et al. 1996: 26).
**Sustainable land management** This is a system of technologies and/or planning that aims to integrate ecological with socio-economic and political principles in the management of land for agricultural and other purposes to achieve intra- and intergenerational equity (Hurni et al. 1996: 27).

# Part I
# Introduction



# 1. Introduction to Energy Problems in Mountain Regions

In 1992 during the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, commonly referred to as the Earth Summit, the world's mountain regions finally received attention at the highest level. This was expressed with the integration of Chapter 13 "Managing Fragile Ecosystems: Sustainable Mountain Development" into Agenda 21, the UNCED's primary output. The years following the Rio Conference have witnessed an enormous increase in awareness of mountain issues on the world scene. Mountains cover a fifth of the world's terrestrial land area and provide the direct life-support base for about a tenth of the world's population. Moreover, mountain areas supply lowland peoples with vital resources such as fresh water, food, wood and minerals. At least half of the human population is dependent on fresh water originating in mountainous regions. Worldwide linking processes between mountains and lowlands, known as highland-lowland interactions, stress the importance of mountain ecosystems for the entire world. Mountains not only provide indispensable resources, but mismanagement of mountain lands also has the potential for overwhelming degradation in the lowlands. (Messerli & Ives 1997; FAO 2001)

Mountain regions are characterized by steep slopes, high altitudes and extreme landscapes resulting in high degrees of fragility (vulnerable to degradation), marginality (resource scarcities), inaccessibility (limited accessibility) and diversity (high location specificity). These features cause harsh conditions for mountain dwellers and demand adaptive and diversified livelihood strategies. For centuries demand and supply options of vital resources have developed within the existing mountain ecosystems. The spread of twentieth century industrialization and the closer integration of this fragile system into mainstream economies has led to the marginalization and disappearance of indigenous knowledge systems. External intervention not only weakened traditional mechanism for coping with risk and vulnerability, but also made the resource use systems more demand driven than determined by supply potential. Thus, although integration has provided benefits to mountain people, it has also marginalized the traditional sources of resilience to stress and vulnerability. (Jodha 2001)

Biomass and human or animal power have been the main energy sources all over the world for centuries. In mountain areas, due to their remoteness, this has not changed until very recently. In many remote areas however these traditional forms of power still prevail. The vast majority of mountain people are still totally dependent on firewood, dung and crop residues to provide energy for cooking, heating and lighting. Increasing demand for energy as a result of rapid population growth and changing needs of mountain communities exerts growing pressure on the limited natural resources. The impact of this aggravating energy situation includes increasing deforestation und added drudgery, especially for women, in procuring the energy needed for households and farms. Inefficient use of firewood and significant losses in agricultural production because crop and animal wastes have to be used as fuel, make the situation even worse. Mountain areas also suffer from inadequate supply of commercial energy resources (fossil fuels, electricity), as these are only available at high costs. On account of diminishing local natural energy resources, decreasing supply of firewood and the commercialization of traditional fuels, it has become very difficult for mountain dwellers to secure an adequate energy supply at reasonable costs. (Kadian & Kaushik 2003; Rijal 1998)

## 1.1 Energy Problems in the Tajik Pamirs

In 1923 Gorno Badakhshan was integrated into the Turkestan Autonomous Soviet Socialist Republic (ASSR), and later became an autonomous province of the newly founded Tajik ASSR. With the integration of Gorno Badakhshan Autonomous Oblast (GBAO) into the Soviet Union, the Tajik Pamirs faced major restructuring (Breu & Hurni 2003: 13). Private land ownership was abolished and agricultural land was collectivized into *kolkhozes*[1] and *sovkhozes*[2]. The people in the Tajik Pamirs were thus forced to renounce traditional livelihood strategies. Under state management the cultivation of fodder for livestock farming and tobacco as a cash crop gained steadily priority. In the late eighties only 25% of the cultivable land served for the production of food. Fodder was grown on 70% of the arable land and five per cent of the land was used for the production of tobacco (Herbers 2001b: 371). That meant the demand for food

[1] *Kolhozes* are collective farms. Apart from the land, the capital and the productive assets belong to the workers (Herbers 2001b: 370).

[2] *Sovkhozes* are state farms. The land and all other property belong to the state, the workers are employees of the state with fixed salaries and the state absorbs all the profits and losses of the *sovkhoz* (Herbers 2001b: 370).

***Picture 1.1:*** *According to Lenin: "Communism – that is Soviet power and electrification of the whole country" (Altrichter 2001: 49). (Photos: T. Hoeck, June 2003)*

and other vital goods had to be covered to a great extent with external sources. Gorno Badakhshan thus got utterly dependent on supplies from outside the region. Even in very remote villages, state shops were established where people could purchase food and other products at fixed prices. The distribution of these goods was subsidized considerably by the state. Moreover, non-agricultural employment possibilities (administrative jobs in the kolkhozes, sovkhozes, and in the education and health sector) were introduced and people received reasonable wages. Energy resources such as coal and kerosene were available at the local state shops and affordable for everyone (Herbers 2002: 81). In 1940 electrification of the Tajik Pamirs began with the construction of a hydropower plant in the *oblast* centre, and other decentralized hydro schemes followed in district centres and villages (Zibung 2002: 88). In the sixties, electricity from hydropower was complemented with the establishment of several diesel power plants. Transmission lines were extensively drawn up the valleys, constituting veritable electricity grids supplying even very remote villages with power (see Picture 1.1).

The collapse of the Soviet Union not only brought independence to the union republics in 1991, but also suddenly caused a power vacuum and a breakdown of the state-controlled subsidized provision system. Shortly after Tajikistan declared its independence on September 9th 1991, a civil war broke out as a result of a power struggle among different political parties and regional groups. Lack of local resources and the cessation of subsidized supplies from the lowlands resulted in a drastic shortage of food and other products (i.e. coal, diesel oil, kerosene) in GBAO. The agricultural system inherited from the Soviets, which concentrated on fodder and cash crop production, was no longer able to supply the local population with food. The situation was aggravated even more by the turmoil of civil war and by the arrival of 55,000 refugees (22.7% of the population in 1993) in Gorno Badakhshan. Increased prices for provisions from the lowlands accompanied by high inflation and the discontinuation of salary payments resulted in a disastrous economic situation (Herbers 2001b: 372). People had no other choice than to rely again on the local natural resources to satisfy their demand for food and energy, as they had 70 years before. But conditions had changed since then: Gorno Badakhshan had experienced a rapid population growth under Soviet rule, from 56,000 in 1926 to 213,000 in 2003 (Breu & Hurni 2003: 10; MSDSP 2003), and indigenous knowledge and traditional livelihood strategies for a mixed mountain agriculture[3] had disappeared as many dwellers pursued other occupations during Soviet time (Herbers 2001a: 21). As coal, diesel oil and kerosene provision have stopped and the electricity infrastructure have severely suffered from the years of civil war (1992–1997)[4], the vast majority of the people nowadays are heavily dependent on local bio-

3 A household practices agriculture and livestock farming on seasonally different altitudes (Herbers 2002: 81).

4 The conflict could finally be settled with a peace agreement signed by the conflicting parties in June 1997 (Herbers 2001a: 18).

mass fuels to cover their basic energy needs. Large forest areas have already been cleared and people thus have to compensate for diminishing firewood sources with the use of shrubs and manure. The energy situation in GBAO is characterized by a huge gap between supply and demand, high domestic energy consumption, insufficient electricity supply, and expensive commercial fuels (electricity, diesel oil, petrol) with a tendency towards increasing prices. This leads to extreme dependence on non-commercial fuels, high pressure to use woody vegetation and rapid environmental degradation. As a result, particularly rural areas in GBAO are suffering severely from a real energy crisis. It is apparent that an adequate energy supply at reasonable prices is part of the groundwork for further development. In other words, scarcity of energy is one of the main constraints in developing the Tajik Pamirs and maintaining the potential of its natural resource base.

***References***

Breu, Thomas and Hurni, Hans (2003) The Tajik Pamirs: Challenges of Sustainable Development in an Isolated Mountain Region. Bern: Centre for Development and Environment, University of Berne.

FAO [Food and Agriculture Organization of the United Nations] (ed.) (2001) FAO and World Energy Council Call for Higher Priority to Energy Problems in Rural Areas. Press Release 00/01. www.fao.org

Herbers, Hiltrud (2001a) Transformation im tadschikischen Pamir. Vom Proletariat zum Bauerntum. In: Geographische Rundschau, Vol. 53, No. 12: 16-22.

Herbers, Hiltrud (2001b) Transformation in the Tajik Pamirs: Gornyi-Badakhshan – An Example of Successful Restructuring? In: Central Asian Survey, Vol. 20, No. 3: 367-381.

Herbers, Hiltrud (2002) Ernährungs- und Existenzsicherung im Hochgebirge: der Haushalt und seine Livelihood strategies - mit Beispielen aus Innerasien. In: Petermanns Geographische Mitteilungen, Vol. 146, No. 4: 78-87.

Kadian, Promila and Kaushik, Sushma (2003) Rural Energy for Sustainable Development. Participatory Assessment of Energy Resources. New Dehli: Deep & Deep Publications ltd.

Messerli, B. and Ives, J. D. (eds.) (1997) Mountains of the World. A Global Priority. New York: The Parthenon Publishing Group.

Jodha, N. S. (2001) Interacting Processes of Environmental and Social Vulnerabilities in Mountain Areas. Issues in Mountain Development, 2001/2. ICIMOD Publication. www.icimod.org/publications/imd/imd2001/imd2000-2.htm 18.11.2002

Rijal, Kamal (1998) Sustainable Energy Use for Mountain Areas: Community-Level Energy Planning and Management. Issues in Mountain Development, 1998/4. ICIMOD Publication. www.icimod.org/publications/imd/imd98-4.htm 18.11.2002

Zibung, Daniel (2002) Eine integrale Analyse der Infrastrukturausstattung und Energieversorgung in der Grossregion Gorno-Badakhshan, Tajikistan. Diplomarbeit. Bern: CDE.

# 2. Objectives and Research Questions

The overall goal of the study is to provide an integral analysis of the energy situation and its consequences for land and energy resource use at the household and village levels in rural areas of the Tajik Pamirs. The study further assesses the impact of micro and mini hydropower stations (MHPS) on land use, local economic activities and environment with regard to a sustainable use of renewable energy resources, and mitigation of resource pressure and land degradation. For a detailed understanding of the energy situation the authors have focused on the following **objectives:**

- To uncover patterns of unsustainable use of renewable energy resources as well as their ecological and socio-economic impact.
- To make an inventory and a quantification of locally available and imported energy resources as well as their use and consumption at the household and village level.
- To indicate impact of MHPS on the sustainability dimensions at the household and village level.
- To determine potential and possibilities of hydropower to relieve pressure on local biomass fuels.

To achieve the above-listed objectives, the study aims at answering the following main **research questions:**

- What are the consequences of increased pressure on renewable energy resources and to what extent does pressure on these energy resources contribute to land degradation?
- What positive or negative effects does the construction of an MHPS have on land use, local economic activities and on the environment with regard to its potential to mitigate pressure on natural resources and land degradation?

As energy supply in the Tajik Pamirs is a very important and urgent issue, this study shall provide the basic information for a better understanding of the energy problems, especially in rural areas. Moreover, concrete short-term and long-term recommendations shall help to initiate projects in the field of energy supply and resource use in Gorno Badakhshan Autonomous Oblast.

# 3. State of the Art

## 3.1 Rural Energy Development

As energy is closely linked to the most urgent social issues highlighted in the international development agenda, such as sustainable development, poverty, gender disparity, population growth, agricultural production, land degradation and climate change, the global social goals agreed on at the UN conferences in the nineties cannot be achieved without paying appropriate attention to the importance of energy in all these issues (Piana 2002). However, improvements in energy supply often concentrate on urban areas and do not trickle down to the rural poor. Therefore, in 2001 the World Energy Council[5] and the UN Food and Agriculture Organization (FAO) called for higher priority of energy problems in rural areas. It was noted that more than three billion people around the world live in rural areas, nearly 90% of them in developing countries. Moreover, only 33% of the rural population in developing countries have access to electricity (FAO 2001). Rural communities cover their basic needs for energy to a great extent by use of biomass fuels, such as wood, charcoal, crop residues, manure and assorted dry vegetation. In very remote regions biomass is often the only accessible and affordable source of energy. Population growth and increased demand for energy create growing pressure on local biomass stocks, resulting in a vicious circle of environmental degradation. Energy, in fact, is one of the most important contributors to environmental problems (FAO 2001; Habtetsion & Tsighe 2001; OSIENALA & GNF 2004; Rijal 1998; Shrestha 2001). In many regions a sustainable use of biomass fuels is not possible considering the present rate of exploitation relative to the stock. As these will remain the major energy resources for rural and mountainous areas, in the near future, appropriate resource management practices and new technologies allowing a more efficient use have to be introduced (Clemens 2001; Habtetsion & Tsighe 2001). Many rural and mountainous regions of the world are facing severe energy poverty[6], so that adequate development strategies are necessary to avert further environmental and social degradation, and allow a sustainable development in these areas. Rural energy development cannot be performed independently. Its integration into the economic and social development of the region is of crucial importance (Shrestha 2001; Piana 2002). The challenge is not just to provide sufficient energy resources to rural communities, but also to build energy infrastructures, management systems and socio-economic conditions, which guarantee meeting the essential needs of the population over a longer term. This is because only an adequate and affordable energy supply will enable rural economies to diversify and encourage the development of alternative livelihood systems. Unfortunately, policy decisions influencing energy supply in mountainous or rural areas are generally made in centers of power far away from the politically marginalized communities. State policies are often not favorable to remote regions, because in development issues they focus on urban or industrial areas, while the needs of rural households, farmers and small businesses are generally lower priority (Habtetsion & Tsighe 2001; Kadian & Kaushik 2003).

Programs for the development of renewable energy resources in rural and mountainous areas have been conducted over the last 15 years (i.e. in the Hindu Kush-Himalayan region), but the expected improvements in energy use and supply were not forthcoming. This is primarily because of lack of proper technical and institutional mechanisms to ensure that energy resources match the needs, lack of understanding of socio-economic and cultural factors, and because the spatial characteristics of the region (mountainous or rural) have not been thoroughly understood (Rijal 1998). New energy resources or technologies were often introduced without a prior assessment of socio-economic characteristics, an analysis of the condition and position of women in the communities, and the ability of households to pay for new energy options. Moreover, poor linkages and coordination between the stakeholders involved in energy planning or on the energy supply and demand sides are responsible for the unsatisfactory performance of programs and waste of unnecessary efforts (Habtetsion & Tsighe 2001; Papola 1996; Rijal 1998). Therefore, energy development in rural and mountainous regions must be decentralized, with local women and men at the heart of planning and implementation (FAO 2001). Since agriculture represents the backbone of the livelihoods of rural mountain communities, the relation between energy and agriculture (as energy user and supplier at the same time) must also be analyzed and considered in energy development strategies (Piana 2002). In recent years, new energy demands have arisen for communication devices (radio, TV, phone, and Internet), household appliances and small-

5 The World Energy Council (www.worldenergy.org ) is a global multi-energy organization with committees and activities in approximately 100 countries, including most of the largest energy producing and consuming countries in the world (FAO 2001).

6 Energy poverty is related to the basic absence of sufficient choice in accessing adequate, affordable, reliable, high quality, safe and environmentally benign energy services to support economic and human development (Piana 2002).

scale industries in mountainous and rural communities, most of which can only be satisfied by electricity (Schweizer & Preiser 1997). Junejo (1997: 1) emphasizes, “electricity is no more regarded as a luxury but a necessity even in the most remote and underdeveloped areas of the world”. Therefore, with respect to the further development and economic advancement of remote areas, sustainable energy development must consider electricity as a key commodity.

Several investigations and case studies (Clemens 2001; Fischbacher 1999; Kadian & Kaushik 2003; Ott & Wymann 1993; Rijal 1999; Shrestha 2001) in the field of energy use at household and community levels analyzed the impact of electricity and other new technologies on rural and mountain communities. The main focus was on resource savings through more efficient use, relieving pressure on biomass fuels through resource substitution, poverty alleviation and income generation. In the Hindu Kush-Himalayan region, more efficient use of firewood could be achieved with the introduction of improved cooking stoves resulting in savings of 30-40% (Shrestha 2001). The electrification of mountain communities in Nepal led to the reduction of firewood consumption to two-thirds of its previous level, as domestic activities such as cooking, heating water and baking bread could be performed to a great extent on electric appliances. Nevertheless, people still rely on firewood, because electric power is not widely used for room heating due to insufficient supply. Moreover, there is no confidence in the long-term availability of electricity (Fischbacher 1999: 197; Ott & Wymann 1993: 35). Hence, in most remote regions, large-scale substitution of electric power for biomass fuels is not realistic considering present electricity supply and the demand for energy (Clemens 2001). It was also noted that the availability of electricity has a positive impact on agriculture, industrialization, employment, social change, education and on income generation. All in all, electricity led to an increase of the living standard of rural communities (Fischbacher 1999; Kadian & Kaushik 2003). However, biomass fuels are likely to remain the most appropriate fuel for most people in mountain regions for decades to come, as commercial fuels to a great extent will not be affordable to rural dwellers. Thus the main concern is to make the consumption of biomass fuels sustainable rather than to restrict the use of it (Clemens 2001; Rijal 1999).

## 3.2 Mini and Micro Hydropower as an Adequate Energy Option for Mountain Regions

The characteristics of rural and mountain areas, such as dispersed settlements, difficult access and thus high importation cost for fuels or electric power, call for decentralized renewable energy options. Hydropower is considered the most viable, cost-effective and environmentally-friendly option for power provision to remote mountain communities (Schweizer & Preiser 1997: 159; Junejo 1997: 1). Moreover, hydropower has already been used in traditional watermills in mountainous regions for centuries, and the mechanism of this technology is principally known to the local population (Raju 2001). Since the use of indigenous technology and management know-how and its improvement are more productive than the introduction of entirely new and modern technologies, the use of hydropower will be an adequate energy option in these regions (Shrestha 2001). A modification of traditional watermills generating mechanical power to micro hydropower plants has already been made in the Hindu Kush-Himalayan region. A villager installed a self-designed turbine, with a capacity of five kilowatts, in a traditional water mill, which generates sufficient electricity to supply the whole village (51 households) with power for lighting (Raju 2001). Micro and mini hydropower exploitation at a decentralized level basically fulfills four important conditions for sustainable development (ICIMOD 2001):

1. It substitutes the use of fossil fuels in the domestic sector and has the potential for the substitution of biomass fuels as well.
2. It holds tremendous potential for improving productivity in the agricultural sector by providing much-needed energy for water lifting and irrigation.
3. Its application potential in small-scale industries is enormous. Rural industrialization could receive a major boost.
4. It reduces the time spent in procuring energy and this contributes to the reduction of drudgery.

However, the development and dissemination of micro and mini hydropower is constrained by various problems: Demand often exceeds supply, with the consequence of reduced firewood-saving effect, frequent need for repairs and maintenance, inadequate management, and lack of desirable quality control not to mention, lack of backup services and absence of competent technicians in most areas (Junejo 1997; Kim & Karky 2002; Shrestha 2001). Nevertheless, a positive impact of micro and mini hydropower on mountain communities has also been reported. Electricity replaces kerosene and diesel for lighting and partially replaces firewood used for cooking and baking, resulting in resource savings of up to 30% (Ott & Wymann 1993: 35). Furthermore, electric power from the hydropower plant is used for income generating activities such as milling, wood processing or tourist lodges. Income generation is important to guarantee the long-term operation of the scheme (Kim & Karky 2002). Nonetheless, mini and micro hydropower is seldom used for productive purposes, which would generate profits and allow sufficient net return for the scheme. Stoffel et al. (2002: 30) propose a model to foster independent development through the use of hydropower. The primary goal of the power plant shall be to make a profit to cover maintenance costs and possibly amortize the initial community investment. But most of the profits shall be available for other sustainable development projects in the community.

Hydropower projects implemented so far have made little contribution to relieving pressure on biomass fuels, since electric power is used mainly for lighting. Insufficient power capacity, the rejection of substituting hydropower for wood in heating and cooking, and the high cost of electricity compared to "freely" available biomass fuels constrain the proper use of electricity in a wide range of domestic activities (Sinclair 2003). It can be concluded that the implementation of mini and micro hydropower in rural and mountain communities had an impact rather on socio-economic level than on the local environment.

However, many community-based micro hydropower schemes have shown success during recent years, and have proved to be a reliable source of renewable energy for mountain communities (Shrestha 2001).

## 3.3 Research in the Energy Sector in the Tajik Pamirs

Few investigations conducted so far in the Tajik Pamirs have focused on the energy situation. The energy problem was often mentioned, but not analyzed, in research reports on desertification and degradation (Kleinn 2002; Kleinn 2003; NABU 2002), on local development profiles (Degen 2001) and on livestock farming in the Eastern Pamirs (Domeisen 2002; Hangartner 2002). These reports provide basic figures concerning the consumption of biomass fuels at the household level in several villages in the Tajik Pamirs. The broad analysis of infrastructure and energy supply in Gorno Badakhshan given in Zibung (2002), and the report of the AKF (2003) focusing on micro hydropower projects and their impact on local communities, provide a more detailed look at energy resource use at the household level. In addition, a number of investigations (World Bank 2002; World Bank & IFC 2002; IFC 1999; IFC & GoT 2001; ZERKALO 2000) have been performed on behalf of the Pamir Private Power Project (PPPP) with regard to electricity consumption, willingness and ability to pay for electricity, and environmental and social impact of the project[7]. These reports clearly depict that there is an enormous shortage of energy resources and therefore an urgent need for better energy supply in Gorno Badakhshan. It is also emphasized that, given the present income situation in GBAO, a majority of the population will not be able to pay for electricity provided at an average price of USD 0.021/kWh, let alone for increased consumption. Thus, it is unlikely that a substantial amount of biomass fuels will be substituted with electricity, even if appropriate power supply from the grid is guaranteed. Moreover, it is stated that even after the completion of the PPPP there will be a lack of sufficient electricity to satisfy the demand of the whole region.

Breu and Hurni (2003) have made a major contribution to the awareness of the importance of the energy crisis in the Tajik Pamirs. To enhance knowledge, highlight problems and opportunities, and elaborate strategic elements for sustainable development in Gorno Badakhshan, a workshop[8] was organized within the Pamir Strategy Project (PSP), and conducted by the Centre for Development and Environment (CDE), University of Berne. The outcome from stakeholder negotiations of a list of strategic objectives and development priorities clearly depicts the urgency of improvements in the energy sector. All stakeholder groups (communities, GBAO administration, Civil Society Organizations working in the region, national administration, international organizations) gave highest ranking to the strategic objective of 'Maintaining energy facilities and increasing energy production' in Gorno Badakhshan (Breu & Hurni 2003: 63). This confirms the importance of sufficient and adequate energy supply as a precondition for sustainable development in the Tajik Pamirs.

Up to now no study using an integral approach had been conducted in the Tajik Pamirs investigating the energy problem. For the proper understanding of the energy situation, a focus has to be made on energy resource use and consumption patterns at household and village levels, considering seasonal differences in demand and supply and the communities' specific socio-economic circumstances. In addition, the linkage between energy resource use and land and resource degradation is of crucial importance in allowing creation of adequate measures to relieve the energy crisis. As micro and mini hydropower is viewed as an adequate energy option for mountain regions and Gorno Badakhshan is home to a great number of small-scale hydro schemes, the investigation of existing hydro schemes with regard to their spatial distribution and operational performances is the groundwork for further possible decentralized energy options. Further, other important issues are the assessment

7 The Pamir Private Power Project consist of the rehabilitation of existing hydropower plants and transmission infrastructures, as well as of a water flow regulation structure at Lake Yashilkul allowing increased and perennial operation of the power plants. For further information the reader is referred to Chapter 8.1.3.

8 The workshop was held in Khorog, the capital of GBAO, in October 2002.

of their impact on socio-economic and ecological levels, as well as their potential to replace biomass fuels and mitigate pressure on woody vegetation. However, since improvement of electricity supply is an important but not a sufficient measure to solve the energy problem in GBAO, the analysis of locally available and renewable energy options, such as the sustainable use of biomass fuels, should not be neglected. The present study aims to fill to a great extent the above-mentioned research gap in the energy sector in the Tajik Pamirs, thereby providing a scientific basis for a sustainable energy resource use, identifying opportunities and defining measures for mitigating the energy crisis in Gorno Badakhshan.

***References***

AKF [Aga Khan Foundation] (ed.) (2003) Lighting up Communities. A Case Study of the Mountain Societies Development Support Program's Mini-Hydel Projects in Gorno Badakhshan Autonomous Oblast. Evaluation Learning and Communication Unit Tajikistan: Dushanbe.

Breu, Thomas and Hurni, Hans (2003) The Tajik Pamirs: Challenges of Sustainable Development in an Isolated Mountain Region. Bern: Centre for Development and Environment, University of Berne.

Degen, Muriel (2001) Local Development Profile of Basid, Tajikistan. Internal Report Pamir Strategy Project. Bern: Centre for Development and Environment, University of Berne.

Domeisen, Michael (2002) Marginalized by the Impact of Transformation. A Study of Post-Soviet Livestock Breeding in the High Mountains of the Eastern Pamirs. Diplomarbeit. Bern: Centre for Development and Environment, University of Berne.

FAO [Food and Agriculture Organization of the United Nations] (ed.) (2001) FAO and World Energy Council Call for Higher Priority to Energy Problems in Rural Areas. Press Release 00/01. www.fao.org

Fischbacher, Christa (1999) Entwicklung durch Technik. Auswirkungen der Einführung des elektrischen Stroms untersucht am Beispiel der Sherpa-Dorfgemeinschaften im Khumbu Himal, Nepal. Dissertation. ÖFSE.

Habtetsion, Semere and Tsighe, Zemenfes (2001) Renewables and Energy for Rural Development. Current Energy Utilization and Future Options in Rural Areas. Second Draft Report. African Energy Policy Research Network (AFREPREN). Energy Research Prgramme 2000-2002.

ICIMOD [International Centre for Integrated Mountain Development] (ed.) (2001) Energy Issues in the Hindu Kush Himalayas. Mini/Micro Hydropower for the Mountains. International Centre for Integrated Mountain Development, Kathmandu, Nepal. http://www.icimod.org/focus/energy/energy_mmhp.htm

IFC [International Finance Corporation] (ed.) (1999) Gorno-Badakhshan Energy Development Project. Review of the Pamir HPP. Preliminary Draft. Zürich: Electrowatt Engineering.

IFC [International Finance Corporation] and GoT [Government of Tajikistan] (eds.) (2001) Evaluation of the GBAO Electric Networks and Assistance in Project Preparation. Volume 3 Environmental and Socio-Economic Measures. Elektrowatt Engineering Ltd.

Junejo, Anwar A. (1997) Development of Mini- and Micro-hydropower : Issues and Constraints. Issues in Mountain Development, 1997/2. ICIMOD Publication. www.icimod.org/publications/imd/issue972.htm 18.11.2002

Kadian, Promila and Kaushik, Sushma (2003) Rural Energy for Sustainable Development. Participatory Assessment of Energy Resources. New Dehli: Deep & Deep Publications ltd.

Kim, Esther and Karky, Bhaskar Singh (2002) Water Resources Use in the Annapurna Conservation Area: Case Study of Micro-Hydropower Management in Sikles and Chhomrong. Case study on "Mountain infrastructure: access, communications, energy", Mountain Forum E-consultation for the UNEP / Bishkek Global Mountain Summit.

Kleinn, Eva (2002) Unpublished Report on the Use of Fuel Resources on the Territory of GBAO Districts. GTZ.

Kleinn, Eva (2003) Unpublished Report on Teresken Acquisition in Murgab Center (Eastern Pamirs). GTZ.

NABU [German Society for Nature Conservation] (ed.) (2002) Biodiversity Assessment and Overview. A Subproject of the Pamir Strategy Project, Centre for Development and Environment. German Society for Nature Conservation. Edited by Eva Kleinn.

OSIENALA [Friends of Lake Victoria] and GFN [Global Nature Fund] (eds.) (2004) Renewable Energy for Fisherfolks of Lake Victoria. A Joint East African Training Programme for Technicians for the Conservation of Lake Victoria Resources and the Environment. A Project of OSIENALA (Friends of Lake Victoria) in Collaboration with Global Nature Fund (GNF). Final Proposal Version 2.0.

Ott, Cordula and Wymann, Susanne (1993), Salleri Electricity Utilization Project. Impact Status Report 1992. Prepared for the Swiss Development Coorporation (SDC). Berne: Centre for Development and Environment (CDE).

Papola, T. S. (1996) Integrated Planning for Environment and Economic development in Mountain Areas: Concepts, Issues and Approaches. Issues in Mountain Development, 1996/1. ICIMOD Publication. www.icimod.org/publications/imd/issue1.html 18.11.2002

Piana, Grazia (2002) The Role of Energy in Sustainable Development: Rio, Johannesburg and beyond. Proposal for a new study. Environment and Natural Resources Service. Sustainable Development Department and Food and Agriculture Organization of the United Nations. www.fao.org

Raju, KV. (2001) Eco-Friendly Hydro-Electric Power in Himalaya Mountain Regions: Implications for Development. World Mountain Symposium 2001. Paper presented in the World Mountain Symposium 2001, Interlaken, Switzerland. Sep 30- Oct 04, 2001.

Rijal, Kamal (1998) Sustainable Energy Use for Mountain Areas: Community-level Energy Planning and Management. Issues in Mountain Development, 1998/4. ICIMOD Publication. www.icimod.org/publications/imd/imd98-4.htm 18.11.2002

Rijal, Kamal (ed.) (1999) Energy Use in Mountain Areas. Trends and Patterns in China, India, Nepal and Pakistan. Kathmandu: International Centre for Integrated Mountain development (ICIMOD).

Schweizer, Petra and Preiser, Klaus (1997) Energy Resources for Remote Highland Areas. In: Messerli, B. and Ives, J. D. (eds) Mountains of the World. A Global Priority. New York: The Parthenon Publishing Group.

Shrestha, Ganesh Ram (2001) Energy Technologies for Mountain Communities. World Mountain Summit 2001.

Sinclair, John A. (2003) Assessing the Impacts Of Micro-Hydro Development in the Kullu District, Himachal Pradesh, India. In: Mountain Research and Development. Vol. 23, No. 1, February: 11-13.

Stoffel, M., Monbaron, M., Maselli, D. (2002) Mountains and Lowlands: Enemies or Partners? Example of the High Atlas, Morocco. A Joint Publication of SDC, OSS, UniFR and CDE. University of Fribourg.

World Bank (ed.) (2002) Tajikistan Pamir Private Power Project. Environment and Social Impact Assessment. Executive Summary. www.worldbank.org

World Bank and IFC [International Finance Corporation] (eds.) (2002) Project Appraisal Document on a Proposed International Development Association in the Amount of up to SDR 7.9 Million to the Goverment of Tajikistan and on International Finance Corporation Financing Consisiting of: An „A“ Loan in the Amount of up to US$ 4.5 Million and an Equity Subscription of up to US$ 3.5 Million to Pamir Energy Company for the Pamir Private Power Project in the Republic of Tajikistan. May 31st 2002.

ZERKALO [Sociological Research Centre] (ed.) (2000) Social Research Report, GBAO October 2000. Dushanbe: Sociological Research Centre.

Zibung, Daniel (2002) Eine integrale Analyse der Infrastrukturausstattung und Energieversorgung in der Grossregion Gorno-Badakhshan, Tajikistan. Diplomarbeit. Bern: CDE.

# 4. Research Concepts

The present study is embedded in the theoretical concepts of sustainability, sustainable land management and syndrome mitigation, which will be briefly discussed in this chapter.

## 4.1 The NCCR North-South[9] Research Approach

The Swiss National Science Foundation (SNSF) introduced a new mechanism in 1999 to support research in Switzerland. As a result 14 National Centers of Competence in Research (NCCRs) were established in four main fields: Life sciences, social sciences, sustainable development and environment, and information and communication technologies.

The NCCR North-South, launched in 2001 with the financial support of the Swiss Agency for Development and Cooperation (SDC), is active in the field of sustainable development and environment, and is defined as a research partnership for mitigating syndromes[10] of global change. It is seeking to address some of the complex problems of the syndromes of global change through specifically focused research in partnership with researchers in developing countries and countries in transition. The NCCR North-South has three main objectives: To promote disciplinary, interdisciplinary and transdisciplinary research focusing on sustainable development, to help developing institutions and train staff in these fields of research in partner countries and in Switzerland, and to support societies and institutions in partner countries in their autonomous efforts to address syndromes of global change over the long term.

The syndrome approach is based on the hypothesis that similar clusters of core problems occur worldwide and that related approaches to mitigating them can be found. The NCCR North-South thus carries out economic, ecological and social research in three syndrome contexts, characterized by critical conditions:

1. Highland-lowland
2. Arid and semi-arid areas in transition
3. Urban and peri-urban areas

The working hypothesis is that these contexts are particularly vulnerable to the emergence of syndromes and that the mitigation of these syndromes is a precondition for achieving sustainable development.

The NCCR North-South consists of eight individual projects (IP) investigating the specific core problems in various field study areas. Research focuses on nine selected regions, so-called Joint Areas of Case Studies (JACS), located on four continents to link scientific insights in a global overview (NCCR N-S 2002).

The present study is linked to the individual project 'natural resources and ecology' (IP 2)[11] focusing on the core problem of 'overuse of renewable energy resources' in mountain areas, and is embedded in the syndrome context 'highland-lowland interactions' in the JACS 'Central Asia'. This thesis is closely connected to the dissertation of Thomas Breu "The Role of Knowledge Generation for Sustainable Land Management and Regional Development in the High Pamir Mountains of Tajikistan".

### 4.1.1 Pressure-State-Response Framework

The Pressure-State-Response framework (as used by the World Bank), supplemented with a second set of themes (Potentials, Dynamics and Innovations) serves as the conceptual framework for research on syndrome mitigation (see Figure 1.1). The first hypothesis argues that **pressure** is exerted on a certain **state** of environment or resources, to which the reaction is a societal **response**. The second hypothesis claims that change can also generate **potentials** instead of pressure, which lead

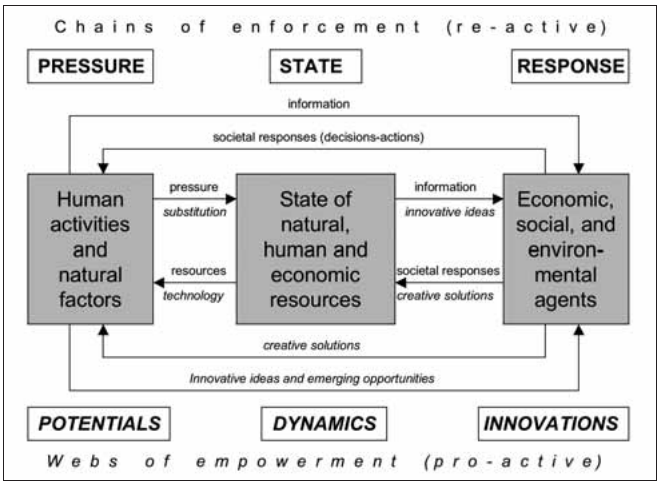



***Figure 1.1:** Conceptual Framework for Research of Mitigating Syndromes. Source: Hurni, Wiesmann & Kohler (1999)*

9 For more information about the activities in the NCCR North-South the reader is referred to the web site www.nccr-north-south.unibe.ch

10 A syndrome is defined as a cluster of core problems indicating a specific pattern of non-sustainable development (NCCR N-S 2002: 5).

11 The Individual Project 2 'Natural Resources and Ecology' (IP2) tackles issues related to land resources – mainly water, soil, vegetation and partially animals (livestock, wildlife). The emphasis is on understanding processes, cycles, indicators, triggers and threshold values with special focus on human activities and impacts (man-nature interactions) which may contribute either to the degradation or over-exploitation, or else to a more sustainable management of the mentioned resources (www.nccr-north-south.unibe.ch).

***Table 1.1:*** *The Six Major Components of the Pressure-State-Response Framework.*
*The right column contains the fields of research covered in the present study.*

| Component | Description | Covered in the present study |
|---|---|---|
| *Pressure* | The corresponding research project observes key processes and determines causes and effects. The monitoring of environmental and social changes as well as of economic dynamics combined with the use of models allows the prediction and analysis of trends | Pressure on natural energy resources, its causes, and consequences at ecological and socio-economic levels are investigated |
| *State* | The respective investigation describes the status of natural, cultural, economic and human resources and links these with processes of pressure to appraise changes. | An inventory and a quantification of locally available and imported energy resources as well as of their use and consumption at the household and village levels are compiled |
| *Response* | This research component focuses on social reactions to syndromes. Mitigation research is initiated to assist people in finding sustainable solutions. | Changes in strategies of action concerning the use of natural resources at household and village levels are observed |
| *Potentials* | The aims of the research project are the identification of potentials in human and natural resources as well as the generation of innovative solutions congruent with sustainable development are. | Potentials and possibilities of hydropower to relieve overtaxed renewable energy resources, which contribute to a sustainable land and resource use, are determined |
| *Dynamics* | The present state of natural, economic and human resources shall be perceived as a dynamic system that is highly sensitive to change. | Changes in energy resource use and processes of land degradation |
| *Innovations* | The respective research project focuses on technological and institutional innovations at various levels, on strategies to reduce negative impacts of the key processes of change and on methods and technologies to reduce pressure and dynamics of change. | Local innovations concerning the use and management of local energy resources |

*Source: Hurni, Wiesmann & Kohler 1999*

to **innovations** and creative solutions. The basic idea assumes the system to always have its own **dynamics** (Hurni, Wiesmann & Kohler 1999).

The six major components of this conceptual framework are briefly explained, and the fields of research covered in the present study are depicted (see Table 1.1).

## 4.2 Concept of Sustainable Development

Sustainable development has been defined by the World Commission on Environment and Development (WCED) in 1987 as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Hurni et al. 1996: 27). This definition was accepted at a global level by the United Nations Conference on Environment and Development (UNCED) in 1992. With global acceptance of this vaguely defined and ideological term there is the danger that sustainability or sustainable development are used in political discourses and interpreted for particular interests (Messerli 2002). Wiesmann (1997: 207) argues that "the term sustainable is meaningless unless it is associated with a specific reference quantity; it becomes meaningful only when it is related to a scale of values." Thus it is of great importance to apply the concept of sustainability in a concrete context. Wiesmann (1997) provides an important contribution to the concretization of the concept of sustainability by applying it in a context of regional development (see Figure 1.2). There is a general consensus that the evaluation of sustainability must consider the principle three components of economy, society and environment, but there is little general agreement about the different scales of values associated with this three main areas.

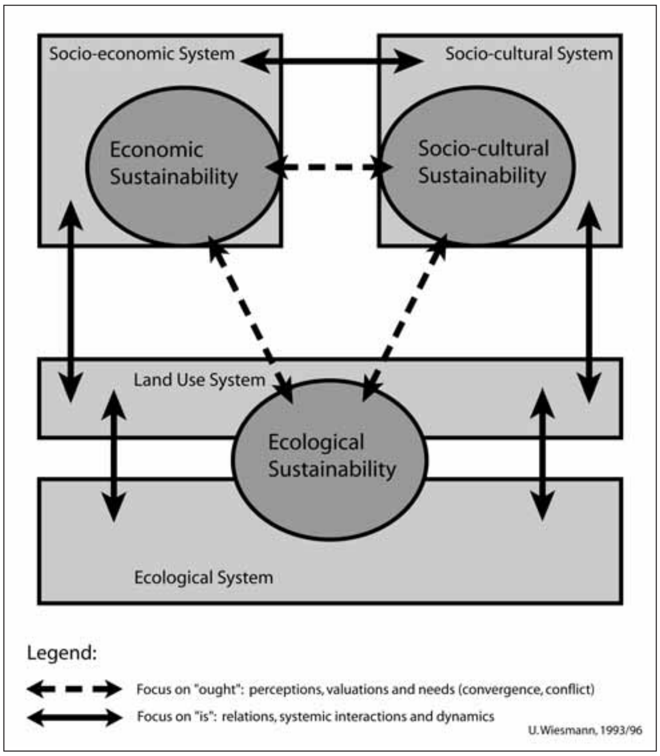



***Figure 1.2:*** *The Magic Triangle of Sustainable Development. Source: Wiesmann (1997: 208).*

The appraisal of what is sustainable, and what is not, is necessarily linked to specific social and political circumstances. The term "sustainability" incorporates several, even conflicting issues, which require reconciliation at the local and political level (Herweg et al. 1998):

- **Individual perceptions:** Different stakeholders may define sustainability differently according to their attitudes and economic, social and ecological interests.
- **Spatial considerations:** Water use in tropical highlands, for example, may be sustainable for the highlanders but unsustainable in adjacent lowlands, where it can cause water shortage.
- **Temporal scales and perspectives:** It is not possible to define sustainability today on behalf of the next generation. But it is possible to maintain the potential of opportunities so that future generations can develop their own values, priorities and possibilities to satisfy their needs.

Scales of values that are applied to socio-economic, socio-cultural and ecological sustainability can be debated independently, but they are not independent in terms of systemic interactions. Changes in one of the components of this system will have an impact on other components through a complex series of relationship. In particular, positive changes in values associated with economic sustainability are often linked to negative changes in values associated with ecological sustainability. Hence sustainable development will inevitably involve conflicts and thus must be seen as a gradual process of socio-political consensus building. There is a tendency to marginalize ecological sustainability in the context of social and political debate about sustainable development, because values associated with ecological sustainability are not sufficiently advocated in the public, are less anchored in society and cannot provide evidence of positive or negative effects as quickly as socio-cultural and economic criteria. Hence there is a particular need to focus on ecological sustainability and formulate criteria and indicators that can be used for its definition and evaluation to strengthen its position in the negotiation process. (Wiesmann 1997)

### 4.2.1 Sustainable Use of Natural Resources and Regional Development

Ecological sustainability, like the concept of sustainable development, is concerned with human-induced change. Human-induced ecological change is rooted in direct or indirect use of natural resources, whether such resource use is intentional or not. The use of resources thus has a decisive influence on ecological sustainability. Moreover, the ecological dimension of sustainable development is directly related to sustainable resource use. Since the ecological impact of land use can only be perceived and understood in a specific spatial-ecological context, measures designed to promote sustainable resource use must also be applied in a specific regional context. Wiesmann (1997: 211) concludes that "therefore the most meaningful way for the scientific community to strengthen the ecological dimension of sustainable development is to formulate criteria, indicators and measures for promoting sustainable use of resources in a context of local or regional development".

Balancing the gains of development against the negative effects of growth on natural resources and ecosystems is an ongoing challenge for countries around the world. One of the most difficult elements of this dilemma is managing energy. Energy is crucial to all aspects of development. Modern societies are preoccupied with satisfying their needs for energy while ignoring strategic and environmental impacts. The demand for energy often exceeds the capacity of local sources of supply, and the production and use of energy resources often results in deleterious impacts on the environment with irreversible consequences. Especially rural areas in developing countries suffer from massive energy problems being highly dependent on the deterioration of local resource bases. The growing number of people without reliable access to very basic energy supply predicates a rapid growth in the demand for energy in the coming years. Agenda[12] 21

12 Agenda 21 is the action programme that resulted from numerous pre-conference consultations prior to the UNCED Conference in Rio de Janeiro in 1992.

highlights the fact that current levels of energy consumption and production are not sustainable, especially if demand continues to increase, and stresses the importance of using energy resources in a way that is consistent with the aims of protecting human health, the atmosphere, and the natural environment. The challenge lies in finding a way to reconcile the necessity and demand for energy supply with its impact on the natural resource base in order to ensure a sustainable path of development. At both the Ninth Session of the Commission on Sustainable Development (CSD-9) and at the World Summit on Sustainable Development (WSSD) nations agreed that stronger emphasis should be placed on the development, implementation and transfer of cleaner, more efficient technologies and that urgent action is required to further develop and expand the role of alternative energy sources. (www.un.org/esa/sustdev/sdissues/energy/enr.htm; FAO 2001)

The present study addresses the core problem of 'overuse of renewable energy resources' at household and village levels, and aims to provide the scientific basis to promote sustainable energy resource use as a precondition for sustainable development in rural areas of the Tajik Pamirs.

## 4.3 Concept of Sustainable Land Management

The continuing population growth and economic growth place ongoing pressure on the earth's natural resources and ecosystems. The global population is so large that the way how land is managed has an impact on global life support systems, such as nutrient cycle, global warming and the hydrological cycle. Already one-third to one-half of the non-glaciated land surface is moderately or intensively managed, and about 70% of the total land surface of the earth is subject to some form of human intervention. Estimations assume that soon all land will be under some degree of management. This calls for strategies towards sustainable land management to ensure the enduring existence of the earth's natural resources and ecosystems (Dumanksi & Pieri 2001). In this context, land has to be viewed as a holistic term fulfilling functions that go beyond the production of food. According to Herweg et al. (1998: 28) land is defined as follows in terms of the functions of its resources:

- **Productive functions:** To produce food, fodder, fuel, construction material, industrial goods, etc.
- **Physiological functions:** To ensure human health by minimizing toxic substances in water, soil and plants, or hazards such as landslides, flash floods, etc.
- **Cultural functions:** T o preserve creation and the integrity of the landscape: the role(s) of water, land, forests and animals as an essential part of the cultural heritage, and to maintain the historical and aesthetic value of the landscape.
- **Ecological functions:** To ensure maintenance of ecosystem functions and global life support functions, including source/sink capacity for greenhouse gases, filtering of water and pollutants, and maintenance of global geochemical (nutrient) cycles, etc.

The concept of sustainable land management (SLM) is a means of coping with key problems occurring worldwide, such as soil degradation, water scarcity and pollution, and loss of biodiversity, threatening natural resources and the sustainability of life support systems (Hurni 2000). SLM seeks to harmonize the frequently conflicting objectives of intensified economic and social development, while maintaining and enhancing the ecological and global life support functions of land resources (Herweg et al. 1998). Sustainable land management has been defined as "a system of technologies and/or planning that aims to integrate ecological with socio-economic and political principles in the management of land for agricultural and other purposes to achieve intra- and intergenerational equity" (Hurni et al. 1996: 27). Thus SLM combines the three development components of 'technology', 'policy' and 'land use planning' so as to simultaneously:

1. maintain and enhance production
2. reduce the level of production risk and enhance soil capacity as a buffer against degradation processes
3. protect the potential of natural resources and prevent degradation of soil and water quality
4. be economically viable
5. be socially acceptable and assure access to the benefits of improved land management

These factors (productivity, stability/resilience, protection, viability and acceptability/equity) are referred to as the "five pillars of SLM" (Dumanski & Pieri 2001). Any evaluation of sustainability has to be based on these objectives. Although there is a general consensus on the basic concept of sustainability, its assessment is the immediate challenge. SLM can be approached by looking for symptoms of unsustainability and by analyzing the choice of options land users have to manage their land in a sustainable manner (Herweg et al. 1998).

A pragmatic method is to approach sustainable land management by looking at it in terms of unsustainability. The following indicators could aid in monitoring trends of unsustainability: Loss of systemic integrity (disappearance or lessening of the resilience capacity of the system or its regenerative capabilities), substitution (ever increasing chemical and/or economic subsidization of the production process to maintain the same or a lower level of production), and marginalization (gradual disappearance of the components of a system or even the system as a whole due to substitution by other components or systems) (Eswaran & Sloger 1994). The second approach focuses on the land user's choice of options. Land users trigger land degradation processes through inappropriate land management. This fact thus raises two questions: What choice of management practices is likely to result in systems more sustainable than the current ones, and what keeps land users from adopting those management practices and systems? In many cases, land users are aware of degradation but are not in a position to correct it, often due to political and economic circumstances. Sustainable land management therefore addresses both processes of resource degradation and underlying causes of unsustainability (Herweg et al. 1998).

Since the energy situation in rural and mountain regions is characterized by heavy dependence on locally available biomass fuels, the aspect of sustainable land management is closely linked to energy resource use in these regions.

### 4.3.1 Multi-level Stakeholder Approach to Sustainable Land Management

The multi-level stakeholder approach (see Figure 1.3) has been developed for finding solutions at local scales considering the five pillars[13] of sustainable land management (Hurni 1997). In contrast to former concepts and technologies used for the appraisal of SLM, which only focused on the land user as the sole actor, the multi-actor perspective includes a wide range of stakeholders[14], considering their different perceptions of damaging effects on natural resources, of potentials and options, etc.

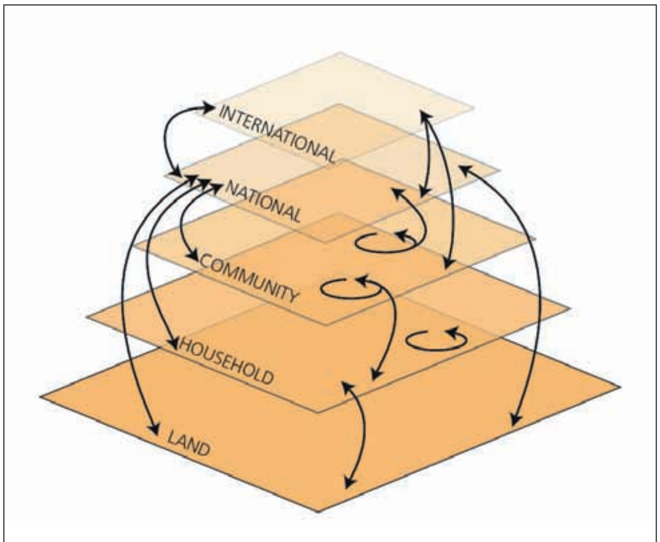



***Figure 1.3:*** *Intervention Levels in a Multi-Level Stakeholder Approach to Sustainable Land Management. Source: Hurni et al. (1996: 34)*

The perception of problems of land degradation varies greatly between land users and other stakeholders, such as administrators, researchers, international organizations, etc. Since knowledge is generally considered as a key factor for achieving better land management, scientific information has to be coupled with indigenous knowledge to offer a better basis for decision-making in the negotiation processes. Thus only a comprehensive, participatory approach involving stakeholders at all levels will have the potential to develop locally useful solutions within a favorable institutional environment (Hurni 2000). As Hurni (1997: 213) emphasizes, "the real strength of this approach is that it does not provide a predetermined concept, but offers a framework and a procedure for working towards a common point of view and defining the next steps to take."

***References***

Dumanski, Julian and Pieri, Christian (2001) Monitoring Progress Towards Sustainable Land Management. In: Stott, D. E., Mohtar, R. H. and Steinhardt, G. C. (eds.) (2001) Sustaining the Global Farm. Selected Papers from the 10th International Soil Conservation Organization. Meeting held May 24-29, 1999 at Purdue University and the USDA-ARS National Soil Erosion Research Laboratory.

Eswaran, Hari and Sloger, Charles (1994) Considerations on Indicators for Sustainable Land Management. USDA Natural Resources Conservation Service, Washington DC and US Agency for International Development, Global Bureau.

FAO [Food and Agriculture Organization of the United Nations] (ed.) (2001) FAO and World Energy Council call for higher Priority to Energy Problems in Rural Areas. Press Release 00/01. www.fao.org

Herweg, K., Slaats, J. and Steiner, K. (1998) Sustainable Land Management – Guidelines for Impact Monitoring. Working Document for Public Discussion. Workbook and Toolkit. Berne.

Hurni, H., Wiesmann, U. and Kohler, T. (1999) Mitigating the syndromes of desertification: The requirements for transdisciplinary research and information exchange. Book of contributions, EU Workshop on "Information Requirements and Organizational Approaches to Support Interdisciplinary Research on Desertification", held in Alghero, Sardinia, 9-11 October 1999, pp. 7-55.

Hurni, Hans (1997) Concepts of sustainable land management. In: ITC Journal 1997 –3/4, pp. 210-215.

Hurni, Hans (2000) Assessing sustainable land management (SLM). In: Agriculture, Ecosystems and Environment 81 (2000), 83-92.

Hurni, Hans et. al. (1996) Precious Earth: From Soil and Water Conservation to Sustainable Land Management. International Soil Conseravtion Organisation (ISCO), and Centre for Development and Environment (CDE), Berne.

Kadian, Promila and Kaushik, Sushma (2003) Rural Energy for Sustainable Development. Participatory Assessment of Energy Resources. New Dehli: Deep & Deep Publications ltd.

NCCR N-S [National Centre of Competence in Research North South] (ed.) (2002) Publication on the National Centre of Competence in Research North-South: Research Partnerships for

[13] The five pillars of SLM are (1) productivity, (2) stability/resilience, (3) protection, (4) viability and (5) acceptability/equity (Dumanski & Pieri 2001).

[14] Stakeholders are interest groups or dependent groups, i.e. categories of people or institutions who share a common interest in a piece of land, be it an individual plot, the territory of a community, or a national conservation area (Hurni 1997: 212).

Mitigating Syndromes of Global Change. Berne: NCCR North-South c/o Centre for Development and Environment (CDE), Institute of Geography, University of Berne.
Wiesmann, U. (1998) Sustainable Regional Development in Rural Africa: Conceptual Framework and Case Studies from Kenya. Geographica Bernensia. University of Berne, Switzerland.

# 5. Methodology

Since the objective of this study is to provide an integral and detailed analysis of the energy situation in the Tajik Pamirs a participatory, actor-oriented, trans-disciplinary and multi-level stakeholder approach (see Chapter 4.3.1 or Hurni et al. 1996: 34) was chosen to understand the complex linking between energy problems at household and village levels, sustainable land management and the use of hydropower. The actors' views, perceptions, ideas, visions and strategies are of great importance for the understanding and solution of problems relating to sustainable land management. For this reason, a wide range of participatory and participatory-supportive methods were applied within this research. The following main aspects were kept in mind and were considered during data generation and evaluation throughout the whole investigation: Social, economic and ecological sustainability in the dimensions of space and time, patterns of unsustainability, the gender dimension and role of children, and the importance of local knowledge. Comparing case studies in three villages with contrasting energy resource bases allowed assessment of impacts of energy resource use on the social, economic and ecological levels as well as of hydropower's potential for mitigating pressure on renewable energy resources and land degradation. As secondary statistics are scarce concerning the investigated field of research, the analysis is composed mainly of primary data gathered during fieldwork in the Tajik Pamirs in 2003.

The field study took place in the Western Tajik Pamirs from late April to early August 2003. It was planned to start the investigation at the end of winter or beginning of spring (March or April), when the stocks of energy resources are exhausted and conditions for the acquisition of new resources are difficult. Problems receiving visas and permission postponed the fieldwork so that the investigation in the field could not be launched before June.

The present study is a joint diploma thesis, which was planned, accomplished and written in close cooperation between the two authors. Experience has shown that teamwork is a productive and enriching way of coping with complex research topics. In addition, mutual support during fieldwork facilitated the accomplishment of objectives and difficult situations.

## 5.1 Research Procedure

This analysis was conducted in four research steps (see Figure 1.4):

1) Selecting village and household samples for case studies in the Tajik Pamirs and gathering background

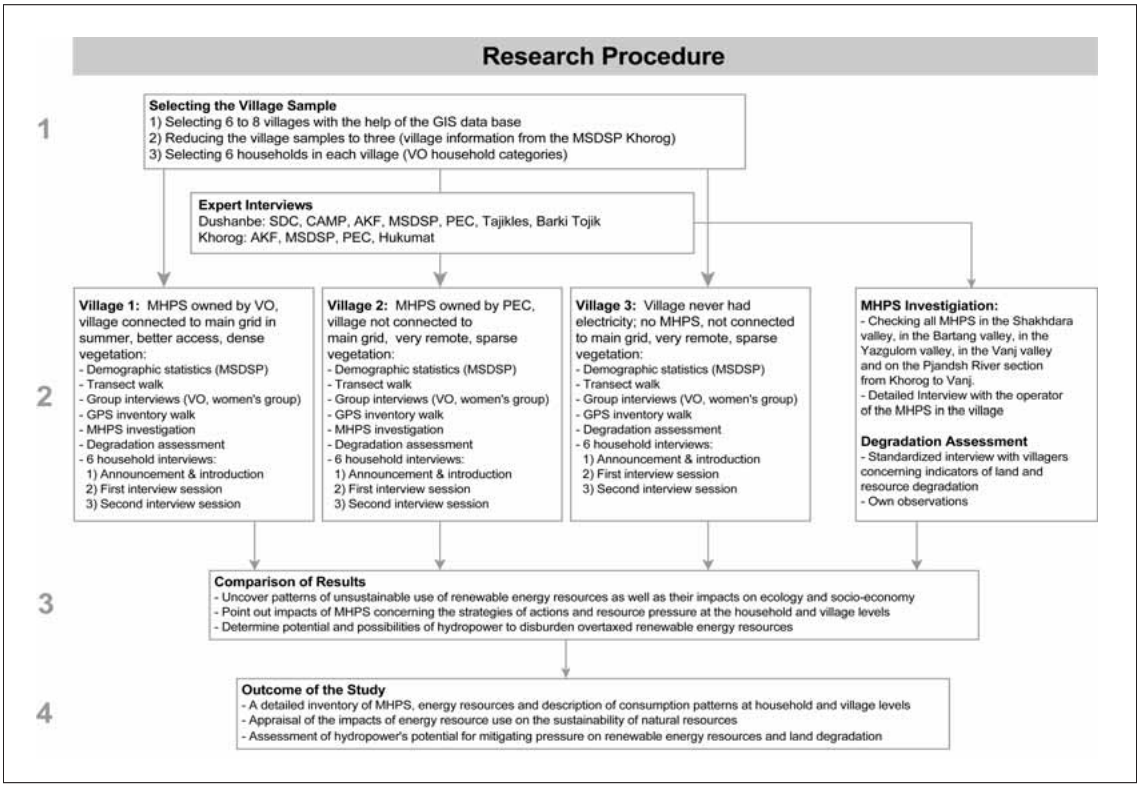



***Figure 1.4:*** *The Research Procedure Applied for the Analysis of the Energy Situation in the Tajik Pamirs.*

information from experts in Switzerland, Dushanbe (Tajikistan) and Khorog (Tajikistan/GBAO).

2) Field study: Performing case studies in three villages, investigating 34 micro and mini hydro schemes, and complete participatory degradation assessment in 25 villages.
3) Data evaluation and comparison of results from the case studies, hydropower investigation and degradation assessment.
4) Drawing conclusions and synthesizing findings from the three fields of investigation to formulate concrete recommendations and present possible ways towards sustainable energy resource use at the household and village levels in the Tajik Pamirs.

## 5.2 Selecting Village Case Studies and Household Samples

The aim of this study is to provide a detailed and in-depth insight into energy resource use and consumption at the household and village levels, and not to perform a representative quantitative analysis based on statistical evaluations at the regional level. Therefore, only three case study villages were chosen for the investigation, and the sample of households interviewed in each village was fixed at a number of six and not adapted to village size to reach a representative sample.

Prior to the fieldwork, a first village sampling was performed with the help of the database on the Tajik Pamirs in the Geographic Information System (GIS) located at the Centre for Development and Environment (CDE) at the University of Berne. The search for potential case study villages was restricted to the Western Pamirs. The following aspects were considered to extract a broader sample of possible villages with different energy resource bases: Demographic statistics, vegetation cover, locations of micro or mini hydropower stations (MHPS), electricity supply from the grids and accessibility. The goal was to obtain a sample of around 12 villages fulfilling the characteristics below (see also Figure 1.4):

- Village type 1: Size of 50 (± 25) households, electricity supply from MHPS and grid, better access, dense vegetation.
- Village type 2: Size of 50 (± 25) households, electricity supply from MHPS, very remote, sparse vegetation.
- Village type 3: Size of 50 (± 25) households, never had electricity supply, very remote, sparse vegetation.

Further and detailed information could be acquired from the Aga Khan Foundation (AKF) and the Mountain Society Development and Support Programme (MSDSP) in Tajikistan and in Gorno Badakhshan to reduce the village sample to a number of three. It was decided to complete the first case study and to determine afterwards the second and third village to have the possibility of including new decisive factors in the sampling procedure.

In each case study village, six households (out of 29, 35 and 54) were selected to perform interviews on energy resource use and consumption. The selection was made while considering the following three aspects:

1) Household categories: The village organization divided all households commonly into three categories for the distribution of humanitarian aid: poor, average and rich. Two households of each category were selected.
2) Size of the household (number of members): small (2-4 members), average (5-7 members) and large (8-13 members). Two households of each size were selected.
3) Spatial distribution of households within the village: Two households at the entrance, two in the middle and two at the far end of the village were selected.

The statistics about the households could be obtained from the village organization.

## 5.3 Data Generation

As shown in the research procedure (see Figure 1.4) a wide range of methods for data generation was applied to fulfill the objectives of this study. The most frequent methods were different forms of interviews and observations, applied according to the object of insight. In addition, measuring and weighing units of energy resources generated quantitative data concerning consumption at the household level. With the help of a GPS[15] appliance, hydro schemes and objects within the case study villages were geo-referenced, thus serving as basic information for map preparation.

***Research Team and Interpreters***

The research team consisted of one male and one female translator, a driver and the two male authors of the thesis. The research could thus be conducted in two subteams working on different issues at the same time. The two interpreters were responsible for translation and transcription from English into Russian, Tajik, Pamiri[16] and *vice versa*, as well as for organizational and administrative tasks. The composition of the research team was changed occasionally as well as the type of work to complete: Degradation assessment and hydropower investigation were performed alternately. Meanwhile, the research in the case study villages was completed with a

[15] Global Positioning System

[16] Pamiri is a generic name for the dialects spoken in the Tajik Pamirs, such as Shugnani, Bartangi, Ishkashimi, Rini (Herbers 2001b: 368).

constant line-up of the teams to ensure more or less identical conditions for the household interviews. Prior to fieldwork the two interpreters were trained to conduct different types of interviews and were briefly introduced into the scientific topics of the research. The cooperation with a female interpreter was of great advantage to access both women and girls as interview partners in the villages and discuss gender-specific issues.

***Expert Interview***

Expert interviews are a specific application of the so-called *Leitfaden*[17]-interviews, where not the respondent himself, but rather his knowledge becomes the focus of the discussion. The interview partner is seen as a representative of a distinct group with undisputed knowledge about a certain field of interest (Flick 1999: 109). Several expert interviews were conducted in Switzerland (AKF Geneva, entec AG, Aerogie.plus, ITECO AG, Stucky Consulting, Elektrowatt-Econo ltd., Seco), Tajikistan (*Barki Tojik, Tajikles,* AKF Dushanbe, MSDSP Dushanbe, PEC Dushanbe) and in Gorno Badakhshan (MSDSP Khorog, AKF Khorog, PEC Khorog, Land Use Committee, Tajik National Park) to obtain general information about the use of micro and mini hydropower, and about different organizations and their activities in the field of energy supply in GBAO, in addition obtaining further contacts and secondary statistics.

***Participatory Transect Walk***

A participatory transect walk serves as a practical method of obtaining a good overview and rather intense impression of a new location considering local knowledge and the possibility to raise new issues which may have been overlooked. The transect walk following a specific route (e.g. highest to lowest point, north to south…) within the study area is conducted by a team to observe and talk about issues of local importance. The team is composed of local informants (insiders) and experts (outsiders). Everything mentioned by the insiders and everything observed and questioned by the outsiders is discussed and noticed. The walk supplements “official” information with subjective and informal observations and experiences. This method can be used for a qualitative approach as well as for a semi-quantitative assessment (Herweg & Steiner 2002: 39).

At the beginning of each case study a transect walk was conducted following a route from the highest to the lowest point of the village. The team consisted of the two interpreters, the two authors and one local informant (commonly the president of the village organization or a teacher). During the walk infrastructures and places of interest (mill, hospital or medical point, school, hydro scheme, plots of arable land, *hukumat* office, library, shop, reforested plots, religious sites, water spring, irrigation channels etc.) were visited and discussed. The information obtained during the participatory transect walk served as a valuable background for conducting the household interviews. Thus new issues could be integrated into the questionnaires.

***Household Interview***

The household interviews were conducted in two sessions:

1) The first part consisted of an interview with a structured and standardized questionnaire covering general information about the household and its energy resource acquisition, use and consumption. The goal of the first session was to gain an overview of the livelihood conditions of the household as well as to create an inventory of energy resources and consumed quantities. The interview took around 1.5-2 hours. Prior to the interview a broad inspection of the household was performed in order to get an overview of the number of rooms, cooking places and appliances. In addition, the room which is heated in winter was measured.
2) The objective of the second session was to broaden the aspects addressed during the first part of the interview with a focus on the respondent’s opinion, perception and view. Therefore, a *Leitfaden*-interview with a non-standard structure allowing an open form of discussion was chosen. The creation of a relatively open interview situation allows the views of the interviewee to emerge more clearly (Flick 1999: 94). The second part took around 1-1.5 hours and was recorded on MiniDisc, and later transcribed and translated into English.

The intention was to perform the household interviews with both the wife and husband, but as it was difficult to integrate both respondents into the discussion, especially during the first standardized part, commonly only one person emerged as the interview partner. Therefore around half of the household interviews were performed with female and half with male respondents. The interviews were announced one day in advance and the two sessions were conducted on two successive days.

***Group Interview***

Representatives from the different areas (health, education, finance, youth, women) of the village organization were gathered and interviewed as a group. On the one hand, an integral picture of the village and of the village organization’s activities could thus be obtained. On the other hand, issues relating to the use of energy resources at village level could be discussed with in-

17 In this context, *Leitfaden* is the German expression for a guideline (or a main thread) of topics, which shall be discussed in the interview.

puts from a wide range of actors. The advantage of a group interview is low time cost compared to the rich data obtained from different respondents (Flick 1999: 131).

***Group Discussion***

The objective of group discussions is to avoid concentrating on people's attitudes, perceptions, opinions and behaviors in an isolated situation as is created in an interview with one interviewer and one respondent. In addition, the correction by the group itself of commonly censored or extreme views can be consulted as a means of validating expressions and views. The group can thus be used as a medium for a better analysis of individual opinions (Flick 1999: 132).

Group discussions were performed with the women's committee in the case study villages (see Picture 1.2). Except for the two male researchers and one male translator, only female persons participated in this discussion. The acquisition and use of energy resources as well as women-specific issues relating to energy problems were discussed. The group discussion was recorded on MiniDisc and later transcribed and translated into English.

***Picture 1.2:*** *In the group interview with the women's committee a focus was made on women specific issues related to energy problems. (Photo: T. Hoeck, June 2003)*

***Participatory Observation***

Participatory observation is a field strategy, in which at the same time the analysis of documents, interviews with respondents and informants, direct participation and observation as well as introspection are combined. This form of observation is characterized by immersion by the researcher in the field under study, as well as his influence on the observed field through his participation (Flick 1999: 157).

***Picture 1.3:*** *Participatory observation allowed deep insights into the daily drudgery of fuel wood procurement. (Photo: T. Hoeck, June 2003)*

Participatory observation was applied as a method to gain insights into energy resource acquisition in all case study villages. Women, men and children were accompanied and supported in their task of collecting firewood or *teresken* shrubs (see Picture 1.3). The objective was to see where biomass fuels are gathered, how the present state of the resource basis considers indicators of land degradation, and to gain a sense of the drudgery of collecting firewood or *teresken* for hours and carrying home heavy head- or back-loads. Moreover, while conducting the case study, the research team was accommodated in a traditional Pamiri house together with a local family. This allowed an insight into the daily routine of the peasants and offered the possibility for interesting informal discussion with all family members.

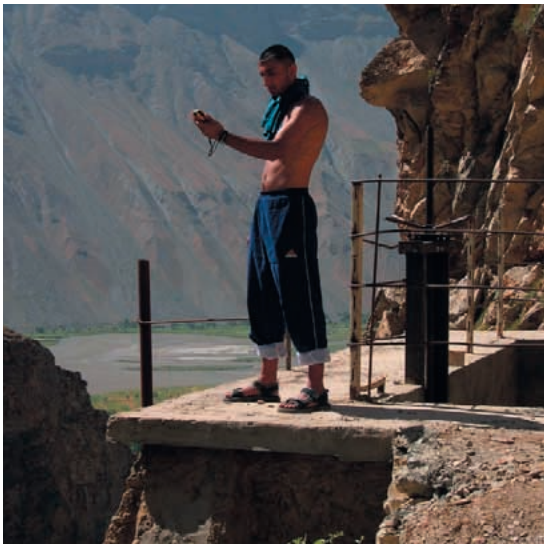
***Quantification of Resource Consumption***

For the analysis of energy resource consumption at the household level bundles or head-loads of firewood, *teresken* and dung cakes were measured and weighed with a spring balance, and thus converted into kilograms (see Picture 1.4).

Water-heating experiments with different energy resources were also conducted. One liter of water was heated with firewood and *teresken* shrubs on a traditional stove. An inhabitant of the village of Basid[18] in the Bartang Valley conducted the experiments several times, recording the quantity (in kg) of wood or shrubs burned and the time until boiling. In addition, a citizen from Khorog and the authors performed water-heating tests on a regular coil cooker supplied with electricity from the main grid in Khorog[19]. The time needed to reach boiling

18 Basid is located at an altitude of around 2400m.
19 Khorog is located at an altitude of around 2100m.

**Picture 1.4:** *The weighing of fuel wood units with a spring balance (here a bundle of teresken shrubs) allowed quantification of daily energy resource consumption. (Photo: T. Hoeck, June 2003)*



**Picture 1.5:** *Interpreter is geo-referencing the forebay tank of the MHPS in Barrushan. GPS points serve as basic information for map processing and for spatial analysis of electricity supply in GBAO. (Photo: T. Hoeck, July 2003)*

was recorded and the consumed power (in kWh) could be calculated.

***Structured Interview for MHPS Investigation***

Investigation of micro and mini hydro schemes in Gorno Badakhshan was conducted in the form of a structured interview with the owner, manager or worker at the power plant. Since the authors lack specific technical knowledge, a sophisticated and detailed inspection of the equipment was not performed. A total number of 34 hydro schemes were visited during fieldwork in the districts of Roshtkala, Ishkashim, Shugnan, Rushan and Vanj (see Appendix 2).

***Participatory Land Degradation Assessment***

Participatory land degradation assessment is a practical approach to gain a farmer-perspective on land degradation. Land users prioritize various aspects of degradation quite differently from local professionals or external experts. They “see” things which concern them and affect their way of life. It is thus important to include the actor into the process of assessment. Participatory land degradation assessment considers the long experience of the farmer in using land and resources, thus accessing valuable local knowledge (Stocking & Murnaghan 2001: 2-5).

Since the objective of degradation assessment was to obtain a good overview of the most common forms of land and resource degradation at the village and valley levels, rudimentary assessment in a larger number of villages was performed. Semi-structured interviews were conducted with land users to discuss direct or indirect indicators for land and resource degradation in a total of 25 villages in the districts of Roshtkala, Shugnan, Rushan and Vanj. The data obtained was supplemented with observations from researchers in the field.

***Geo-Referencing and Map Processing***

All hydro schemes and objects of interest that were visited in the case study villages were geo-referenced (see Picture 1.5). The GPS-records were fed into *ArcView-GIS* and supplemented with data from the existing GIS-database (at the CDE) on the Tajik Pamirs to create overview maps of electricity supply and hydro schemes. This allows spatial analysis of power supply in Gorno Badakhshan.

## 5.4 Data Preparation and Evaluation

The two interpreters were responsible for transcribing and translating the recorded interviews into English. Clear instructions were given to ensure careful transcription of the audio-recorded data. At the same time, the authors transcribed, structured and supplemented their field notes with personal comments on the computer. The data generated in the first session of the household interviews, in the MHPS investigation and in the degradation assessment was directly inserted into prepared tables, after which questionnaires were designed. At the end of the fieldwork all generated data was available in digital files.

The qualitative content analysis of the data received from the various interviews in the case study villages was performed with the help of *WinMax97*. This software allowed integration and organization of all transcribed interviews (as txt-files) into one database. An identical multi-level code-system was elaborated for the three villages, and was completed, supplemented and refined during the process of encoding (according to Flick 1999: 169). Based on structured compilation of split statements relating to various codes available in the *WinMax*-database, analysis of energy resource use and consumption at the household and village levels could be completed.

Quantitative data on energy resource consumption was compared with statements from the interviews, thus permitting a certain validation of the data obtained through weighing and measuring. In addition, energy consumption of different resources (wood, dung, shrubs and electricity) was converted into one identical unit (Joule) considering their specific conversion factors (see Appendix 3). This allowed the comparison of different households and villages concerning overall energy consumption.

An inductive research process was applied not only during data generation, but also in the phase of evaluation and writing. Since two authors conducted the present study, initial results after evaluation could be discussed, mutually revised and complemented with new inputs. This led to further evaluation and integration of new aspects into the topics elaborated thus far.

## 5.5 Suitability of Applied Methods and Viability of Data

It should be kept in mind that the original data upon which this study is based comes from sources in four different languages (English, Russian, Tajik and Pamiri). The bulk of the data could not be accessed in its original state but only after translation. Further, English is neither the mother tongue of the two researchers nor of the two interpreters, so that language specific aspects could not be considered in the qualitative analysis.

Quantification of energy consumption through measuring and weighing units of wood, shrubs and dung definitely provided accurate figures, although it could not be verified when units are consumed. The authors thus had to rely on information obtained from users and interview partners. Moreover, data concerning energy consumption and the quantity of resources acquired by a household sometimes deviated[20] considerably. After a validation of the figures with statements made in the second interview session, corrected or mean figures were used for calculation of a household's energy consumption.

The degradation assessment conducted for this study should not be seen as a sophisticated and complete investigation. The results should serve as a compilation of common degradation appearances at the village level and provide an idea of vulnerable and endangered resources. The method applied (structured interview focusing on direct and indirect indicators for land degradation and observations made by the researchers) does not allow definite conclusions about cause-and-effect relations between the human activities and the processes of degradation.

After completion of fieldwork and as a result of experiences, the authors judge that the methods applied and the research procedures are appropriate for accomplishing the objectives of this study.

***References***

Herweg, Karl and Steiner, Kurt (2002) Impact Monitoring and Assessment. Instruments for use in Rural Development Projects with a Focus on Sustainable Land Management. Volume 2: Toolbox. Bern: CDE.

Flick, U. (1999) Qualitative Forschung. Theorie, Methoden, Anwendung in Psychologie und Sozialwissenschaften. Reinbek bei Hamburg: Rowohlt Taschenbuch Verlag GmbH.

Stocking, Michael A. and Murnaghan, Niamh (2001) Handbook for the Field Assessment of Land Degradation. London: Earthscan Publications ltd.

Hurni, Hans et al. (1996) Precious Earth: From Soil and Water Conservation to Sustainable Land Management. Berne: International Soil Conservation Organization, and Centre for Development and Environment.

Hurni, Hans (1997) Concepts of Sustainable Land Management. In: ITC Journal 1997 –3/4, pp. 210-215.

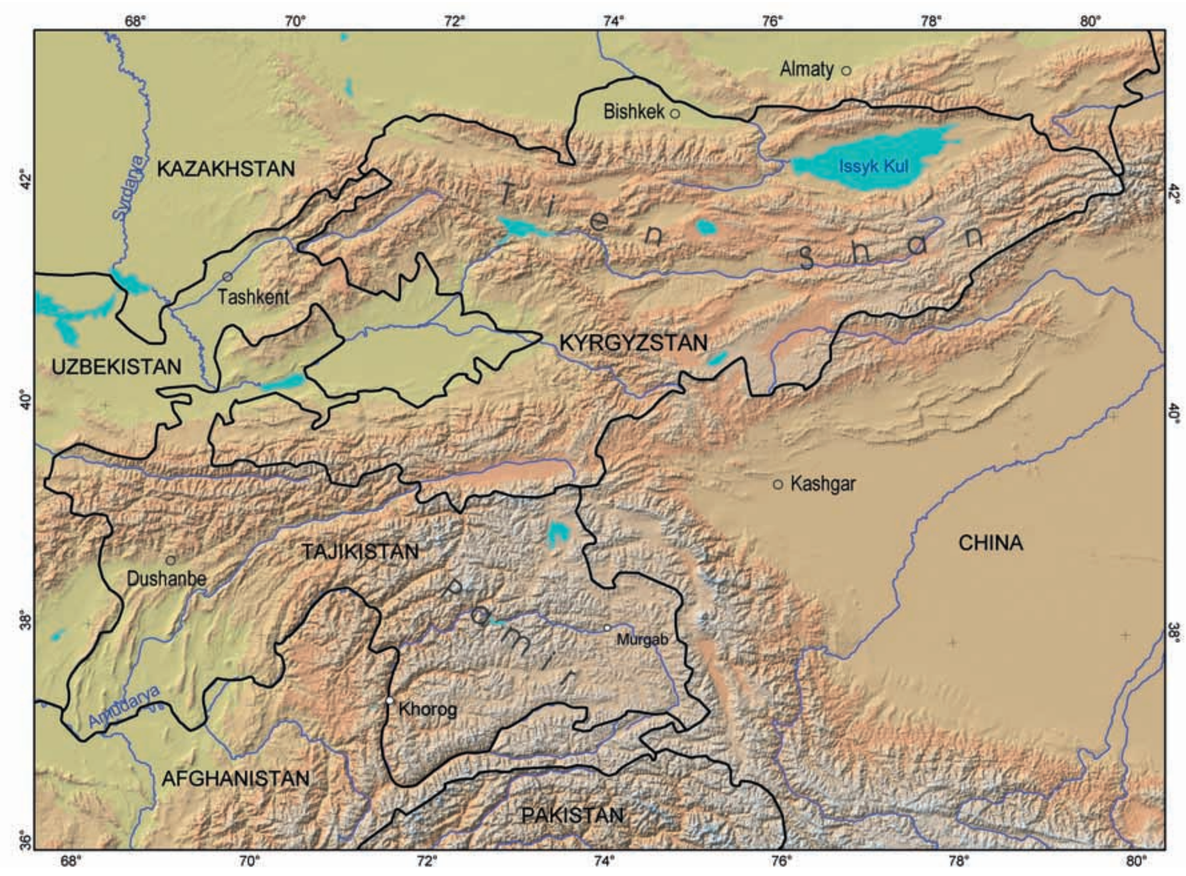
20 Commonly a household reported acquisition of higher quantities of energy resources than the reported use during a year.

# 6. Study Area

## 6.1 The Republic of Tajikistan: Lost in Transition

Tajikistan is one of Central Asia's former Soviet Republics, which gained independence after the collapse of the Soviet Union in 1991. Its present borders were created with the formation of the Tajik SSR in 1929. Tajikistan is bordered by Afghanistan to the South, Uzbekistan to the West, Kyrgyzstan to the North and China to the East (see Map 1.1). More than 90% of the country's territory, which constitutes 143,100 km$^2$, is covered with high mountains, arid plateaus and glaciers. Tajikistan has four main natural zones: The Pamir mountains and plateaus in the east, the center zone dominated by three east-west mountain ranges (Turkestan, Zarafshan and Hissar), the Khatlon province located in the south-west between the Hissar range and the Amu Darya (or Pandzh) river, and in the north the former Leninabad province (renamed Sodg province in 2000) in the river valleys of Zarafshan and Syr Darya. (Akiner 2001)

Tajikistan evolved from the 'bankrupt estate' of the Soviet Union and always had the reputation of being the poor man of the Union. After independence the country not only faced the challenge of transition from a planned economy to a free market economy, but also experienced years of civil unrest (Herbers 2001b). In spring 1992 the struggle for state power between different political parties and regional ethnic groups developed into a violent conflict (see Picture 1.6). During the first year of fighting around 50,000 people were killed, 600,000 were internally displaced and more than 80,000 sought refuge abroad, mostly in Afghanistan. A peace process led by the UN finally resulted in cessation of the civil war and signing of a peace agreement in June 1997 (Akiner 2001). Due to its difficult start into independence, the Tajik economy experienced a profound post-Soviet dip: In 1996 the Gross Domestic Product (GDP) plummeted to 30% of its value prior to independence (1990), recovering to 50% in 2003 (Lambert 2003: 12). The per capita GDP reached a meager 519 Tajik *somoni*, (around USD 176)[21] in 2002. Tajik-




*Map 1.1: Tajikistan and Its Location Within Central Asia. Tajikistan shares borders with Afghanistan, Uzbekistan, Kyrgyzstan and China. Map by Thomas Breu*

[21] In October 2002 USD 1 was 2.95 *somoni* (ADB 2002).

**Picture 1.6:** *The struggle for political power after independence resulted in a violent conflict with around 50,000 victims. (Photo: T. Hoeck, Mai 2003)*

**Figure 1.8:** *Nurek water reservoir supplies Tajikistan's largest hydropower plant with a capacity of 3000MW. (Photo: T. Hoeck, July 2003)*

istan remains the poorest country in the Commonwealth of Independent States (CIS) and faces a serious problem with external indebtedness. With an average monthly salary of eleven dollars, 80-90% of the population lives below the official poverty line of USD 15 per month (Seco 2003). The population of Tajikistan increased considerably during the past decade, from 5.3 million (1990) to 6.44 million in 2002. Agriculture is the main occupation in this mountainous country: Two-thirds of the population is occupied with cultivation of cotton, wheat, potatoes, grapes, rice, barley and corn. The industrial (8.9%) and the service sectors (24.5%) provide only minor employment possibilities. Cement, wheat flour and aluminum are the main products. (www.adb.org)

**Picture 1.7:** *The Tadaz aluminium smelter, established during Soviet times, is Tajikistan's most important industry, employing 40% of the country's electricity consumption. (Photo: T. Hoeck, Mai 2003)*

Tajikistan's most important exports are aluminum, electricity and cotton: In 2001, 61% of export revenues[22] depended on the enormous Tadaz aluminum smelter (see Picture 1.7), 12% on electricity generation and 10% on cotton production (Lambert 2003: 12; SCSRT 2002: 135). The aluminum factory consumes huge quantities of electricity, constituting around 40% of the country's power consumption.[23] Water and mountains are Tajikistan's only abundant energy resources. The potential for hydropower is vast, but only about ten per cent of its potential 40,000MW is currently used. Due to the arid climatic conditions, hydropower generation depends on water from melting snow and glaciers in summer and on storage water in reservoirs in winter. When the storage level is low, the country has to rely on imported fossil fuels (oil, gas and coal) or on electricity from neighboring Uzbekistan.[24] Because of limited storage capacities, Tajikistan has to import a large amount of expensive electricity to meet peak loads from January until April every year.[25] In contrast, in summer when water discharge is abundant and reservoirs are full, water has to be discarded, as there is not sufficient demand for export of excess electricity. The industries around Khujand in the north, which constitute most of the non-aluminum related industries, have to rely on electricity supply from Uzbekistan as there are no grid interconnections between the north and the south of Tajikistan, where the huge hydropower schemes are located. Tajikistan lacks a comprehensive electricity grid to balance spatial and temporal demand and supply. Nurek, the largest hydropower plant in Tajikistan with 3000MW (see Picture 1.8) has insufficient storage capacity, so that excess water in sum-

22 In 2001, from export revenues of USD 651.5 millions, aluminum accounted for USD 397.4 million, electricity USD 78.5 million and cotton USD 63 million (SCSRT 2002: 135).
23 Tajikistan consumed 16,029GWh in 2002 (www.adb.org)
24 Tajikistan spent almost a third of overall expenditures for import of energy resources in 2001 (SCSRT 2002: 137).
25 In 2001, Tajikistan exported electricity for USD 78.3 million and imported electric power for USD 98.3 million (SCSRT 2002: 135-137).

mer cannot be stored to supply the domestic winter deficit of around 4000GWh. On account of insufficient hydropower capacity, poor distribution infrastructure and negligible deposits of fossil fuels, Tajikistan is totally dependent on external energy supply at high costs. (ADB 2002)

## 6.2 Gorno Badakhshan Autonomous Oblast

Gorno Badakhshan Autonomous Oblast (GBAO) is one of Tajikistan's four provinces or *oblasts*, covering the eastern extent of the country (see Map 1.2). As the area of GBAO is almost exactly identical with the Pamir Mountains on Tajik territory, the terms Gorno Badakhshan and the Tajik Pamirs are used synonymously. With 63,700 km$^2$ GBAO constitutes almost half the country's area, although accommodating only 3.3% of its population (Breu & Hurni 2003: 8). The Tajik Pamirs can be separated into two parts: The Western Pamirs (see Picture 1.9) and the Eastern Pamirs. The boundary between these two regions is not only manifested by distinct topography and climate but also by socio-cultural differences. The west is characterized by deep valleys, high mountain ranges, permanent settlements and a mixed mountain agriculture dominated by the Tajik people, whereas the high arid plateaus of the Eastern Pamirs are home to the traditionally semi-nomadic people of Kyrgyz origin who depend on livestock raising. (Herbers 2001b: 368)

Gorno Badakhshan is divided politically into eight districts, seven in the Western Pamirs (Darvaz, Vanj, Rushan, Khorog, Shugnan, Roshtkala and Ishkashim) and one in the Eastern Pamirs (Murgab). Each district consists of six to nine *jamoats*[26], the smallest political entity. Khorog, the capital of GBAO, with 27,914 inhabitants (MSDSP 2003), is the largest settlement and the only city in the Tajik Pamirs. Access to Gorno Badakhshan is not perennially guaranteed. The only connections with Western Tajikistan are provided by two roads, which are closed in winter and early spring: One runs over the Khaburabot Pass (3252m) to Kalai-Khumb, and the other also runs over a pass and then up the Pandzh River, connecting the Northern part of GBAO with the Kulyab region. Flights from Dushanbe (the capital of Tajikistan) to Khorog depend on weather conditions and are thus infrequent.[27] The Pamir Highway (M41), the former military communication route during the 'Great Game', and running from Osh (Souhtern Kyrgyzstan) via Murgab to Khorog and continuing from there to Dushanbe, is the main motor road in GBAO. The borders to Afghanistan are still controlled by Russian military, whereas most of the Russian troops were recently removed from the Chinese and Kyrgyz borders. (Breu & Hurni 2003; Herbers 2001b)

***Picture 1.9:*** *The Western Pamirs are characterized by deep valleys, high mountain ranges and large glaciers. (Photo: T. Hoeck, July 2003)*

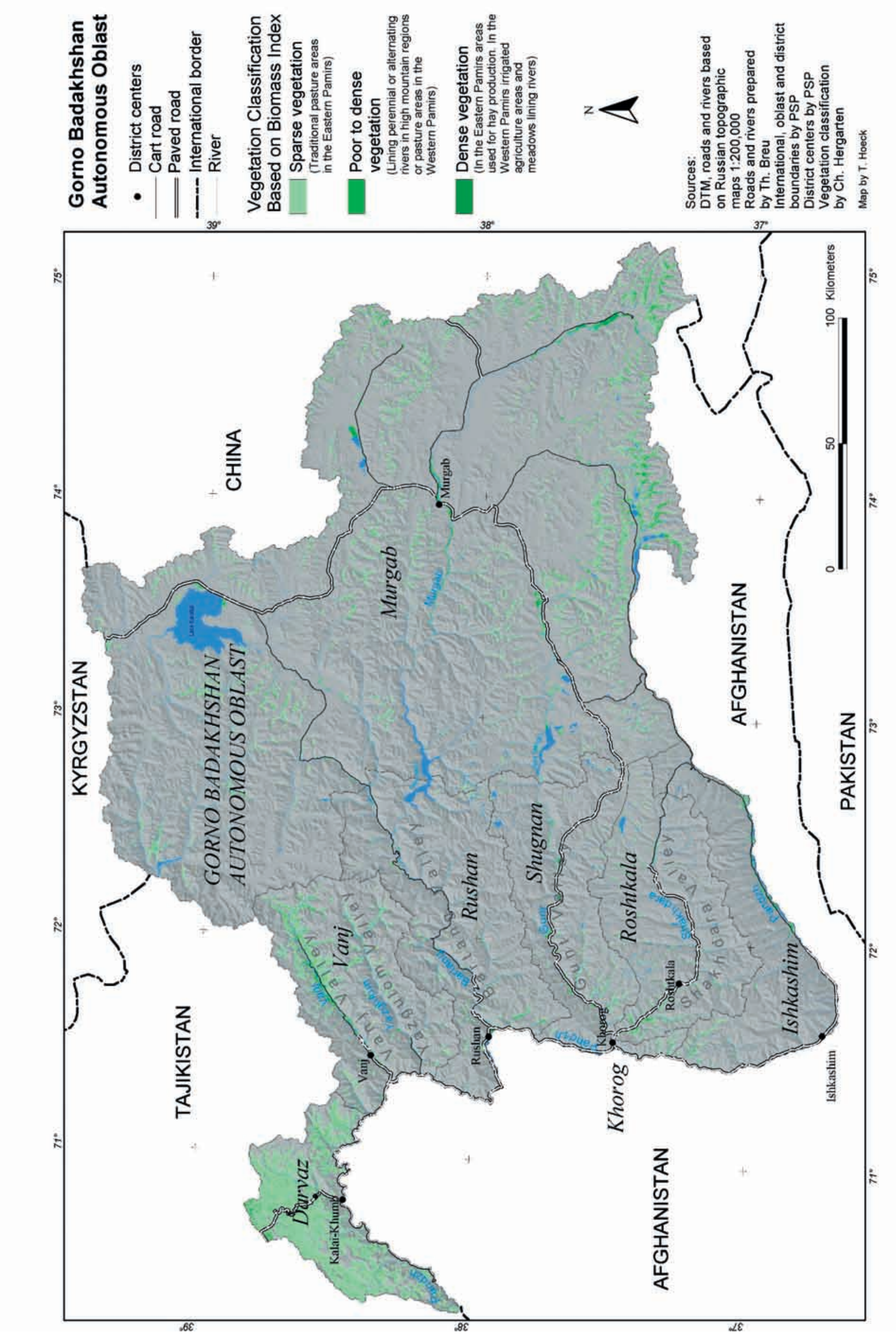
### 6.2.1 Limiting High Mountain Conditions

The Tajik Pamirs, with their continental climate and scarce land resources, create harsh living conditions for the dwellers of GBAO to survive. Most of the territory is barren land or rocky terrain, to a great extent covered by glaciers and snow. Deeply incised valleys, separated by high mountain ranges (Ismoil Somoni Peak the highest point with 7495m) in the west, and arid high plateaus at 3000-4000m in the east provide only limited habitat for

***Picture 1.10:*** *Alluvial fans and riverbanks are the preferred locations for settlements and agricultural production since the Tajik Pamirs only offer limited habitat for humans, fauna and flora. (Photo: T. Hoeck, July 2003)*

26 A *jamoat* is commonly composed of 2-24 villages (MSDSP 2003).

27 For example, from February 28th to March 25th 2004 there were no flights from Dushanbe to Khorog due to unfavourable weather conditions.




**Map 1.2:** *Gorno Badakhshan Autonomous Oblast. Map by T. Hoeck*

*Picture 1.11: Forest vegetation is limited to the floodplains of river and brooks since these are the only sites with perennial water supply. The picture shows one of the last dense tugai forests in the Shakhdara valley. (Photo: T. Hoeck, June 2003)*

humans, fauna and flora. Arable land in the Western Pamirs is estimated at 240km$^2$, not even 0.4% of the total land area (see Map 1.2). Alluvial fans or riverbanks are the preferred location for settlements and cultivable land (see Picture 1.10). But these are also risky places, as frequent natural hazards, such as avalanches, debris flows, floods and rockfalls threaten villages, arable land and roads. The climate is characterized by contrasting temperature regimes and seasonal precipitation with great variability of rainfall over the years. The Western Pamirs have moderately warm summers and moderately severe winters, whereas in the East summers are cold and winters extreme. A steep precipitation gradient running from northwest to southeast is observed in the Pamirs. Kalai-Khumb (1288m) in the Darvaz district in the North receives average annual rainfall of around 500mm, whereas Ishkashim (2524m) in the South and Murgab (3576m) in the East experience very arid conditions with less than 100mm of annual precipitation. Due to limited rainfall the water regime is mainly influenced by water from melting snow and glaciers. Maximum discharge is observed in summer from June to August. Dense vegetation is limited to the lifelines of the Pamirs. Riparian forests, so-called *tugais*, consisting of willow and poplar trees, line the various rivers and brooks (see Picture 1.11), whereas the mountain slopes and high plains are home to sparse, scrub or meadow vegetation. Given minimal precipitation, the harsh temperature regime and a vegetation period of 200-230 days, biomass production is severely limited in the Tajik Pamirs. (Breu & Hurni 2003)

### 6.2.2 Large Population Growth as a Soviet Heritage

Gorno Badakhshan is only thinly populated: The population density amounts to 3.3 persons per km$^2$. Under Soviet rule, GBAO experienced rapid population growth, from 56,000 in 1926 to the present figure of 212,844 people (Breu & Hurni 2003: 10; MSDSP 2003). Around 92% of the population lives in the seven districts of the Western Pamirs, whereas the extensive high plains in the east are home to only 14,114 dwellers[28]. As Khorog, the *oblast* capital, is the only real city in the Tajik Pamirs, the vast majority of Gorno Badakhshan's population (87%) lives in the existing 398 villages in rural areas. On the average, six to seven people share one household (MSDSP 2003).

The Tajik Pamirs are characterized by considerable linguistic and cultural heterogeneity among peoples of the different main valleys. There are eight distinct peoples belonging to the Eastern Iranian language family collectively referred to as Pamiris. The dominant religious group throughout the Pamirs are the Ismailis, a part of the Shi'a Imami Ismaili branch of Islam. Only in the districts of Darvaz and Vanj do the Tajik language and Sunni Islam prevail, as in other parts of Tajikistan. The Eastern Pamirs (Murgab district) is predominantly home to the Kyrgyz people of the Sunni Muslim confession (Breu & Hurni 2003; MSDSP 2003; Akiner 2001; Herbers 2001b).

### 6.2.3 Insufficient Self-Sufficiency

Khorog is the economic center of the Tajik Pamirs, since all of the regions' main services are concentrated in the *oblast* center (see Picture 1.12): Airport with flights to Dushanbe, university, post office, hospital, government offices, main *bazaar* and small shops, hotels, guesthouses, restaurants, bank, Pamir Energy Company (PEC) and various charity organizations. Since June 2003 Khorog even enjoys Internet access. International organizations and the PEC are important employers in the region as they pay reasonable salaries[29]. In contrast, governmental institutions (administration, hospital, schools and university) pay only token monthly wages[30] of 9-30 *somoni* (USD 2.85-9.50) to their employees, which is insufficient to live on. Thus in the city as well, people still rely to a certain degree on food production in their kitchen

28 The demographic statistics (MSDSP 2003) for Murgab district provide a number of 17,035 inhabitants, but only 14,114 actually live in the Eastern Pamirs. The village of Sari-Mangol, located across the border in Kyrgyzstan and still included in the to Murgab district, is home to 2921 inhabitants.

29 The PEC pays around 100 *somoni* (USD 31.75) a month to their regular workers. Employees of international organizations receive between USD 100-500 per month.

30 For example, the chief surgical nurse at the province hospital in Khorog earns 9 *somoni* (USD 2.85) per month.

**Picture 1.12:** *Khorog, the only city in the Tajik Pamirs, is the economic center of Gorno Badakhshan. Even though several institutions offer employment, salaries are usually too low to live on. (Photo: T. Hoeck, July 2003)*

gardens. As most goods have to be imported over long distances from Dushanbe or Osh (southern Kyrgyzstan) at high transport costs[31], the majority of the products are very expensive compared to the people's income. Daily required comestible goods such as flour and rice cost between 0.8 and 1.5 *somoni* (USD 0.25-0.48) per kilogram, a ninth of a nurse's monthly salary.

The collapse of the Soviet Union had a severe impact, especially in marginal areas, as these regions enjoyed considerable subsidies on supply of food and energy resources. The cessation of provisions and the dissolution of *sovkhozes*, a major employer during Soviet time, required urgent restructuring and higher self-reliance in the villages. With the help of the Mountain Society Development and Support Programme (MSDSP), arable land could be extended and productivity significantly augmented during the past decade. The self-sufficiency ratio increased to 70% in 2000, compared to a value below 20% in 1993 (Herbers 2002: 82). As employment possibilities are scarce and wages are low, people rely almost completely on local natural resources. For the vast majority, arable land and livestock are the main assets to survive in this mountainous region. Due to the arid climatic conditions and maximum rainfall in winter, agricultural activities are only possible with regular irrigation. Arable land is scarce[32] and thus harvests are commonly not even sufficient to cover the farm family's food needs. Therefore, even in 2003 many households were dependent on humanitarian assistance for provision of food (edible oil, flour) and chicken. External support also comes from family members, who migrated to Dushanbe, Russia or other CIS countries in the hope of employment. Such financial contributions constitute an essential source of income for many families in the Tajik Pamirs.

Gorno Badakhshan's economy is predominated by the subsistence-oriented agricultural sector with irrigated farming and livestock raising as its main pillars (see Picture 1.13). The industrial sector consists of the power industry, with a small number of old Soviet plants attempting to adapt to the new market situation and a growing number of small-scale enterprises located in Khorog and district centers. The service sector is dominated heavily by health care, education, governmental administration and charity organizations. Gorno Badakhshan inherited a comprehensive health and education system from the Soviet Union. In virtually all villages, schools provide ed-

**Picture 1.13:** *For the rural population arable land and livestock are the main assets to survive. (Photo: T. Hoeck, June 2003)*

31 Long distances, roads in poor condition and high prices of fossil fuels determine the transport cost. In July 2003, one litre of petrol could be purchased at 1.4 *somoni* (USD 0.44) in Khorog, at 1.2 *somoni* (USD 0.38) in Dushanbe, and one litre of diesel oil at 0.8 *somoni* (USD 0.25) in Khorog and 1 *somoni* (USD 0.32) in rural areas. However, fuel prices in GBAO have increased during the past months, so that today (March 2004) one litre of petrol costs 3.5 *somoni* (USD 1.11) and one litre of diesel oil costs 2 *somoni* (USD 0.63) in Khorog.

32 Arable land per person in GBAO varies between 0.025-0.1ha (Herbers 2001a: 21). According to Umarov (1998) 0.5-1ha of land is necessary to feed one person.

ucation up to the 11th grade, and local hospitals in the *jamoat* centers allow basic medical care. (Breu & Hurni 2003)

***International Assistance Filling the Gap***

As Gorno Badakhshan faced the prospect of a catastrophic famine as a consequence of the collapse of the Soviet Union and the ensuing years of civil war, international organizations began first-aid programs to avert a humanitarian catastrophe. In 1993, relief-programs coordinated by the Aga Khan Development Network launched food provision and initiated an agricultural development program to secure long-term food supply. Charity organizations have gradually overtaken to a great extent the commitments of the state in the sectors of infrastructure, energy supply, agriculture, health and education. Today a wide range of international non-governmental organizations is working in the fields of humanitarian aid and development assistance: The Mountain Society Development and Support Programme (MSDSP), the Aga Khan Development Network (AKDN), the United Nations World Food Program (UNWFP), the Agency for Technical Cooperation and Development (ACTED), Focus, the International Red Cross, and Medicins sans Frontières. The MSDSP and AKDN continue to play a major role in the development of Gorno Badakhshan.

*Aga Khan Development Network*

The Aga Khan Development Network (AKDN) is a worldwide group of development agencies working in health, education, culture and rural and economic development, primarily in Asia and Africa. It consists of eight agencies: The Aga Khan Fund for Economic Development (AKFED), the Aga Khan Foundation (AKF), Aga Khan Education Services (AKES), Aga Khan Health Services (AKHS), Aga Khan Planning and Building Services (AKPBS), Aga Khan Trust for Culture (AKTC), Aga Khan University (AKU) and University of Central Asia (UCA) (www.akdn.org).

*Mountain Society Development and Support Programme*

In 1993 the Aga Khan Foundation (AKF) established the Pamir Relief Development Programme (PRDP) with the principle aim of averting the hazard of famine and improving living standards through agricultural development. In 1997 the project extended its activities to other parts of Tajikistan (Garm Valley) and was renamed Mountain Society Development and Support Programme (MSDSP). The MSDSP is affiliated with the AKDN and has been working towards the promotion of equitable and sustainable improvement of rural livelihoods in Tajikistan. The aim is to strengthen the capability of communities to manage their own resources at the household and village levels in order to improve their living standards, thus enabling them to play an active role in developing society. Village-level and community-based organizations have been created while considering an integrated development approach with a focus on building local capacity. These so-called Village Organizations (VO), already established in virtually all villages in the Tajik Pamirs, consist of different departments (education, health, agriculture, finance, youth, women, etc.) with democratically elected representatives and a VO president as the head of the village. The MSDSP has been implementing five core strategies to support long-term development of GBAO: Humanitarian Assistance, Infrastructure Activities, Agricultural Reform and Diversification, Credit and Marketing, and Social Organization Development (MSDSP 2001; Herbers 2001b).

***References***

ADB [Asian Development Bank] (ed.) (2002) Technical Assistance to the Republic of Tajikistan for the Hydropower Development Strategy.

Akiner, Shirin (2001) Tajikistan: Disintegration or Reconciliation? London: The Royal Institute of International Affairs.

Breu, Thomas and Hurni, Hans (2003) The Tajik Pamirs: Challenges of Sustainable Development in an Isolated Mountain Region. Bern: Centre for Development and Environment, University of Berne.

Herbers, Hiltrud (2001b) Transformation in the Tajik Pamirs: Gornyi-Badakhshan - An Example of Successful Restructuring? In: Central Asian Survey, Vol. 20, No. 3: 367-381.

Herbers, Hiltrud (2002) Ernährungs- und Existenzsicherung im Hochgebirge: der Haushalt und seine Livelihood strategies - mit Beispielen aus Innerasien. In: Petermanns Geographische Mitteilungen, Vol. 146, No. 4: 78-87.

Lambert, Caroline (2003). At the Crossroads. A Survey of Central Asia. In : The Economist, July 26th 2003. New York: Newspaper Group Inc.

MSDSP [Mountain Society Development and Support Programme] (ed.) (2001) Annual Report 2001 of the Mountain Society Development and Support Programme. Dushanbe.

MSDSP [Mountain Society Development and Support Programme] (ed.) (2003) Demographic Statistics of Gorno Badakhshan Autonomous Oblast 2003. Mountain Society Development and Support Programme. Dushanbe.

SCSRT [State Committee on Statistics of the Republic of Tajikistan] (ed.) (2002) Tajikistan in Figures. The Brief Digest. Dushanbe.

Seco [Swiss State Secretariat for Economic Affairs] (ed.) (2003) Pamir Private Power Project Tajikistan. A Project Description. Bern: Eidgenössisches Volkswirtschaftsdepartement.

Umarov, Khojamakhmad (1998) The Demographic Boom and its Impact on the Mountain Regions of Tajikistan. In: Akiner, S., Tideman, S. and Hay, J. (eds.) (1998) Sustainable Development in Central Asia. New York: St. Marin’s Press.

www.akdn.org

www.adb.org

# Part II
# Results



# 7. Historical Flashback Focusing on Energy Issues

The following chapter provides a brief retrospect of the energy situation and its consequences for the inhabitants of Gorno Badakhshan over the last 150 years. It should serve as background for a better understanding of the present situation.

## 7.1 Spoiled with Firewood but Starving: Pre-Soviet Livelihood

In 1274, Marco Polo crossed the Pamirs as the first occidental voyager. Besides describing a huge wild sheep[1], he characterized the lush high pastures of the Great Pamir[2] by saying that a rawboned mare gets fat within ten days (Polo 1972).

Prior to the establishment of the socialist system in GBAO, the majority of the Pamiris lived in very poor circumstances. At that time, Badakhshan[3] was dominated by a feudal system ruled by *khans*[4] who remained subservient to the *Amir* of Bukhara. Together they coerced the peasantry to work on their farms, cultivating barley, wheat, rye, millet, peas, beans and mustard[5] (Hafizullah 1998). The latter was used to daub the chip of pinewood serving as a lamp (see Figure 2.1). Some woolen fibers soaked in animal oil also served as oil lamps.

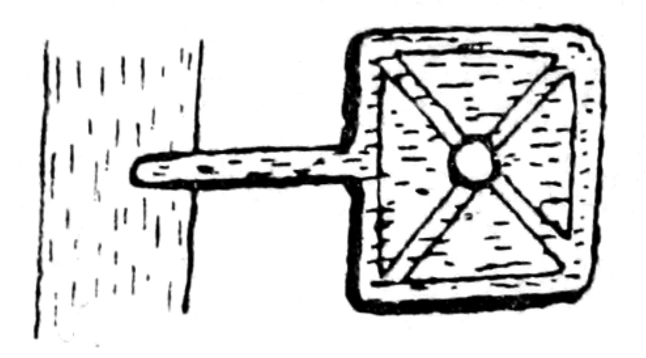


***Figure 2.1:*** *Holder for Chip of Pinewood: It was used as light source. Source: Schultz (1914: 37)*

***Picture 2.1:*** *Pre-Soviet peasants piled up the hey on the roof of their simple houses and used mainly firewood as fuel (mid). Source: Schultz (1914: 111)*

Apricots and mulberries were part of the main nourishment during summer. These berries were dried, ground and used instead of wheat flour. The other common food was *attalya*, a soup made of grasses, beans or peas, with the addition of a handful of flour on rare occasions (Luknitsky 1954: 228). Due to the lack of arable land, the peasants were forced to extend the plots by constructing terraces high up on the slopes. Peasants having a sufficient acreage leave the plots fallow every second year. Manuring was not done annually, but dung served already at that time as fuel. It was used together with firewood on open fireplaces located inside and outside the house. Schultz (1914: 31) specifies bushes, poplar and laurel and occasionally birch trees as sources of firewood. The wood was used very carefully and economically, so that fires were made only when absolutely necessary. The fire was only used for cooking, after which the wood was allowed to burn off. That means that additional wood was not used for heating purposes. The small room was also heated considerably by the body heat of the family members and by the livestock, which in some cases are kept in the living room in winter. Schultz (1911: 27) considers the open fireplace and the stuffy air in the living room, where the domestic life of the Pamiris took place in winter, as the cause of pulmonary diseases

1 The 'Marco Polo sheep' (*Ovis ammon polii*) received its name due to its detailed descriptions in Marco Polo's travel report.

2 The word 'Pamir' signifies desert and is derived from the Khokandese. The transition zone where the upper end of the main valleys fade to the eastern high plateau were called 'Pamirs'. Consequently, there were about five different regions called 'Pamir': Small Pamir, Big Pamir, Alichur Pamir, Rangkul Pamir, Charogschi Pamir.

3 The Russian and British border commission established the frontiers between Russia and Afghanistan in 1895 which remain valid to the present day. Since that time Afghan Badakhshan and Gorno Badakhshan (Tajik) have been separated.

4 *Khans* were important regional rulers in Badakhshan.

5 Tobacco and poppy plants were commonly cultivated and consumed as natural stimulants.

and eye complaints. The pivotal point of family life was the small, sooty living room, with an average volume of 20m[3] (see Figure 2).

Markoff (1900: 676) describes the poorly constructed Pamiri houses that he encountered in Vezdara during his

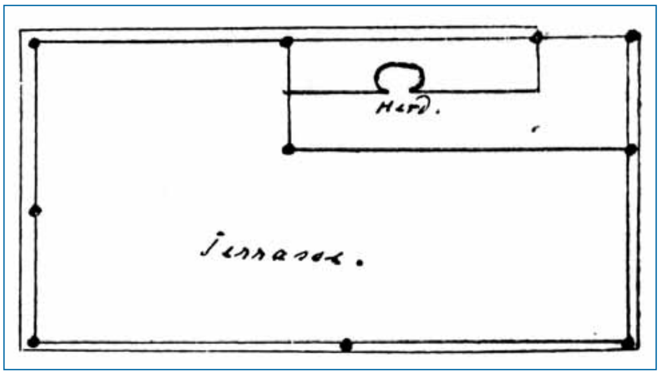



***Figure 2.2:*** *Floor Plan of a Ordinary Traditional Pamiri House (Scale: 1:50). Source: Schultz (1914: 30)*

expedition of 1894:"The 'saklyas' (huts) of the Tajiks are made of stones, held together with clay, and look like so many rude cowsheds. These huts often have no windows, and the doors are always made very small, several boards being roughly nailed together. As there are no windows, the huts of the Tajiks are very dark, damp and foul."

The large *tugai* forests, situated in the floodplains and teeming with wildlife, were a major obstacle for travelers. Especially the forests of the Shakhdara and Gund valleys (see Picture 2.2) were often mentioned in different expedition reports, for example in Markoff's itinerary (1900: 673): "After leaving kishlag Sendip [Sindev] the road descends abruptly to the banks of the Shakh-Dara, and

***Picture 2.2:*** *Pre-Soviet peasants piled up the hey on the roof of their simple houses and used mainly firewood as fuel (mid). Source: Schultz (1914: 111)*

crosses an immense *tugai* over rather marshy soil. The trees grow so thickly there that at some places we rode through long vaults of green formed by the interlacing branches". Geiger (1887: 144) even calls the riparian forestlands in the Pandzh Valley 'jungle'. The mature riparian forests were also used as pastureland, and the brushwood forests consisting mainly of willow trees and sea buckthorn served as a source of firewood.

Cobbold (1900: 203) proudly describes his Marco Polo sheep, shot in the eastern Pamirs and a snow leopard skin originating from a valley behind Khorog. Johnston (1882: 84) emphasizes not only the great diversity of wild animals but also their economical importance: "Martens are caught in traps, their skins being worth about 6s[6] each; while a leopard skin costs about 4s, and a bear skin 10s. Probably about 3000 foxes, 1000 martens, 100 bears, 40 leopards, and 1000 wild sheep and goats are killed in Darwaz and Karategin[7] every year. The pursuit of mountain partridges and ducks, with falcons, on the banks of the rivers is also common, especially in Karategin and Kulyas [Kuliab] on the Khing-ab."

At the end of the 19th century the three largest world empires – China, England and Russia – set out to enter the mountainous regions of Central Asia. Their clashes were terminated when the Russo-British boundary commission established new frontiers between Russia, China, Afghanistan and beyond the Wakhan Corridor, which served as a buffer area between the Russian and the colonial India. The territory to the north of the Pandzh river became part of the Russian empire. At the end of the 19th century the Pamirs gradually lost their image of an enigmatic country wrapped in mystery and legend.

### 3.1.1 Illuminated Ice Rink[8] in Khorog: Modern Times in Gorno Badakhshan

As the Pamiris *Beg*[9] to be accepted as Russian subjects, the Tsar's garrisons enlarged their importance in this region at the beginning of the 20$^{th}$ century. Soon after the October Revolution the Communists assumed power in the Pamirs as well, and the officers of the garrisons fled to India. In October 1924, when the new Soviet Republics were constituted in Central Asia, Gorno Badakhshan gained its autonomous status (Grevemeyer 1882). The Bolsheviks had gained full control in Central Asia in the mid-twenties and the state launched a series of development projects aimed at deconstructing the old policy and its corresponding cosmology by creating institutions based on socialist ideology. The inhabitants of Khorog and Rosthkala enjoyed the first cinema films in 1928. In the following year the first airplane landed in Khorog on

6 The currency could not be defined.
7 The Garm Valley was known as Karategin Region at this time.
8 Luknitsky expressed his delight about the lighted rink in Khorog: "In the winter hockey is played on the ice at night, in brilliant electric light, and in the countryside mass skiing competitions are held." (Luknitsky 1954: 238)
9 *Beg* is the title for a local seigneur in Badakhshan.

the banks of the Pandzh. Even before establishing the Stalin Great Pamir Higway[10] in 1940 Gorno Badakhshan was developed by the Soviets. Luknitsky (1954: 2) describes how, before the establishment of this transport link, the school desks were transported by aircraft to the remote villages in the Pamirs. In 1931 the first regular detachment of Soviet Frontier Guards arrived in Khorog accompanied by two automobiles bringing diesel generators to produce electricity in addition to food, medical instruments, printing machines and new movies (Luknitsky 1954: 236). GBAO's primordial economy was transformed and modernized to the extent that, in the period of 1928–34, a silkworm and a leather factory were established in Khorog. The construction of the first hydropower plant started in 1934 and six years later, the city of Khorog was lighten by electricity. Electric power was the basis for further industrial development. The image of 'virgin soil' in Gorno Badakhshan was definitely vanishing by the time the Great Pamir Highway M41 was completed in 1940, traversing the Pamirs in a 730km road from Osh via Khorog to Stalinbad (Dushanbe). This was one of the major preconditions for further development and construction requiring huge material provision.

The state collectivized agricultural land and permitted individual families to own up to two hectares of agricultural land. They were also allowed limited private ownership of livestock, private homes and small private garden plots of 8000m$^2$. The inhabitants were thus no longer forced to cultivate their own lands, which meant that they could be reinvolved in new occupations. Many Badakhshani became Soviet employees working in the government machinery. Thanks to the increased purchasing power, intensified collective agriculture, the sound employment situation (mainly shifting from the primary sector to the service sector) and a solid supply guarantee, the Badakhshani civilization was transformed from a patriarchal peasant self-sufficient economy, governed by feudalistic seigneurs, into a proletarian *apparatchik*-state, fostering the standard of education and equal opportunity (Hafizullah 1998).

Contrary to common expectations, that population growth slows down due to improved living conditions[11],

***Table 2.1:*** *Estimated Population of Gorno-Badakhshan in 1908 and 1961.*

| | 1908 | | | 1961 | | |
|---|---|---|---|---|---|---|
| | Kyrgyz | Tajik | Total | Urban | Rural | Total |
| Inhabitants | 2000 | 17,000 | 19,000 | 9000 | 71,000 | 80,000 |
| Percent | 11 | 89 | 100 | 11 | 89 | 100 |

*Source: Snessareff (1908:180), Krader (1963: 235)*

the trend in Badakhshan was the opposite. The population grew exponentially in the last century, even though the general living standard improved. After a careful consideration of this issue it becomes clear that the birthrate actually increased due to active promotion by the Soviets regarding extended families. Mothers having more than ten children have been awarded and given medals. The total population has more then quadrupled within 53 years (see Table 2.1).

Owing to the increased demand of energy resources, the Soviets started to deliver coal on a grand scale in 1949. Each household received three to five tons of coal for cooking, baking and heating purposes in winter (Field study 2003). At the same time, the Soviet supply service started to distribute metal stoves to virtually all households. Owing to this campaign, the domestic energy situation was considerably ameliorated. Moreover, households in very remote villages no longer had to suffer from the cold during winter and the inhabitants' health improved remarkably, because they were not exposed to the smoke any more. Many households also purchased kerosene stoves for cooking and baking.

The result of all these ambitious campaigns was that, within three decades, virtually the entire region was electrified and equipped with an extensive transport and communication network, as well as with the institutions of a modern state. If the villages were too remote to be connected to the grid, diesel generators were established to supply electric power. It was mainly used for lighting, radio[12] and later TV.

The Pamirs, once considered one of the most underdeveloped areas of the Soviet Union, were successively modernized and completely incorporated into the Soviet philosophy already at the beginning of the seventies.[13]

10 "[…] to make this [road] a people's undertaking and to complete it not in five years, but in a hundred and twenty days. In May 1940 twenty-two thousand collective farmers went out on the track to help the workers and technical specialists. […] On September 1 the first automobile passed through the Darvaz Gorge, and six days later the builders reported to Stalin the whole road was opened for traffic" (Luknitsky 1954: 221-222).

11 Demographic Transition is a model that describes population change over time induced by a country's development and industrialization. It experiences declines in death rates followed by declines in birthrates resulting in a decrease of the population growth rate. In the Pamirs only the death rate decreased while the birthrate increased (Knox et al 2001).

12 According to Hafizullah (Hafizullah 1998: 11) the Soviets established a radio station in 1943 providing people in Khorog, Rushan, Vanj and other regions of the Pamirs with access to news broadcasts from most parts of the Soviet Union. Of course, it was a good media, especial in mountainous regions, to spread the idea of the Soviet socialism.

13 Hafizullah comments on the Soviet impact as follows: "Although development and modernization in GBAO under Soviet rule resulted in Soviet cultural domination, the disaffirmation of Tajik identity, the disintegration of traditional socio-economic structures exemplified in the coerced relocation of some Badakhshanis in the 1940s and 1950s, Ismaili intellectuals hailed such a development as a road to their entry into the modern world" (Hafizullah 1998: 12).

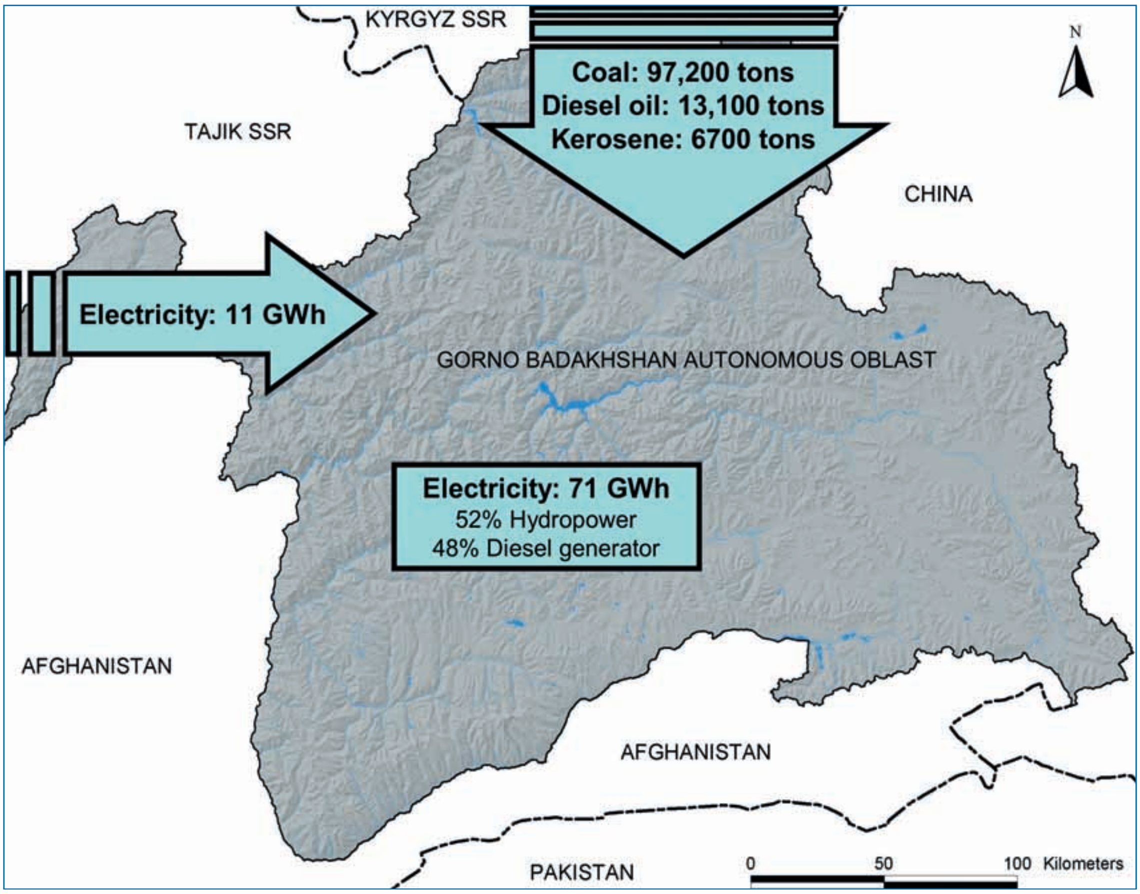



***Figure 2.3:*** *Energy Resource Import and Production of GBAO in 1974: 96% of all energy resources were imported from outside. Source: Kleandrov (1974), Zibung (2002)*

The immense speed of development and turnabouts in society caused several concomitant negative phenomena: On the one hand, a great deal of traditional local knowledge disappeared, especially in terms of cropping systems and handicrafts being beneficial for basic needs. On the other hand, highland-lowland interactions became substantially unidirectional, causing an enormous dependency on the lowlands. This fact is emphasized by Figure 2.3, illustrating the import and the production of energy resources in GBAO in 1974. According to Zibung (2003) the main channel of supply came through the Kyrgyz Republic because of higher reliability in winter. Firewood and dung were only marginally used during Soviet time, amounting to a negligible quantity compared to the other consumed energy resources.

In Tajikistan, as well the Soviets began to establish the first gigantic projects during the sixties, including the 2.7GW-GES[14] located in Nurek. Transmission lines were drawn from Nurek across the Kahburabot-Pass to the Pandzh Valley, so that the GBAO could profit from electric power.

It was at this time, that the main Pamir-Grid was connected to the southern Tajik grid (Nurek-Dushanbe). Nurek was not only planned for electricity generation but also for large scale irrigation of the neighboring Dangara, Jawansu and Obi-Kiik Valleys (Renner 1977). After ten years of construction Nurek was connected to the grid in 1971, although it was not totally finished. Already before its completion, the shot firers penetrated another 100km upstream the Vakhsh river more into the mountains, in order to construct another, larger hydropower plant: the Rogun station (3.2GW). But the collapse of the USSR occurred before than its completion. The building site thus had to be abandoned. To this day a large ghost town in the middle of the mountains continue to rust and crumble.[15]

It was planned to construct seven large-scale hydropower plants as a cascade on the Vakhsh river. An even more powerful cascade comprising of nine hydropower stations was also foreseen in the Pamirs on the Pandzh River. The estimated overall electricity output produced by these nine power plants and 40 smaller

14 'Nurek' is a Tajik word which can be translated as 'light beam'. GES is the abbreviation for the Russian term 'Gidro elektrostanzi' (hydropower station).

15 According to www.worldinformation.com Tajikistan's President Rakhmonov and Russia's President Putin agreed in April 2003 to restart the construction of the Rogun hydropower plant. If completed, the plant will be the largest hydropower facility in Central Asia, producing electricity that could be sold to markets as far away as Iran and Pakistan.

plants amounted to 10,706MW (see Appendix 2). The aim was to export the electricity all over the USSR, which means the Soviet Republic of Tajikistan should have become the second largest energy supplier after Russia in the entire USSR. But, as is generally known, this utopian plan could not be accomplished.

Although many projects were launched and planned in the Pamirs during the eighties, economic retrogression already commenced at this time. The collapse of the Soviet Union induced in Tajikistan a series of reactions considerably affecting the energy sector. They are discussed in the following chapters.

***References:***

Akhunov I.I (1967). Generation of the national income in Tajik SSR. In: Irfon. Dushanbe.

Akiner, Shirin (1998) Social and Political Reorganisation in Central Asia: Transition from Pre-Colonial to Post-Colonial Society. In: Post-Soviet Central Asia. T. Atabaki and J. O'Kane, (eds.) pp. 11-34. London: Tauris Academic Studies, International Institute for Asian Studies (IIAS).

Breu, Thomas and Hurni, Hans (2003) The Tajik Pamirs: Challenges of Sustainable Development in an Isolated Mountain Region. Bern: Centre for Development and Environment, University of Berne.

Clemens, Jürgen (2001) Ländliche Energieversorgung in Astor: Aspekte des nachhaltigen Ressourcenmanagements im nordpakistanischen Hochgebirge. Bonner Geographische Abhandlungen. Heft 106. Sankt Augustin: Asgard-Verlag.

Cobbold, Ralph (1898) Report on his Journeys on the Pamirs and in Chinese Turkestan. To the Foreign Office. Srinagar. Kashmir.

Cobbold, Ralph (1900) Innermost Asia. William Heinemann: London.

Geiger, Willhelm (1887) Die Pamir-Gebiete. Eine geographische Monographie. In: Geographische Abhandlungen. Volume 2. Eduard Hölzel: Wien.

Grevemeyer, Jan-Heeren (1982) Herrschaft, Raub und Gegenseitigkeit: Die politische Geschichte Badakhshans 1500-1883. Dissertation. Wiesbaden: Harrassowitz.

Hafizullah Emadi (1998) Politics of Transformation and Ismailis in Gorno-Badakhshan, Tajikistan. In Internationales Asienforum International Quarterly for Asian Studies.. Volume 29, 1-2/98.

Kleandrov I.M. (1974) The Economy of the Soviet Badakhshan. In: Irfon. Dushanbe.

Knox, Paul et al. (2001) Humangeographie. Spektrum Akademischer Verlag. Heidelberg.

Krader, Lawrence (1963) Social Organization of the Mongol-Turkic Pastoral Nomads. Indiana University Publications, Uralic and Altaic Series. Volume 20. The Hague: Mouton & Co.

Luknitsky, Pavel (1954) Soviet Tajikistan. Moscow: Foreign Languages Publishing House.

Markoff, A. (1900) On the Afghan Frontier: A Reconnaissance in Shugnan. Notes from a Journal of the Russian Officer Lieut.-Colonel A. Serebrennikov in 1894. In: Geographical Journal, Vol. 16, No. 6 (Dec. 1900): 666-679. www.jstor.org

Masov R.M. (1981) Essays on Soviet Badakhshan history. In: Irfon. Dushanbe.

Nazarshoev, M.N. (1970) Partial Organization of Pamir in Struggle for Socialism and Communism. In: Irfon. Dushanbe

Polo, Marco (2000) Von Venedig nach China. Die grösste Reise des 13. Jahrhunderts. Thienemann Verlag.

Renner, Georg (1977) Biwak auf dem Dach der Welt: Auf Bergfaden durch Tadschikistan. VEB F.A.Brockhaus Verlag. Leipzig.

Schultz von, Arved (1911) Zur Kenntnis der arischen Bevölkerung des Pamir. In: Orientalisches Archiv. Illustrierte Zeitschrift für Kunst, Kulturgeschichte und Völkerkunde der Länder des Osten. Volume 2. Giessen

Schultz von, Arved (1914) Die Pamirtadschik. Veröffentlichung des Oberhessischen Museums und der Gail'schen Sammlung zu Giessen (Abteilung für Völkerkunde). 1. Heft. Giessen: Verlag von Alfred Töpelmann (vormals J. Rickmers)

Snessareff, A (1908) Religion und Gebräuche der Bergvölker des westlichen Pamir. In: revue orientale pour les études ouralo-altaïques. Journal du comité hongrois de l'assocation inernationale pour l'exploration de l'asie centrale de l'extreme-orient. Budapest.

Stein, Sir Aurel (1982) On Ancient Central-Asian Tracks. Taipei: Southern Materials Center. Reprint (Original: 1933).

Zibung, Daniel (2002) Eine integrale Analyse der Infrastrukturausstattung und Energieversorgung in der Grossregion Gorno-Badakhshan, Tajikistan. Diplomarbeit. Bern: CDE.

# 8. Energy Supply and Resources in the Tajik Pamirs

This chapter provides an overview of the present supply of energy resources in Gorno Badakhshan. Focus is on electricity supply and on micro and mini hydropower stations, whereas biomass fuels like firewood, shrubs and manure, and fossil fuels are only briefly discussed. A more detailed view of the use of biomass and fossil fuels at the household and village levels is provided in the Chapters 10, 11 and 12.

## 8.1 Electricity Supply from Hydropower

### 8.1.1 Electricity Grids and Hydropower Stations

The Republic of Tajikistan has three separate power systems: the Northern, the Southern and the GBAO electric system. The Northern and Southern systems are operated by *Barki Tojik*[16], whereas in GBAO a private power company manages electricity supply. High mountain ranges form a physical barrier between the Sodg (former Leninabad) region in the North and the Southern Dushanbe region. These two electric networks are not directly interconnected within the country, but only linked through Uzbekistan. The Northern districts of GBAO are linked to the Southern Tajik power system via a 35kV transmission line. But electricity supply is limited to Darvaz and parts of the Vanj districts, and the lines are not linked to the main grid in GBAO supplied from Khorog, the *oblast* center (see Map 2.1). Thus Gorno Badakhshan can be considered as a separate power system (World Bank 2002; ADB 2002). GBAO has no interconnections with electricity grids from the neighboring countries of Afghanistan, China or Kyrgyzstan. Hence there is no way of importing power to fill supply gaps or compensate for power deficiencies.

One part of Tajikistan's Soviet legacy is extensive physical electricity infrastructure that covers almost the entire country. Even remote areas such as GBAO were equipped with an extensive electricity grid providing power even to dwellers in small and distant villages located at altitudes of more than 3500m (World Bank & IFC 2002). In addition, decentralized hydro and diesel power plants were installed to provide electric power to less accessible settlements.

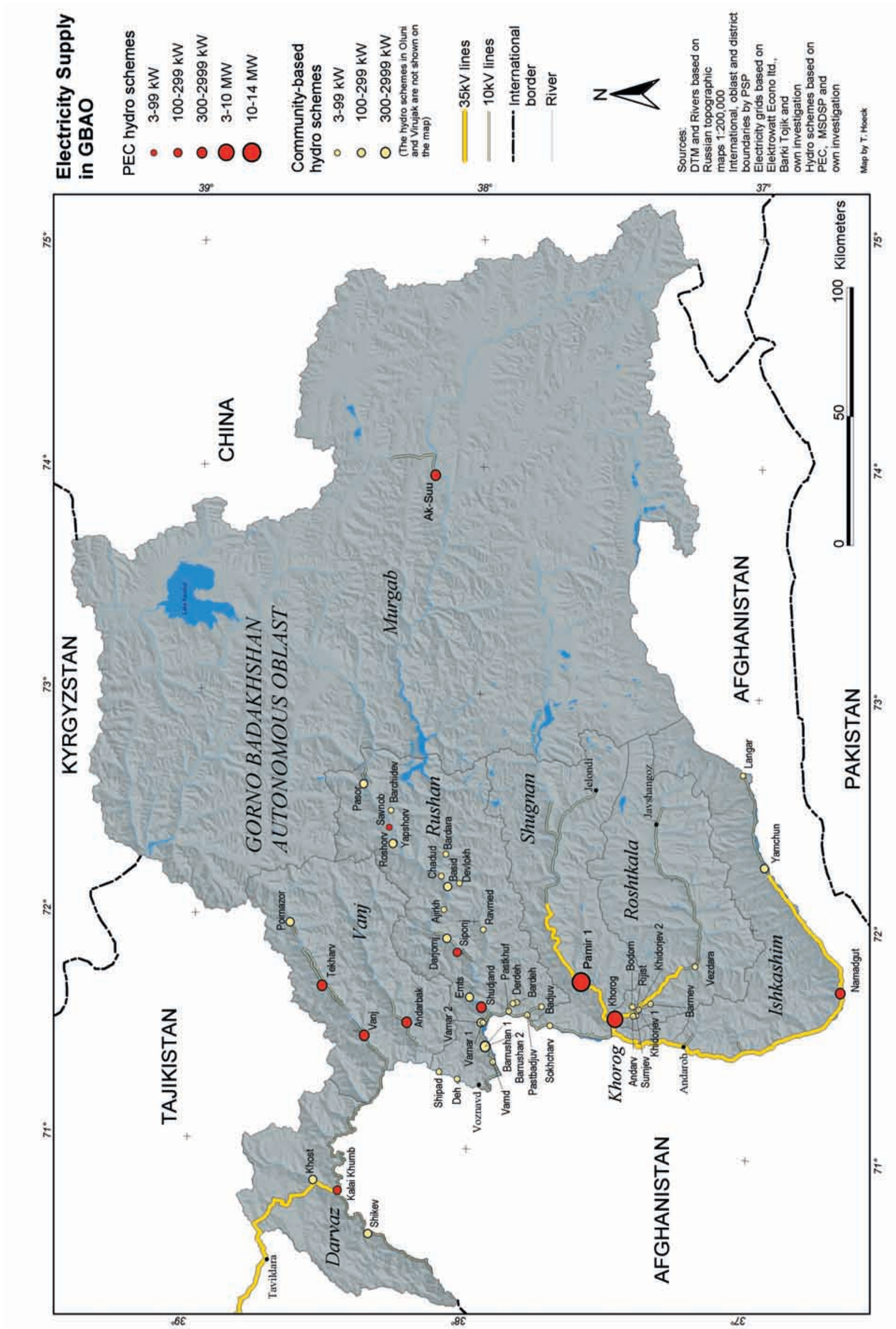
The formerly extensive electricity grid deteriorated in the years of civil war (1992-1997). Transmission lines and transformers were largely destroyed by warlike activities, resulting in the disconnection of a great number of villages from power sources. Only about 15% of the original transmission system, consisting of 1227km of 35kV and 10kV power lines[17], was still functioning after the civil war (Seco 1999; World Bank & IFC 2002). At present, one large and several smaller and isolated electricity grids provide power to the population of the Tajik Pamirs (see Map 2.1). The Pamir 1 (14MW) and Khorog (8.7MW, see Picture 2.3) hydropower plants feed the main grid supplying Khorog, the *oblast* center, the Shakhdara valley up to Javshangoz (Roshtkala district), the Gunt valley up to Jelondi (Shugnan district) and the villages on the River Pandzh upstream to Ishkashim center and downstream to the village Voznavd (Rushan district). The district centers of Rushan and Ishkashim are not provided with power from the mains, but from separate hydro schemes. The main grid supplies about 15,900 customers[18] in summer. Due to reduced water discharge in winter, provision of electric power is limited to the *oblast* center accomodating 4600 customers[19]. About 70,000 dwellers in villages outside of Khorog are disconnected from November to late March or April. But in several communities micro and mini hydropower stations provide electricity during the winter months. The hydropower plants are not interconnected with the grid or among themselves. In the Bartang, Yazgulom and Vanj valleys, where no power from the main grid is provided, independent micro and mini hydro schemes ensure electricity supply over small grids, commonly for one to seven villages. The hydropower plant in Tekharv (Vanj district) supplies an exceptionally large but independent grid with a total of 26 villages connected. Darvaz and parts of the Vanj district are connected to the Southern Tajik power system supplied by the Nurek power station, with a capacity of 3000MW the largest hydro scheme in Tajikistan, located on the River Wakhsh. The 35kV transmission line running from Tavildara to Kalai-Khumb provides electricity via 10kV lines to villages on the River Pandzh and in

16 *Barki Tojik* is the national energy company of Tajikistan.

17 This is the figure provided by WB & IFC (2002). The final report for project identification in the energy sector in GBAO (Seco 1999) contains a map from the former power department of GBAO from 1997, which depicts electricity grids and power stations in Gorno Badakhshan. On that map, the extension of electric network amounts to 2590km in 1997 and its increase to 3000km was predicted for 1998.

18 Equal to about 100,000 people.

19 Equal to about 28,000 people.



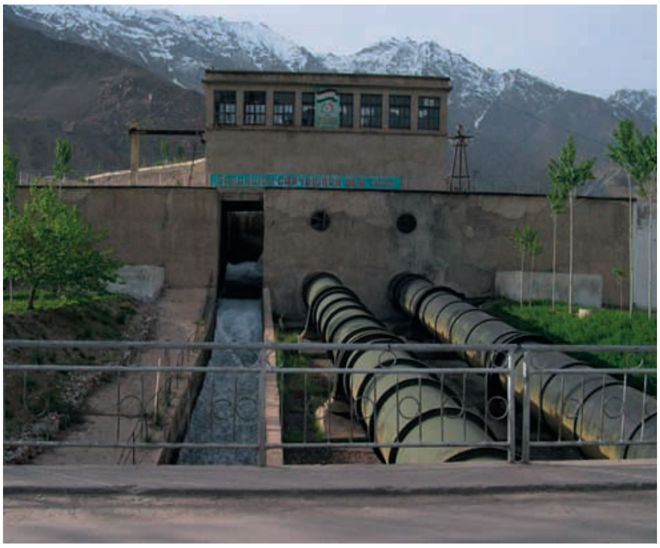

*Map 2.1: Electricity Supply in Gorno Badakhshan. The map shows electricity grids and hydropower stations. The MHPS in Oluni and Virujak could not be located and are thus not shown on the map. Map by T. Hoeck*

the lower Vanj Valley[20]. In the Eastern Pamirs electricity is generated by a single hydropower station supplying only Murgab center.

During Soviet times several diesel and hydropower plants with an overall installed capacity of 42MW[21] provided electricity to the population of GBAO. In 1984 the institute for small hydropower stations compiled a list of 40 possible projects to increase power supply to the population of the Tajik Pamirs. The projected hydro schemes ranged between 150kW and 24MW and had an overall capacity of 136.4MW. Large power projects were planned even in very remote areas: For example, in the village of Gudara in the upper Bartang Valley a hydropower plant of 8MW was projected. Further feasibility studies were performed under Soviet rule to exploit the huge potential for hydropower on the Pandzh River. A total number of nine possible giant power schemes were considered with capacities of 250-3000MW, resulting in an overall hydropower volume of 10,570MW. Due to the breakdown of the Soviet system these projects have not been translated into action (IHTSSR 1984).

Since 1995 total electricity production in Gorno Badakhshan is generated by hydropower due to lack of financial means to import fuels for the diesel power plants. In 2003 a total number of 53 run-of-the-river schemes[22] in the range of 3-14,000kW and with an overall installed capacity of 31.7MW supplied 94.6% of the population of the Tajik Pamirs[23] with power. The hydropower plants are equipped with old machinery, mostly in poor condition and operating at low efficiency rates, so that the actual output capacity is estimated at 26.8MW. When also considering transmission losses averaging 17%[24], the net capacity for customers in GBAO is down to 22.2MW. The presently available capacity is far too low to satisfactorily supply the population of the Tajik Pamirs with power: A power capacity of 22.2MW covering about 30,200 domestic customers[25] results in an average available net capacity of about 735W per household.

A shift in electricity consumption patterns could be observed in Tajikistan over the past decade. Today about 40% of the electricity is consumed in the residential sector compared to 9% in 1990 (World Bank & IFC 2002: 7). Figures from the Pamir Energy Company (statistics from



***Picture 2.3:*** *The hydropower plant in Khorog will be rehabilitated within the Pamir Private Power Project, thus enabling it to operate again at full capacity. (Photo: T. Hoeck, June 2003)*

2003) depict an even more drastic picture for Gorno Badakhshan: In May 2003, 84% of electricity was distributed to the domestic sector and only 16% was used for commercial activities; 14% was consumed by governmental institutions and only 2% by industrial consumers. Figures for the year 1998 show that only 26% of the electricity was consumed by the village population, 57% by urban domestic consumers and 17% by industrial and non-industrial enterprises (IFC 1999).

### 8.1.2 The Pamir Energy Company

The Pamir Energy Company (PEC) is a private power company founded in 2002 and responsible for electricity provision in GBAO. The Pamir Private Power Project (PPPP) includes the establishment of the power company (PEC) as well as the rehabilitation and construction of the electricity infrastructure. The PEC is responsible for power generation, transmission and management of the regional power utilities, and was implemented under a concession contract over a period of 25 years. The International Finance Corporation (IFC), the International Development Association (IDA) and the Aga Khan Fund for Economic Development (AKFED) developed this private power company with financial support from the Swiss

20 In June 2003 the PEC purchased 2381MWh from the Southern Tajik power system to supply customers in Darvaz and the Vanj district with electricity (PEC 2003).

21 In the late eighties 10 major diesel plants with a capacity of 27MW and eight hydro schemes (Lenin in Khorog 1940, Kalai-Khumb 1959, Ak-Suu 1964, Vanj 1968, Shudjand 1969, Khorog 1970, Namadgut 1974 and Savnob 1989) with an installed capacity of 15MW were completed under Soviet rule (Zibung 2002: 89; Field study 2003).

22 In contrast to storage schemes, which use a dam to retain river flow and accumulate a reservoir of water, run-of-the-river schemes divert a part of the river flow into a channel and forebay tank (see Chapter 8.2).

23 In 2003 GBAO was home to 212,844 inhabitants, of which 11,544 were not provided with electricity (Field study 2003; personal communication with Abudullo from MSDSP 2004).

24 Transmission losses for power distribution in May and June 2003 average 17% (PEC 2003).

25 There were no figures available for commercial customers. Moreover, Darvaz district is provided with electricity from the Southern Tajik power system.

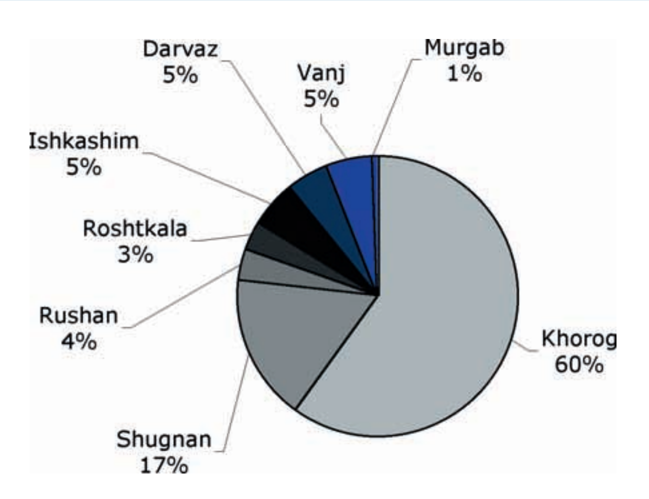



***Figure 2.4:*** *Power Distributed by the Pamir Energy Company to the Customers in All Eight Districts of Gorno Badakhshan in 2001. Source: PEC 2003*

State Secretariat for Economic Affairs (seco). The PEC is owned to 70% by the AKFED and to 30% by the IFC (Seco 2003). The overall project costs for the establishment of the new energy company, including construction and rehabilitation of electricity infrastructure amount to USD 26.5 Mio (PEC 2002: Appendix D). International firms will assist the newly founded company for the initial years: These are Electrowatt-Econo in partnership with Electrique de Fribourg (Switzerland) and staff from a Bulgarian power utility company (Seco 2003).

The PEC owns a total number of 11 hydropower plants with an installed capacity of 28.4MW. The Pamir 1 hydro scheme, with 14MW, is the largest power plant in GBAO followed by the Khorog hydropower plant (HPP) with an installed capacity of 8.7MW. In addition, six mini hydro schemes ranging between 300-2500kW and three micro hydropower plants (80-208kW) are managed by the PEC (see Map 2.1). The Pamir 1 and Khorog HPP generate 81% of overall power production of the Pamir Energy Company, feeding the main grid connected to about 15,900 domestic customers (49% of GBAO's population). The nine independent MHPS supply about 7500 customers (23% of GBAO's population) in five districts year round with electricity. In 2001 the PEC distributed 122,182MWh to its customers: 60% of it to the *oblast* center and only a marginal amount of electricity to the other seven districts in GBAO (see Figure 2.4). The overall monthly power distribution in June 2003 amounts to 12,645MWh[26] of which 18% (2380MWh) was purchased from the Southern Tajik power system (managed by *Barki Tojik*) to provide the Sagridasht and Kalai-Khumb region with electricity[27].

Electricity costs are presently set at USD 0.0075/kWh and will steadily increase to USD 0.03/kWh by 2010 according to the Concession Agreement between the PEC and the Government of Tajikistan (PEC 2002). In 2003, however, the fees were commonly not calculated on a kWh basis but on a flat rate basis (see Picture 2.4). In Khorog, for example, households paid monthly bills of USD 9.50 regardless of their actual power consumption. The PEC justifies the present way of billing by saying that the electric meters installed in the households do not function properly. As is emphasized in socio-economic surveys[28] performed on behalf of the IFC in 1999 and 2001, a majority of the population will not be able to pay for electricity at prices that are four times higher, let alone for increased power consumption. As a result, a "Lifeline Tariff" block of 200kWh/month in winter and 50kWh/month in summer was introduced to ensure a level of social protection for the residential consumers in GBAO. The difference between the "Lifeline Tariff" of USD 0.0025/kWh and the residential tariffs contemplated in the Concession Agreement is covered by a Social Pro-

***Picture 2.4:*** *Individual billing is not possible since the installed electricity meters do not function properly. (Photo: T. Hoeck, June 2003)*

26 The net distribution considering transmission losses is 10,495MWh (PEC 2003).
27 The PEC can purchase electricity from *Barki Tojik* at a price of 50% of the estimated resale cost (PEC 2002: Appendix E).
28 These are IFC (1999) and IFC & GoT Tajikistan (2001).

tection Account established by the Government and supplemented with a grant support of five million dollars from the Swiss State Secretariat of Economic Affairs (Seco). Funds in the Social Protection Account are expected to be sufficient to ensure the "Lifeline Tariffs" for seven to ten years (PEC 2002: Appendix E).

### 8.1.3 The Pamir Private Power Project

According to the Concession Agreement, the Pamir Energy Company is committed to conducting "[…] partial rehabilitation of the electricity generation, transmission and distribution system in the city of Khorog and in surrounding areas of the GBAO", the construction of the regulating structure at the outlet of Lake Yashilkul and completion of the Pamir 1 hydropower station. The following electricity infrastructure in GBAO shall be rehabilitated or constructed by 2005 (PEC 2002: Appendix C):

- Completion of the Pamir 1 hydro scheme (28MW): Construction of the Pamir 1 power plant on the Gunt River started already under Soviet rule in 1984. By 1994 two of four units of 7MW had been completed. The third and fourth unit are only partially installed, but not yet operational. The goal of the project is to complete the installation of unit 3 and 4, rehabilitate unit 1 and 2, and expand penstock, headrace tunnel and surge tank to increase the power plant's operational capacity to 28MW.
- Construction of a regulating structure at Lake Yashilkul: The objective is to regulate the outflow at Lake Yashilkul to ensure sufficient water flow all year in the Gunt River to operate all four units of the Pamir 1 power plant. Water will be retained in summer and released during low flow periods (October till April) into the Gunt River.
- Rehabilitation of the Khorog hydro scheme (8.7MW): The project envisions a thorough general overhaul of turbines, generators and intake valves as well as the replacement or repair of broken instrumentation and monitoring devices.
- Rehabilitation of Vanj hydro scheme (1.3MW): What is planned is a general overhaul of turbines, generators and intake valves as well as the replacement or repair of broken control instrumentation and monitoring devices (see Picture 2.5).
- Rehabilitation of Namadgut hydro scheme (2.5MW): The objective is a general overhaul of the hydro scheme's equipment and repair or replacement of broken components.
- Erection of a new 35kV line between Pamir 1 and the substation in Khorog.
- Rehabilitation of the 35kV line between Khorog and Andarob.

***Picture 2.5:*** *The decentralized Vanj hydro scheme will also benefit from the Pamir Private Power Project. A general overhaul of the equipment should guarantee improved power supply to the population. (Photo: T. Hoeck, July 2003)*

- General rehabilitation of critical sections of other 35kV and 10kV lines within the Khorog area.

After completion of all projected construction and rehabilitation work, the hydropower stations should run steadily and operate all year at full capacity. Thus the overall hydropower volume in GBAO will be increased to about 49MW. The PEC will be able to provide the main grid with a total capacity of 36.7MW (compared to 21MW in 2003) and supply the independent grids in the district centres of Vanj and Ishkashim with increased power capacities. The villages outside of Khorog connected to the main grid should then as well enjoy year round electricity supply. However, as mentioned in the report of the IFC & GoT (2001: 16), "even with Pamir 1 in full operation, there will apparently still not be enough energy to satisfy the demand of the whole area all the time. This means that there will still be a need for other forms of energy, including fuel wood." Estimations made by the AKF (1996) for electricity needs in GBAO set at 70MW confirm the insufficiency of power supply even after the completion of the Pamir Private Power Project.

### 8.1.4 The Forgotten Regions

Only little more than half of Gorno Badakhshan's population will probably profit from the PPPP. The remaining part of the inhabitants, approximately 70,000 dwellers[29] with insufficient or no power supply, has to cope with the present energy situation (see Picture 2.6), which is especially alarming in rural regions. According to the PEC[30] no grid extensions are projected in the nearer future. Hence there is no hope for the population, which is presently not connected to the mains in GBAO, of benefiting from better electricity supply in the forthcoming years. It is there-

29 Not considering Darvaz district, which is supplied from the Southern Tajik power system.
30 Personal communication with the general director of Pamir Energy Company in Dushanbe on May 20th 2003.

***Table 2.2:*** *Villages without Electricity Supply. At the present time, 38 out of 398 villages and district centers in GBAO have no access to electricity supply. A total of 2300 households, home to 11,544 inhabitants, have no electric power.*

| | District | Jamoat | Village | Households | Inhabitants | Electricity infrastructure |
|---|---|---|---|---|---|---|
| 1 | Murgab | Murgab | Mamadzohir | 23 | 115 | No |
| 2 | Murgab | Alichur | Alichur | 267 | 1191 | No |
| 3 | Murgab | Alichur | Bulunkul | 30 | 178 | No |
| 4 | Murgab | Alichur | Bashgumbez | 146 | 641 | No |
| 5 | Murgab | Rankul | Kara-Truk | 18 | 92 | No |
| 6 | Murgab | Rankul | Suubashi | 19 | 143 | No |
| 7 | Murgab | Rankul | Chechekty | 43 | 175 | No |
| 8 | Murgab | Rankul | Shatput | 22 | 224 | No |
| 9 | Murgab | Rankul | Rankul | 186 | 760 | No |
| 10 | Murgab | Kara-Kul | Kara-Art | 186 | 870 | No |
| 11 | Murgab | Kara-Kul | Booke | 13 | 84 | No |
| 12 | Murgab | Kara-Kul | Janijer | 10 | 41 | No |
| 13 | Murgab | Kizil-Rabot | Tokhtamish | 190 | 810 | No |
| 14 | Murgab | Kizil-Rabot | Akbeit | 3 | 15 | No |
| 15 | Murgab | Kizil-Rabot | Cheshtebe | 20 | 70 | No |
| 16 | Murgab | Kizil-Rabot | Shaimak | 169 | 695 | No |
| 17 | Murgab | Kizil-Rabot | Kizil-Gorum | 8 | 40 | No |
| 18 | Murgab | Kona-Kurgan | Cheshtibe | 15 | 161 | No |
| 19 | Murgab | Kona-Kurgan | Tokhtamishbek | 2 | 12 | No |
| 20 | Murgab | Kona-Kurgan | Madiyan | 40 | 183 | No |
| 21 | Murgab | Kona-Kurgan | Kona-Kurgan | 203 | 844 | No |
| 22 | Rushan | Savnob | Aktash | 5 | 28 | No |
| 23 | Rushan | Savnob | Nisur | 35 | 240 | No |
| 24 | Rushan | Savnob | Roshorv | 170 | 997 | MHPS broken |
| 25 | Rushan | Savnob | Yapshorv | 38 | 225 | MHPS broken |
| 26 | Rushan | Savnob | Rukhch | 40 | 275 | No |
| 27 | Rushan | Savnob | Gudara | 57 | 327 | Disconnected from Pasor MHPS |
| 28 | Rushan | Savnob | Bopasor | 54 | 325 | Disconnected from Pasor MHPS |
| 29 | Rushan | Savnob | Pasor | | | MHPS broken |
| 30 | Rushan | Savnob | Barchidev | 27 | 184 | MHPS broken |
| 31 | Rushan | Basid | Bardara | 90 | 525 | MHPS broken |
| 32 | Rushan | Rushan | Rid | 11 | 36 | No |
| 33 | Rushan | Rushan | Chizev | 14 | 70 | No |
| 34 | Vanj | Rovand | Poimazor | 56 | 376 | MHPS under construction |
| 35 | Vanj | Rovand | Sumgad | 13 | 69 | To be connected to Poimazor MHPS |
| 36 | Vanj | Rovand | Van Vani Bolo | 44 | 280 | To be connected to Poimazor MHPS |
| 37 | Vanj | Rovand | Van Vani Poyon | 16 | 105 | To be connected to Poimazor MHPS |
| 38 | Ishkashim | Zong | Ratm | 17 | 138 | No |
| | Total | | | 2300 | 11,544 | |

*Source: Field study 2003; personal communication with Abudullo from MSDSP 2004*


***Picture 2.6:*** *Approximately 70,000 people will not benefit from the improvements provided by the Pamir Private Power Project. They will have to continue coping with no or insufficient power supply. Although transmission lines exist, the village of Roshorv has no electricity supply. Villagers in Chadud constructed an insufficient transmission system with branches and wires. The MHPS in Bardara is broken due to severe damage at the old equipment. (Photos: T. Hoeck, June 2003)*

fore important to launch activities in the field of electricity and energy supply in addition to the PPPP and not forget the remote regions of GBAO. A total of more than 11,500 inhabitants (or 5.4% of the population) have no electricity supply at all due to broken power plants, inexistence or deterioration of electricity infrastructures in the districts of Vanj (far end of the Vanj valley), Rushan (entrance and upper Bartang valley), Ishkashim (last village at the far end of the valley) and Murgab[31] (whole district except for Murgab centre supplied from HHP Ak-Suu and Sari-Mangol[32] supplied from Kyrgyzstan), who have to rely on scarce biomass and expensive fossil fuels to cover their needs for energy (see Table 2.2).

***References***

AKF [Aga Khan Foundation] (ed.) (1996) Aga Khan Foundation Development Programme, Gorno-Badakhshan, Tajikistan. Concept Paper for Funding Twelve 600 kW HEP Stations.

ADB [Asian Development Bank] (ed.) (2002) Technical Assistance to the Republic of Tajikistan for the Hydropower Development Strategy.

Harvey, Adam (1993) Micro-Hydro Design Manual. A Guide to Small-Scale Water Power Schemes. London: Intermediate Technology Publications.

IFC [International Finance Corporation] (ed.) (1999) Gorno-Badakhshan Energy Development Project. Review of the Pamir HPP. Preliminary Draft. Zürich: Electrowatt Engineering.

IFC [International Finance Corporation] and GoT [Government of Tajikistan] (eds.) (2001) Evaluation of the GBAO Electric Networks and Assistance in Project Preparation. Volume 3 Environmental and Socio-Economic Measures. Elektrowatt Engineering Ltd.

IHTSSR [Institute of Hydropower of the Tajik SSR] (ed.) (1984) Compilation of a list of small and large-scale hydropower projects in Gorno Badakhshan. Dushanbe.

PEC [Pamir Energy Company] (ed.) (2002) Concession Agreement Between Government of the Republic of Tajiistan and Pamir Energy Company. Dushanbe May 24th 2002.

PEC [Pamir Energy Company] (ed.) (2003) Statistics of Power Generation and Distribution in Gorno Badakhshan 2003. Khorog: PEC.

Seco [Swiss State Secretariat for Economic Affairs] (ed.) (1999) Project Identification in the Energy Sector in Gorno-Badakhshan, Tajikistan. Final Report August 13th 1999. Elektrowatt Engineering.

Seco [Swiss State Secretariat for Economic Affairs] (ed.) (2003) Pamir Private Power Project Tajikistan. A Project Description. Bern: Eidgenössisches Volkswirtschaftsdepartement.

World Bank (ed.) (2002) Tajikistan Pamir Private Power Project. Environment and Social Impact Assessment. Executive Summary.

World Bank and IFC [International Finance Corporation] (eds.) (2002) Project Appraisal Document on a Proposed International Development Association in the Amount of up to SDR 7.9 Million to the Goverment of Tajikistan and on International Finance Corporation Financing Consisting of: An „A“ Loan in the Amount of up to US$ 4.5 Million and an Equity Subscription of up to US$ 3.5 Million to Pamir Energy Company for the Pamir Private Power Project in the Republic of Tajikistan. May 31st 2002.

Zibung, Daniel (2002) Eine integrale Analyse der Infrastrukturausstattung und Energieversorgung in der Grossregion Gorno-Badakhshan, Tajikistan. Diplomarbeit. Bern: CDE.

[31] It should be added that there are some villages in Murgab district which are actually no longer inhabited or which only consist of a hunting camp. Nonetheless they are still listed in the demographic statistics of Gorno Badakhshan and thus also in the list above. For example, it was reported by a local informant that there is only one village inhabited in the Kara-Kul *jamoat*, namely the village Kara-Kul (named Kara-Art in the list above).

[32] The village of Sari-Mangol lies within the boundaries of the Chong Alay district of Kyrgyzstan. A piece of land in the Alay Valley, and with it Sari-Mangol, was rented to Tajikistan by Kyrgyzstan in the sixties. Although the rent deadline has already been long overdue, it seems to still belong to the Murgab district (*jamoat* Kara-Kul), and thus to Tajikistan, as Sari-Mangol still appears in the demographic statistics of Gorno Badakhshan (MSDSP 2003) with 2921 inhabitants and 518 households.

## 8.2 Micro and Mini Hydropower Generation

This chapter gives an overview about existing and planned micro and mini hydropower stations (MHPS) in Gorno Badakhshan Autonomous Oblast (GBAO). The implementation of hydropower projects, the equipment and performance of power plants, their operation, maintenance and management and the most common problems of MHPS are discussed. Further, a financial evaluation is performed to assess the economic viability of MHPS in the Tajik Pamirs and future hydropower projects are presented. In addition the authors focus on two MHPS located in the case study villages Vezdara and Savnob, illustrating the above-mentioned aspects embedded in the specific energy situation as found in the two villages.

Detailed information about 46 existing power plants[33] and three planned hydropower projects had been collected during a field study in summer 2003. In combination with data obtained from the Mountain Society Development and Support Programme (MSDSP) and Pamir Energy Company (PEC) an inventory has been established of 53 existing hydro power plants (see Map 2.1). According to Harvey (1993) hydropower plants can be classified into four levels of size (see Table 2.3).

Applying this classification to the hydro schemes in the Tajik Pamirs, we notice that there are only one full-scale (Pamir 1) and one small (Khorog) power plant both supplying the main grid in Gorno Badakhshan. The remaining 51 hydro schemes fall into the range of mini (7) and micro (44) hydropower plants with an overall installed capacity of almost nine megawatts (see Picture 2.7). During the fieldtrip in 2003 34 existing MHPS and three planned projects in the districts of Ishkashim, Roshtkala, Rushan, Shugnan and Vanj were visited on site. Unfortunately the available database, consisting of own collected information and data received from MSDSP and PEC do not allow including all 51 micro and mini hydro schemes in this analysis. This chapter is therefore mainly based on the data of the 34 power plants the authors visited personally supplemented with information from other sources.

### 8.2.1 Implementation of Hydropower Projects

The Lenin power plant in Khorog was the first hydro scheme providing electricity to the population of Gorno Badakhshan in 1940[34]. Further efforts were made in the sixties and seventies to ensure sufficient electricity supply for this region with the installation of additional hydro and several diesel power plants. Under Soviet rule a total number of eight hydro schemes with an overall capacity of more than 15MW had been completed. After the collapse of the Soviet Union diesel provision stopped and consequently the operation of diesel plants, thus drastically reducing electricity supply[35] in GBAO. During the years of civil war (1992-1997) many infrastructures such as roads, transmission lines and hydropower plants had been destroyed or could no longer be properly maintained. As a consequence many villages in northern Badakhshan became disconnected from the Nurek Grid, which also formerly supplied parts of Darvaz, Vanj and even of the Rushan district (see Map 2.1). There was an urgent call for action to rehabilitate existing infrastructures and develop further sources of energy. The MSDSP thus started implementing micro and mini hydro schemes within the framework of humanitarian aid, completing the first MHPS in 1993. In addition villagers independently took the initiative to regain or improve electricity supply by installing micro hydropower plants. As a result more than 40 micro and mini hydro schemes were constructed during the past ten years.

Basically, four different types of implementing hydropower projects can be distinguished in Gorno Badakhshan:

*Projects implemented with external initiative*

1. Hydro schemes[36] constructed and financed under Soviet rule between 1940 and 1989: After the breakdown of the Soviet Union the existing energy infrastructure was first incorporated into the national energy department *Barki Tojik* and in 2002 into the newly founded

***Table 2.3:*** *Classification of Hydropower Plants into Four Levels of Size*

| Classification of Hydropower Plants | | |
|---|---|---|
| Full-scale | > 10MW | Full-scale hydro schemes produce more than 10MW of power supplying large towns and extensive grids with electricity. |
| Small | 3-10MW | Small hydropower plants make smaller contributions to national grid supply. |
| Mini | 300-3000kW | Mini hydro schemes provide power to small grids supplying rural communities or districts. |
| Micro | 0.2-300kW | Micro hydropower schemes are usually not connected to the national grid and supply independent mini-grids with electricity, sometimes providing only sufficient power for domestic lighting. |

*Source: Harvey (1993)*

33 Two of them (Barrushan and Poimazor) were still under construction.
34 The Lenin hydro scheme is no longer in operation.
35 The overall installed capacity of diesel generators in GBAO was about 27MW (Zibung 2002: 89).
36 These are Ak-Suu, Kalai-Khumb, Khorog, Lenin, Namadgut, Savnob, Shujand, Siponj and Vanj.


***Picture 2.7:*** *Hydropower schemes of different sizes in the Tajik Pamirs. (Photos: T. Hoeck, June 2003)*

private energy enterprise Pamir Energy Company based in Khorog. Two hydropower plants, Namadgut and Ak-Suu, were recently rehabilitated with support from the MSDSP and international donors, although still managed by the PEC.

2 a. Projects[37] initiated by the MSDSP, financed by international donors within the framework of humanitarian aid and handed over to the PEC for operation and maintenance.

2 b. Hydropower projects[38] initiated by the MSDSP, financed by international donors within the framework of humanitarian aid and then donated to the local communities: The village organizations are responsible for the scheme's management, maintenance and operation. Further financial investments or expenses for repairs have to be borne by the villagers themselves. Commonly the dwellers were only integrated into the project during construction helping on a "food for work" basis.

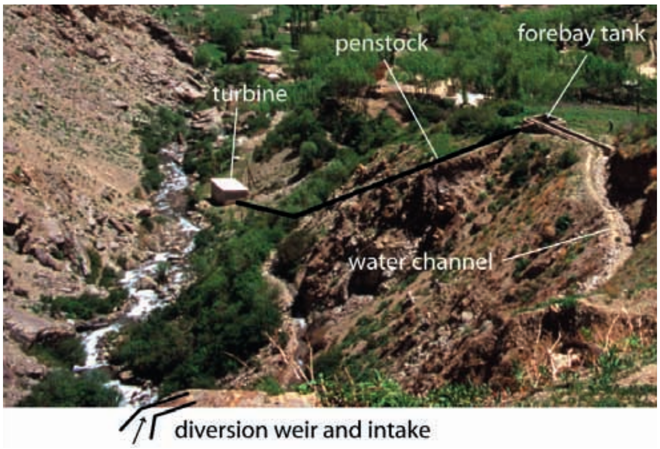
*Projects implemented with local initiative*

3. Hydropower projects[39] initiated by villagers and supported by the MSDSP and international donors: The common procedure is the following: Discussions in a meeting of the village organisation lead to the conclusion that the construction of an MHPS is an adequate option to improve electricity supply in the village. The decision is made to collect money or agricultural products from the households to launch the project. A specialist or engineer is hired for advice and a rudimentary feasibility study is performed. With the collected financial means the villagers purchase a second-hand turbine or generator. Usually it takes one or two years until sufficient money is gathered to buy the necessary equipment. Then a request is submitted to the MSDSP demanding support for the completion of the hydro scheme. If the project is accepted, construction material (timber, cement, transmission lines, poles) and further equipment (pipes) is provided. Labour is mostly paid by "food for work". The power plant's management, maintenance and operation is organized at the village level.
4. Projects[40] initiated and financed by the villagers without support from the MSDSP or donors: Shortly after the breakdown of electricity provision in the early nineties, many dwellers dreamed of regaining year round electricity supply through the construction of a MHPS. The possibility of purchasing or sometimes even receiving for free an old water pump or a generator from a diesel plant sold by Russian soldiers or former *kolkhoz* engineers, raised hopes of completing the project. Lack of financial means and donors usually postponed such projects for several years. The continuous collection of money or goods from the households finally enabled the villagers to obtain further equipment and materials to install the hydro scheme. Usually no electricity fees are demanded from the villagers because all customers contributed to the construction of the MHPS. These power plants consist of a patchwork of equipment, usually with low output capacity and providing merely sufficient electricity for lighting.

### 8.2.2 Equipment and Performance of MHPS

The hydropower plants in GBAO are so-called 'run-of-the-river schemes' (see Picture 2.8). In contrast to 'storage schemes' using a dam to retain the river flow and accumulate a reservoir of water, run-of-the-river schemes divert a part of the river flow into a channel and a forebay tank. From there, the water is released through a pipe (penstock) to the turbine. The disadvantage is the insufficiency of water storage to compensate for seasonal differences in water availability. The advantages of run-of-the-river schemes are that they can be built locally at low costs and that they do not affect the seasonal river flow patterns downstream (Harvey 1993). Snow and glacier melting and minimum precipitation in summer determine

[37] These are Andarbak in the Yazgulom valley and Tekharv in the Vanj valley.
[38] These are the hydro schemes in Langar, Pasor, Poimazor, Shipad, Vamar 2 and Yamchun.
[39] These are the power plants in Vezdara, Emts, Darjomch, Ajirkh, Roshorv, Basid, Yapshorv, Barchidev, Bardara, Barrushan, Deh, Pastkhuf and Vamd.
[40] These are Bajuv, Barmev, Chadud, Khidorjev1, Khidorjev 2, Pastbadjuv, Rijist and Vamar 1.




***Picture 2.8:*** *The MHPS in Vezdara as an example of a run-of-the-river scheme. (Photo: T. Hoeck, June 2003)*

the water regime in the Western Pamirs. Maximum water discharge is observed from June to August whereas in winter the tributaries' run-off is sometimes reduced to a mere trickle (Breu & Hurni 2003: 8-11). The arid climatic conditions and the topography of this mountainous region demand the transportation of water over long distances. This is why water channels sometimes run for several kilometres located at dizzying heights and in rocky faces (see Picture 2.9) ensure sufficient head[41] and perennial water supply. The hydropower plants are located at altitudes of 1750-3000m and deliver power dependent on their capacity to a few households, to entire villages or even small independent grids connecting up to 26 villages. Although many MHPS were constructed during recent years (1991-2003) and with support from international donors, they mainly consist of old Soviet equipment: Either second hand turbines[42] and generators were used to install a hydro scheme or old water pumps[43] - originally used for irrigation - and generators from former diesel plants were combined. There are even three MHPS with handmade turbines manufactured by engineers from Dushanbe and Khorog (see Figure 2.5 and Picture 2.10). The MHPS in Siponj and Savnob, for example, still run with Austrian equipment from 1951 and the hydro scheme in Tekharv with an English turbine from 1937. Even dynamos from trucks joined with a handmade water wheel are used to construct very small plants supplying only a couple of households with electric power. Not only do generator and turbine often not fit together in terms of rotational frequency and joint axle, but also the water discharge does not correspond to the penstock and turbine, or the forebay tank and head are inadequate to create sufficient pressure. This patchwork of equipment used for the installation of hydropower schemes demands special regular maintenance and repairs, reducing considerably efficiency and frequently causing long-term problems. Out of 34 inspected hydro schemes only one, exceptionally nice MHPS (in Emts) was operating with adequate and new equipment, good efficiency and reliable performance. The equipment of the micro hydro schemes is usually very basic: Turbine, generator, switchboard and manual water flow regulation. Occasionally an accumulator to start the generator, a flywheel to stabilize frequency or a half automatic flow regulation is installed.

***Picture 2.9:*** *Water channel in Barrushan located in a rock face some 130m above the power plant. Water channels are highly prone to be damaged by natural hazards. (Photo: T. Hoeck, July 2003)*

The use of centrifugal 'pumps as turbines' (PAT), as done at 17 MHPS in the Tajik Pamirs, could be an economic alternative to regular hydropower equipment. In many countries there are no manufacturers of water turbines but of pumps. Potential advantages of reverse pumps are therefore low cost due to mass production, local production, availability of spare parts and wider dealer or support networks. Furthermore, they are easy to install, and knowledge of pump maintenance is widespread. The disadvantages are lower typical efficiency, unknown wear characteristics, poor part-flow efficiency, fixed flow rate for a particular head and the fact that it is difficult to characterize the turbine's performance. Nonetheless, PAT can be applied to a wide range of heads and flows by switching between two or more units of different size (Harvey 1993: 182).

The majority of the MHPS provide perennial electricity supply to their customers (see Figure 2.6). Low water discharge in winter and insufficient water storage capacities for the Pamir 1 and Khorog hydropower plants considerably reduces the available electricity for the main grid. As a consequence most villages are disconnected from the grid during wintertime to ensure sufficient electricity supply for the capital of GBAO. Thus in villages which are not perennially provided with electric power

[41] The head is the vertical height through which the water drops (Harvey 1993: 4).
[42] Pelton and other types of vertical, horizontal, low-, mid- and high-pressure turbines are used.
[43] Reverse single and twin pumps.

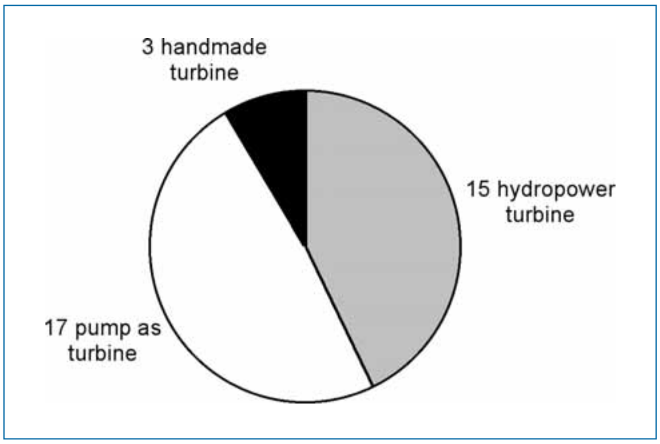



**Figure 2.5:** *Installed Hydropower Equipment in MHPS in GBAO. Out of 35 MHPS, 15 plants have regular turbines, three have handmade turbines and 17 schemes are operating with pumps as turbines. Source: Field study 2003*

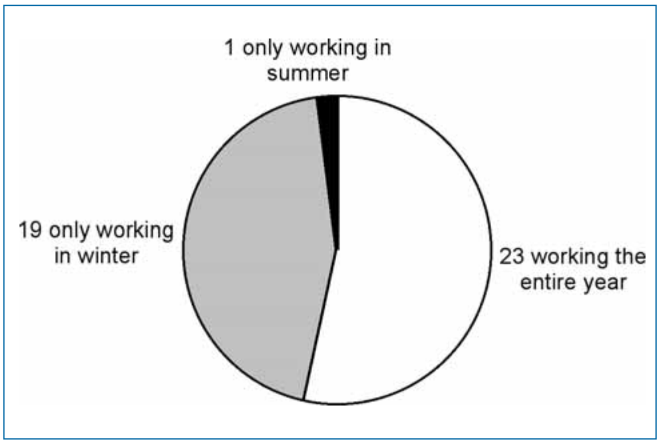


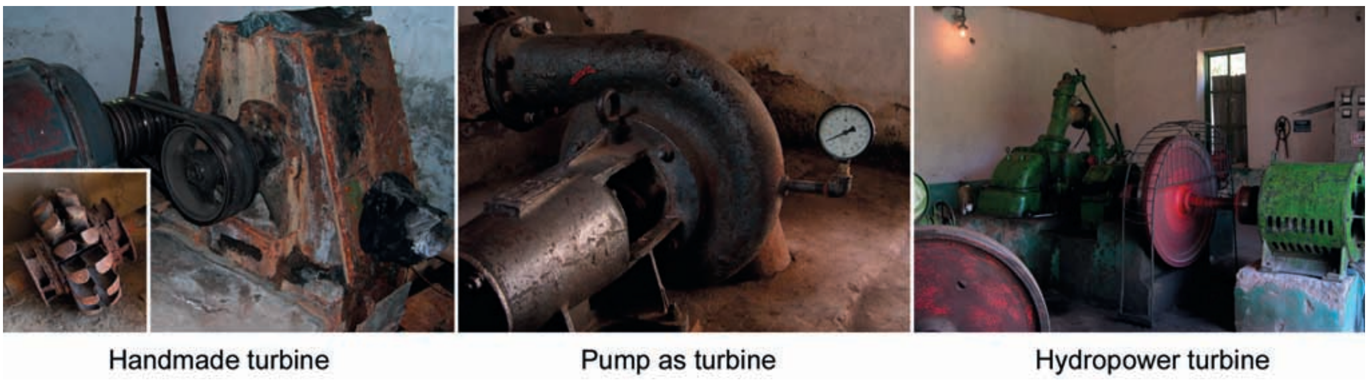

**Figure 2.6:** *The Operation Period of MHPS in GBAO. Not all MHPS are working throughout the year. The power plants constructed in villages connected to the main grid operate only in winter because the grid provides sufficient electricity during summer. Source: Field study 2003*

from the main grid, the MHPS fill the power supply gap during wintertime. As the provided capacity from the grid is usually better than the micro hydro scheme's output there is no need to run the MHPS during summer. A water shortage in summer can result in conflicts with competing water users. If the MHPS is provided with water from an irrigation channel, it cannot operate during periods when people water their croplands because top priority is commonly given to land cultivation. The hydro scheme in Deh is only operating in summer because run-off is severely reduced during winter months, making electricity generation impossible.

There are two main factors determining a hydro scheme's efficiency and performance: Insufficient water availability and inadequate and old equipment considerably reduce the maximum output of a hydro scheme. As seen in Figure 2.7, twelve out of 30 MHPS provide the declared output capacity, whereas the remaining 18 power plants operate far below the installed capacity. The MHPS in Yapshorv in the Bartang valley, for example provides not even 17% of the installed capacity due to a shortage of water discharge. It is not only the natural availability of water determined by climatic conditions that influence the scheme's efficiency. The way in which water is made available for the MHPS with the construction of diversion weir and intake, water channel and forebay tank is also important.

Sufficient and perennial water supply is not guaranteed for all hydropower sites. As a consequence of reduced run-off in winter the plant's output can decrease considerably. Output in winter can shrink to less than half of the output generated in summer (see Figure 2.8).

Depending on the hydro scheme's output and the number of customers supplied with electricity, the available capacity per household is sometimes only sufficient for domestic lighting. Some power plants generate higher output per customer, which enables people to use other electrical appliances such as TV, radios, cookers, ovens, and water kettles. Figure 2.9 shows the potentially and actually available watts per household for 34 MHPS. Assuming a lower limit of 1500W[44] per household




**Picture 2.10:** *The three different types of hydropower equipment installed in the hydro schemes in Gorno Badakhshan: A handmade turbine in Vamd, a pump as turbine in Vezdara and a regular hydropower turbine in Siponj. (Photos: T. Hoeck, June 2003)*

[44] The capacity of 1500W allows use of a few light bulbs (100W) and an electric coil cooker (1000W), electric oven (1300W) or electric water kettle (2500W).

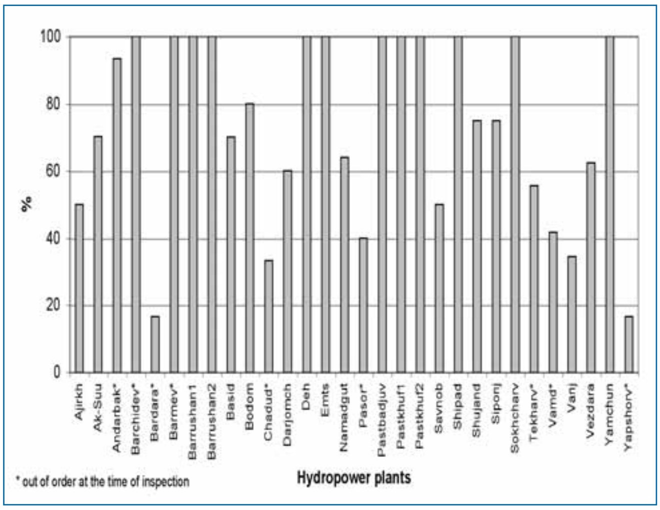



***Figure 2.7:*** *Maximum Output Capacity in Percentiles of Installed Capacity. Source: Field study 2003*

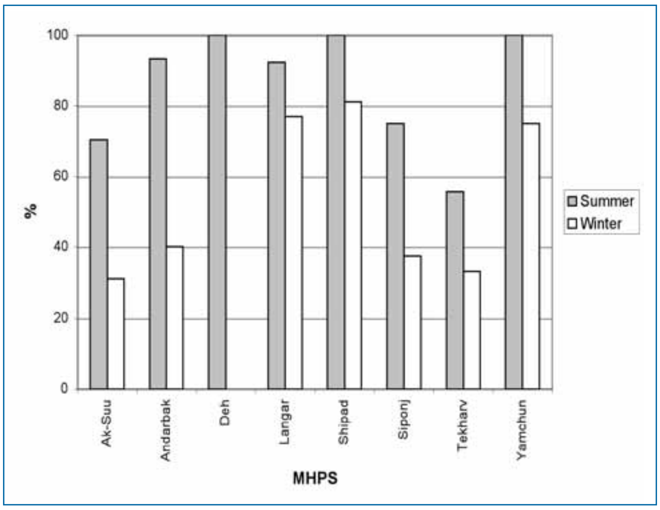



***Figure 2.8:*** *Seasonal Differences of Output Capacity in Percentiles of the Installed Capacity of Eight Selected MHPS. Source: Field study 2003*

to ensure the proper use of basic domestic appliances for lighting and preparing meals, only one power plant provides higher output. The majority of the hydro schemes generate capacities in the range of 120-950W per household. Even if all MHPS ran at full-capacity, most of them could not deliver a sufficient amount of electricity to the connected households.

In some villages measures have been taken to increase the capacity per household and allow people to use their electric appliances. The hydropower plant in Namadgut provides electricity according to a day and night schedule. During the daytime supply is limited to the capital of Ishkashim and at night electricity provision is extended to include seven neighbouring villages. In Andarbak and Langar the electricity distribution schedule follows a 24-hour term. The village of Langar is divided

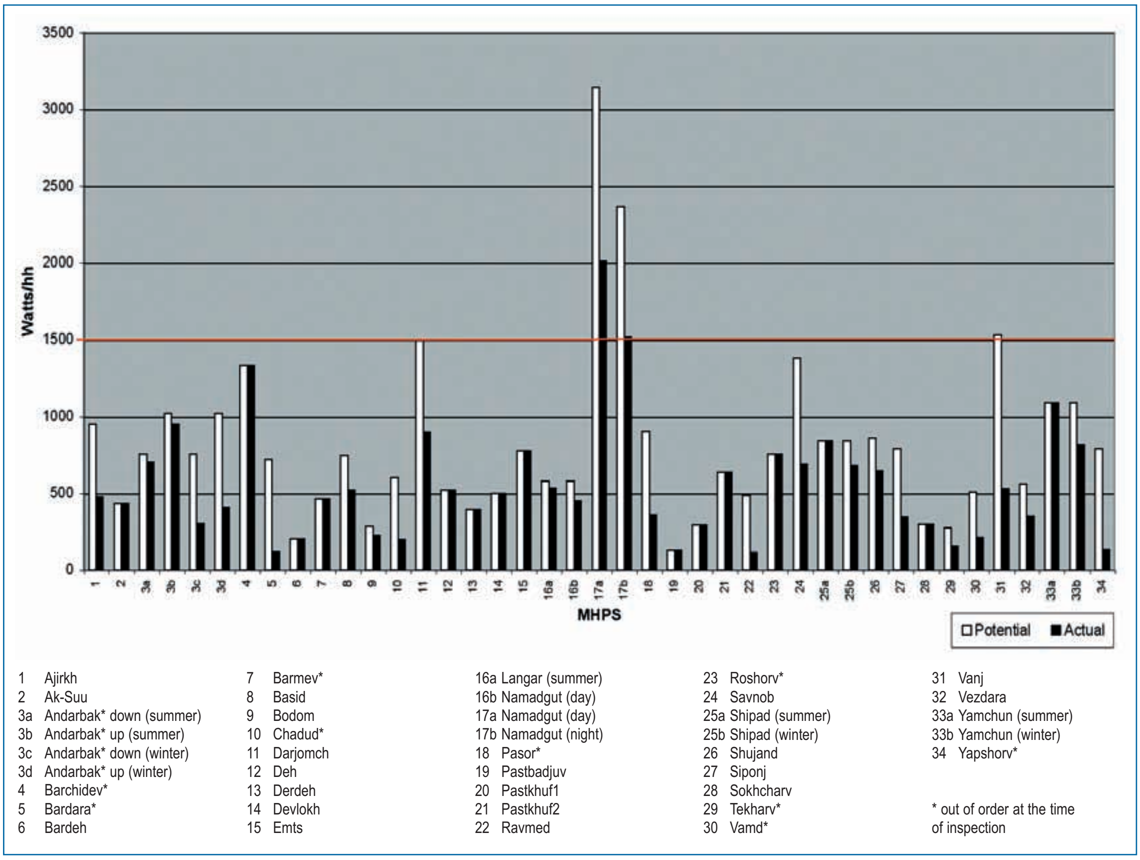



***Figure 2.9:*** *Potentially and Actually Available Power Capacity per Household for 34 MHPS. The potential capacity in watts is calculated on the basis of the installed capacity and number of customers connected to the power plant. The actual capacity in watts per household include the present output of the hydro scheme. Source: Field study 2003*

into two parts that are alternately supplied with electricity. Andarbak hydropower station provides electricity on one day to the down-line with four villages and on the next day to the up-line with three villages. With the use of a part-time power distribution schedule the available watts per household can be doubled. Commonly the hydropower plants provide power for households and public institutions and infrastructures. As seen in Figure 2.9, the available capacities are mostly only sufficient for lighting, TV and radio[45] but not for preparing meals and heating the accommodation. The bulk of the power generated by mini and micro hydro plants is for domestic purposes. There are only a few examples where the electricity is used for economic and income generating activities. In the village of Khidorjev the power plant supplies a garage and a small carpentry workshop with power in winter. Unfortunately the capacity is too low to additionally provide a small steel and tool workshop with electricity. In Barrushan welding services are offered and there are plans to establish a workshop to cut and polish stones. The hydro scheme in Vezdara supplies an electric saw with electricity during wintertime, and in Emts a public event room is connected. An electric saw that was also supplied from the power plant in Emts was disconnected due to lack of funds to pay the electricity bills. The district centres mostly have better electric power supply than the villages. Small enterprises or other economic activities use electricity to generate income.

The main reasons for the breakdown of a mini or micro hydropower plant in the Tajik Pamirs are old and inadequate equipment and lack of know-how on proper maintenance and repairs. Further natural hazards such as debris flows, rockfalls and avalanches destroy intakes or water channels, causing longer breakdown periods. Design faults or lack of funds and construction materials for proper installation of the MHPS cause slow damage to the equipment, resulting in regular down times and high maintenance costs. Ten out of 39 hydro schemes in GBAO were not operating due to damage at the time of inspection in June and July 2003 (see Table 2.4). The remaining 29 MHPS were running but only seven[46] were steadily generating power without major problems. In the Bartang valley where 15 hydropower plants are located, six were out of order in summer 2003. Particularly in remote villages such as in the upper Bartang valley[47], lack

***Picture 2.11:*** *Due to antiquated equipment and lack of know-how to perform repairs, the MHPS in Roshorv has not been operating since October 1998. (Photo: R. Droux, July 2003)*

***Table 2.4:*** *MHPS Out of Order in GBAO. Ten MHPS out of 39 were out of order at the time of inspection in June and July 2003. For more detailed information about the hydro schemes the reader is referred to the compilation of the visited MHPS in the Appendix 2.*

| | Village | Jamoat | District | Reasons for breakdown of the MHPS | Out of order since |
|---|---|---|---|---|---|
| 1 | Barmev | Tusyon | Roshtkala | Lack of construction material and financial means | April 2003 |
| 2 | Vamd | Barrushan | Rushan | Hand made equipment prone to damage (turbine will be replaced) | Mai 2003 |
| 3 | Pasor | Savnob | Rushan | Design fault (turbine and generator installed the wrong way). Lack of know-how to perform proper maintenance and repairs | Spring 2003 |
| 4 | Roshorv | Savnob | Rushan | Old equipment prone to damages. Lack of know-how to perform repairs (engineer left the village) | October 1998 |
| 5 | Barchidev | Savnob | Rushan | Old equipment prone to damages. Lack of know-how to perform repairs | July 2001 |
| 6 | Yapshorv | Savnob | Rushan | Old equipment prone to damages. Lack of know-how to perform repairs | July 2002 |
| 7 | Bardara | Basid | Rushan | Old and inadequate equipment prone to damage | April 2003 |
| 8 | Chadud | Basid | Rushan | Lack of construction material and financial means. Old and inadequate equipment prone to damages. Natural hazards destroyed intake of water channel | April 2003 |
| 9 | Andarbak | Yazgulom | Vanj | Design fault at intake (stones damaged turbine) | June 2003 |
| 10 | Tekharv | Tekharv | Vanj | Old equipment prone to damages. Natural hazards destroyed water channel | January 2003 |

*Source: Field study 2003*

45 Simultaneous use of five light bulbs (100W), TV and radio requires about 550W.
46 These are Vezdara, Shujand, Emts, Darjomch, Savnob, Vamar and Vanj.
47 Location of the MHPS of Roshorv, Pasor, Yapshorv and Barchidev.

of technical know-how for analysis of dysfunctions and problems can result in breakdowns lasting several years (see Picture 2.11).

### 8.2.3 Operation, Maintenance and Management of Hydropower Plants

The hydropower plants in GBAO are owned and managed either by Pamir Energy Company, by the village organizations or by private persons. In Yamchun the community hydro scheme is not operated by the owner but leased to a private person (AKF 2003).

The PEC trained local staff to run and maintain their micro and mini hydropower plants. Documentation for proper operation and maintenance is provided, and the employees are instructed to keep records of performed activities. Between two and ten workers are employed to operate an MHPS. Power plants supplying smaller grids such as in Vanj, Yazgulom and Ishkashim require between 16 and 54 workers to manage, operate and maintain the scheme as well as transmission lines and transformers. In case of severe equipment failure or the complete breakdown of the scheme the turbine or generator is transported to Khorog for analysis and repair at the PEC workshop (see Picture 2.12).

Community based MHPS installed with support from the MSDSP and international donors have a staff of one to seven workers responsible for operation and maintenance. Depending on the hydro scheme's size and operational periods, one or more workers are alternately on duty to supervise the machinery and regulate the water flow. Commonly the operators were briefly trained by engineers from the MSDSP on how to start and stop the power plant or how to read the control panel and handle the switchboard. But no further training at a later stage of operation was performed to refresh or upgrade skills. Very few MHPS keep records of performed maintenance or repairs, and instruction manuals are rarely available. Under the terms of the contract the power plant as well as all responsibilities were handed over to the village organisation. But no information was provided about where to find spare parts or whom to contact for technical advice or proper repairs. It is illusory to believe the MHPS could independently operate at the village level without further outside assistance. The installer of the hydro scheme (in many cases the MSDSP) should provide full operation and maintenance (O+M) documentation and information about sources of spare parts. Operation manuals, maintenance, repairs and further training, not to mention a logbook to record regular checks, are indispensable items to be delivered to the MHPS. More complex jobs must be done by the manufacturer or an engineer. Hence the staff should receive detailed instructions on level of responsibility and when to call for external assistance (Harvey 1993: 310).

**Picture 2.12:** *In case of severe equipment failure or complete breakdown of hydro schemes managed by the PEC, the turbine or generator is transported to Khorog for repair. (Photo: R. Droux, July 2003)*

Private micro hydropower plants are commonly installed, operated and maintained by the owner. As there are usually no regular fees demanded from the customers, maintenance costs or repairs are financed by contributions from beneficiaries when necessary. The installer of the scheme usually has the required technical know-how to maintain and repair the hydropower plant.

Operation and maintenance of a hydropower plant requires monthly expenses for salaries, spare parts and lubricants. Employees at the micro and mini hydro schemes managed by the PEC receive the highest salaries, between 50-100 *somoni* (USD 16-32), while community-based MHPS pay monthly wages of 5-30 *somoni* (USD 1.60-9.50). In a few cases the workers receive no regular salaries. Costs for lubricants and spare parts are difficult to estimate, with few operators able to deliver concrete figures for these costs. The informants in Basid, Bardara, Pastbadjuv and Vamar cited monthly expenses of 50-70 *somoni* (USD 16-22)

The electricity fees are the only regular source of income to finance the hydro scheme's operation, maintenance and repair of the hydro scheme. There are four different ways of calculating the fees:

*1. PEC tariff setting*

Pamir Energy Company defined electricity fees on the kWh basis in dollars, charging higher rates in wintertime and for consumptions beyond a certain limit. The fees are converted into the national currency (*somoni*) on the basis of the current exchange rate (see Table 2.5). According to the PEC the meters installed in the households during Soviet rule do not work properly. A meter located at the MHPS is thus calculating the village's electricity consumption. Overall use is divided evenly among all customers with no computation of individual differences in consumption. On the average, depending on overall use of power and seasonal demand, a household pays 2-6 *somoni* (USD 0.63-1.90) per month for electricity from the MHPS.

***Table 2.5:*** *Fees for Electricity Provided by the PEC in 2003*

| | | | | |
|---|---|---|---|---|
| **Winter** | Cost/kWh up to 200kWh/month[48] | | Cost/kWh over 200kWh/month | |
| | 0.25 USD cents | 0.773 *diram* | 0.75 USD cents | 2.319 *diram* |
| **Summer** | Cost/kWh up to 50kWh/month | | Cost/kWh over 50kWh/month | |
| | 0.25 USD cents | 0.773 *diram* | 0.54 USD cents | 1.669 *diram* |

*Source: PEC 2003*

*2. Tariffs according to the meter*
Four MHPS managed at the village level assess individual power consumption by calculating the electricity bills according to the meter installed in each household. The village of Emts uses the fees from the PEC for billing. Vamar, Deh and Shipad use their own prices per kWh. The cost per kilowatt-hour varies between 0.3-0.5 *diram* (USD cents 0.01-0.15) resulting in monthly expenses of 0.2-8 *somoni* (USD 0.06-2.55) per customer. The bills are usually paid in cash, although agricultural products such as eggs or flour are also accepted as a payment. Revenue from the electricity fees is usually sufficient to ensure operation and regular maintenance.

*3. Flat rate tariff setting*
In most villages a monthly flat rate is charged for electricity supply. Depending on the hydro scheme's performance and output the fees range between 0.2-6 *somoni* (USD 0.06-1.90) per household. Instead of being fixed, the fees are adapted either to the power plant's output or to the maintenance costs incurred. In Bardeh, for example the monthly flat rate was first set at 13 *somoni* (USD 4.10) per customer to ensure the hydro scheme's amortization, and then was reduced to the present fee of three *somoni* (USD 0.95). In Vezdara the dwellers initially paid 1.5 *somoni* (USD 0.50) per month, which was not sufficient to finance some larger repairs, so that the fees were increased to 2.5 *somoni* (USD 0.80). When customers do not have sufficient financial means to pay their electricity bills, they can also deliver agricultural products such as vegetables, flour, potatoes, eggs, wheat or tobacco. Usually the income from the fees is only sufficient to cover regular maintenance costs. In case of a severe breakdown or damage of equipment demanding further investment a request is submitted to the MSDSP for advice and support. If no assistance is granted, additional money or other goods have to be collected from the customers.

*4. Electricity free of charge*
Four hydropower plants[49] provide free electricity to their customers. These micro hydro schemes were mostly constructed without external assistance and only deliver sufficient power for lighting purposes. The operator of the MHPS receives no regular salary. Occasionally households provide him with agricultural products dependent on his workload. If there is a need for further investment, money is collected from all the customers.

Usually the electricity fees are too low to guarantee long-term operation of the power plant. Income is sufficient to finance operation and maintenance but not to cope with a severe breakdown of the scheme. Under the terms of the contract, all responsibility for operation and maintenance lies with the owner (village organization) of the power plant. Thus the MSDSP has no program to further assist hydropower projects. However if technical and financial assistance is needed, the first address to contact is usually the MSDSP due to lack of alternatives. To be independent from external support, which is not reliable or even not at all granted, some VO have established additional sources of income for the MHPS. In Vezdara farming animals have been donated to the hydro scheme and kept as livestock. Sheep, goats and cows can be sold at the market if there is a need for further financial investment (see Chapter 8.2.7). In Barrushan there are plans to establish a vegetable garden and fruit tree orchard on the surroundings of the power plant. Thus money can be stocked by selling harvest or even products like fruit jam. Few power plants have sufficient net returns to stock money for future investments. In Emts and Yamchun the allocated money is used to provide small loans to local borrowers or credits to young people who want to leave for Russia. This might be a reasonable way to reinvest the financial means. However in Yamchun several borrowers were not able to repay their loans (AKF 2003).

### 8.2.4 Most Common Problems of Hydropower Plants

The majority of the hydro schemes faces severe long-term problems making an efficient operation and satisfactory performance impossible and considerably increasing maintenance costs. The operator of the MHPS has to cope with harsh climatic conditions, technical faults in equipment and infrastructure, and difficult conditions for proper maintenance. A compilation of the most common problems and constraints of hydro schemes is listed below.

48 The tariffs are reduced due to a lifeline tariff block of 200kWh in winter and 50kWh in summer.
49 These are Khidorjev 1, Khidorjev 2, Rijist and Chadud.

**Picture 2.13:** *Melting snow and freezing water in combination with the engine vibration cause damage to the building and equipment. (Photo: T. Hoeck, June 2003)*

*Climatic conditions and natural hazards*

- Melting snow and freezing water damage the building's floor and walls, the water channel, forebay tank and pipes (see Picture 2.13).
- Natural hazards like floods, avalanches, debris flows and rockfalls destroy diversion weir and intake, water channel, forebay tank or the building.
- Insufficient water availability does not allow operation of the MHPS at full capacity.
- Seasonal differences in water discharge results in reduced power capacity in wintertime.

*Equipment and infrastructure*

- There are insufficient financial means and construction materials for proper installation of the MHPS. Often the water channel is not cemented, the turbine and generator are not accurately fixed to the ground or there is no building covering the hydropower equipment, so that it is exposed to the harsh climatic conditions.
- The turbine and generator are not properly fixed to the ground, so that vibration causes damage to axles and bearings.
- The turbine and generator are not perfectly in line. Hence axles and bearings do not turn smoothly harming the equipment.
- Inadequate equipment is used for installation of the MHPS. The pipes are too big or the forebay tank is too small to generate sufficient pressure with the available low run-off. The generator and turbine do not match each other in terms of rotational frequency and capacity. The water discharge does not match the turbine's demand for water. The transmission lines are unable to sustain the high voltage generated by the power plant.
- Old equipment prone to damage is used for the installation of the MHPS (see Picture 2.14): Mostly equipment from Soviet times, either hydropower units or former water pumps and generators from diesel power plants, is used, demanding painstaking and costly maintenance.
- Handmade processed equipment (e.g. handmade turbine) is prone to damages.
- Current fluctuations caused by manual flow regulation and lack of equipment (e.g. flywheel) for stabilizing it.
- Lack of transformers to stabilize current over longer distances.
- Outbreaks from water channels and forebay tanks cause erosion and reduce water supply (see Picture 2.15).
- Design faults increase maintenance costs and decrease efficiency: Turbine and generator are installed the wrong way. Diversion weir and intake are not adequately designed to prevent stones from entering pipes and turbines, regularly causing severe damage.

*Maintenance and operation*

- Large sediment loads accumulate in the forebay tank or water channel, requiring frequent cleaning.

**Picture 2.14:** *The MHPS in Rijist is a patchwork of old equipment (water pump, truck axis and generator), and is not even fixed on the ground. (Photo: T. Hoeck, June 2003)*

**Picture 2.15:** *Water channel and leaking forebay tanks cause erosion and reduce water supply for the hydro scheme. (Photo: T. Hoeck, June 2003)*

**Picture 2.16:** *Spare parts are usually not available, so that old equipment is dismantled and adapted to replace the missing parts. (Photo: T. Hoeck, July 2003)*

- Defective switchboards or control panels prevent proper flow regulation and surveillance of the hydro scheme's performance.
- Lack of maintenance materials and equipment (e.g. welding tools) to perform repairs. When the MHPS is out of order electricity is not available for using a welding tool to repair it, so that the defective part has to be transported to a site with better equipment.
- Spare parts are usually not available locally but can only be found in Khorog or Dushanbe, thus increasing the costs for repairs and prolonging the hydropower plant's down time (see Picture 2.16).
- Lack of know-how on proper maintenance and operation causes damage on equipment and short circuits.
- Lack of know-how and funds to perform repairs result in long breakdown times. Income from electricity fees is inadequate to stock sufficient financial means for expensive repairs.
- Conflicts about scarce water resources with other water users (irrigation or milling) results in frequent down times (e.g. no electricity during daytime in summer), because hydropower usually does not have first priority to meet its demands for water.

### 8.2.5 Financial Evaluation of Micro and Mini Hydropower

Financial analysis of micro and mini hydropower in GBAO is performed according to Harvey (1993). There are three useful key indicators for a financial evaluation, which are discussed in this chapter:

1. Economy of scale: Shows where hydro schemes' costs (per installed kW) are situated in comparison with other small and large scale hydropower plants.
2. Plant factor: Represents the number of customers connected and their power consumption as well as the hydro schemes performance. The plant factor is a quick assessment on whether or not a hydro scheme is likely to be successful.
3. Unit energy cost: Express as the costs per kWh considering return and maintenance costs. Comparing the unit energy costs is one way of assessing the viability of a hydro scheme.

The plant factor and the unit energy cost are useful indicators for cost benefit analysis and financial evaluation of a power plant. They can easily be calculated in a very early stage of planning, making it possible to predict the financial viability of a hydropower plant already in the prefeasibility phase. Furthermore they can be used to compare micro and mini hydro schemes with alternative power sources like diesel plants or grid extension (Harvey 1993: 305).

Financial evaluation is based on data collected during the field study in 2003 and on data received from the MSDSP. Generally it was difficult to obtain the requested financial data so that most of the figures concerning operation and maintenance are rough estimates made by the operators themselves. In other cases the responsible person were unable to provide any financial figures at all. Further it has to be considered that the figures often do not represent the full costs: There is commonly a lot of unpaid work or barter payment that is not reflected in the financial data.

#### *Economy of Scale of Micro and Mini Hydropower*

The economy of scale is expressed as the overall costs or capital costs[50] in USD needed for the installation of the scheme, divided by the installed capacity in kW. This ratio serves as an indicator to compare small hydro schemes of different sizes and gives an overview about the range of capital costs for the installation of a hydropower plant in GBAO. Between USD 83-1251/kW were needed to install a hydro scheme in the Tajik Pamirs. These big variations in capital costs per kW can be explained by the type of project implementation. Hydropower projects initiated and totally financed by the villagers themselves using second hand equipment and performing only a basic installation have very low capital costs. In addition, the construction is accomplished with considerable volunteer work and non-financial contributions in the form of agricultural products. It is therefore difficult to estimate the real capital costs for these projects. Projects implemented with local initiative and with support from the MSDSP and international donors have

[50] The capital costs include all expenses needed for the completion of the hydropower project, such as expenses for the feasibility study, project design, construction materials and labor.

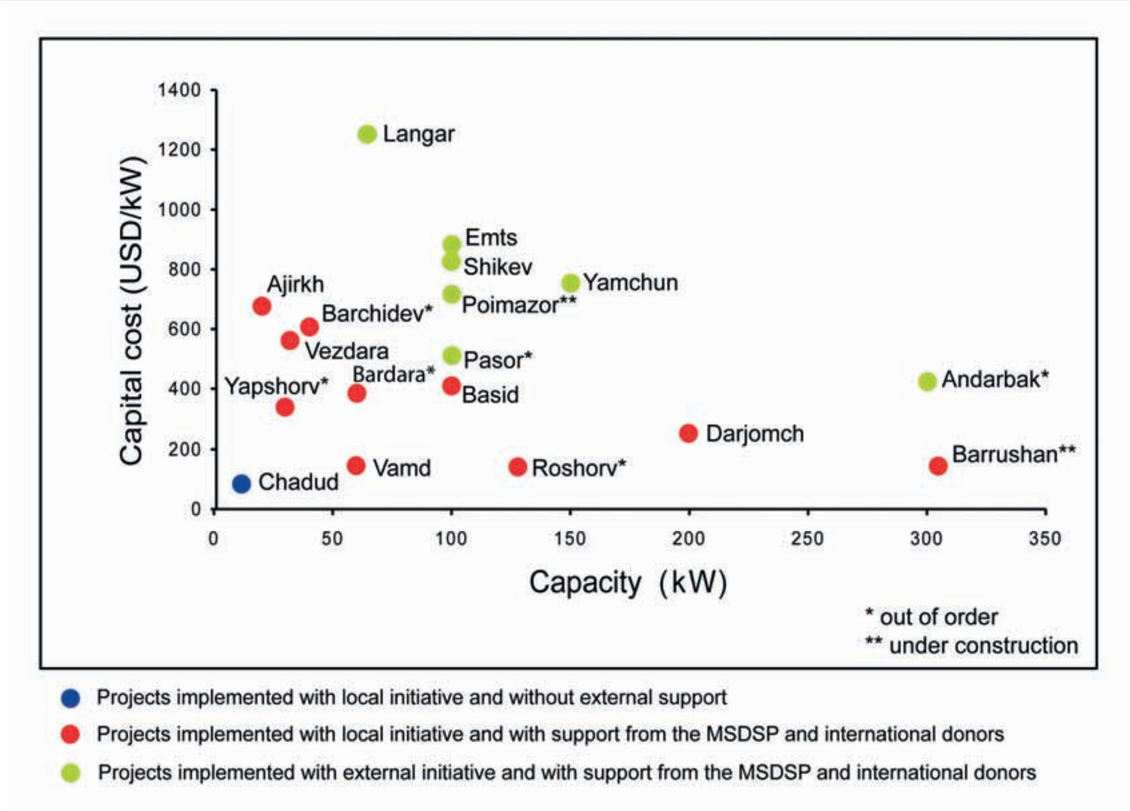



***Figure 2.10:*** *Economy of Scale of the MHPS in the Tajik Pamirs. Source: Field study 2003 and MSDSP (2002)*

more financial means at their disposal. The common procedure is that villagers first gather money to buy the turbine and generator, hire an expert for a rudimentary feasibility study and then make a request to the MSDSP for further support with construction materials (e.g. cement and wood) and equipment (e.g. pipes). As seen in Figure 2.10, projects implemented with external initiative cause highest capital costs per kW. This can be explained with the fact that the whole project has to be financed, including costs for a complete project design, feasibility study, better hydropower equipment and the proper construction of the building, water channel, diversion weir and intake even if the installed capacity is small.

The comparison of the hydro schemes in the Tajik Pamirs with the common band of capital costs for micro and mini hydropower mentioned in Harvey (1993) shows that most of them were constructed with a really low budget (see Figure 2.11).

***Plant Factor***

The plant factor is a practical indicator for the financial viability of a hydro scheme. It is the ratio between energy used and energy available, but also considers the hydro scheme's down-times and seasonal differences in power generation. The plant factor is calculated according to the formula below:

Plant factor (PF) = (power used x time power used) / (power installed x period considered)

For power plants not operating during several months annually, giving different outputs in summer and winter or providing electricity according to different seasonal schedules, the plant factor is correspondingly adjusted.[51] A low plant factor implies costly power and a higher plant factor indicates a better hydro scheme. Following Harvey (1993: 8) an economically viable power plant has a plant factor over 0.4 in the first year of operation and over 0.6 from the second year on. Figure 2.12 shows the plant factors calculated for 23 MHPS in the Tajik Pamirs. Only two of them achieve factors higher than the lower limit of 0.6 for economic viable hydro schemes. Most MHPS are not able to provide sufficient electricity to meet the village's demand. Hence a low plant factor is here not an indicator for lack of demand for electric power but for equipment failures and long non-operational periods. Low output compared to installed capacity, poor efficiency due to old and inadequate equipment, lack of water discharge and seasonal differences in water availability, electricity supply from the grid during summertime, conflicts with other water users or regular down-times to perform repairs considerably reduce the plant factors of the hydro schemes in GBAO.

51 To give an example: For the MHPS in Vezdara the plant factor is calculated as follows: PF = (20kW x 18h) / (32kW x 24h) = 0.469. Since the hydro scheme is not operating during winter months, the PF is adjusted to 8/12 x 0.469 = 0.313.

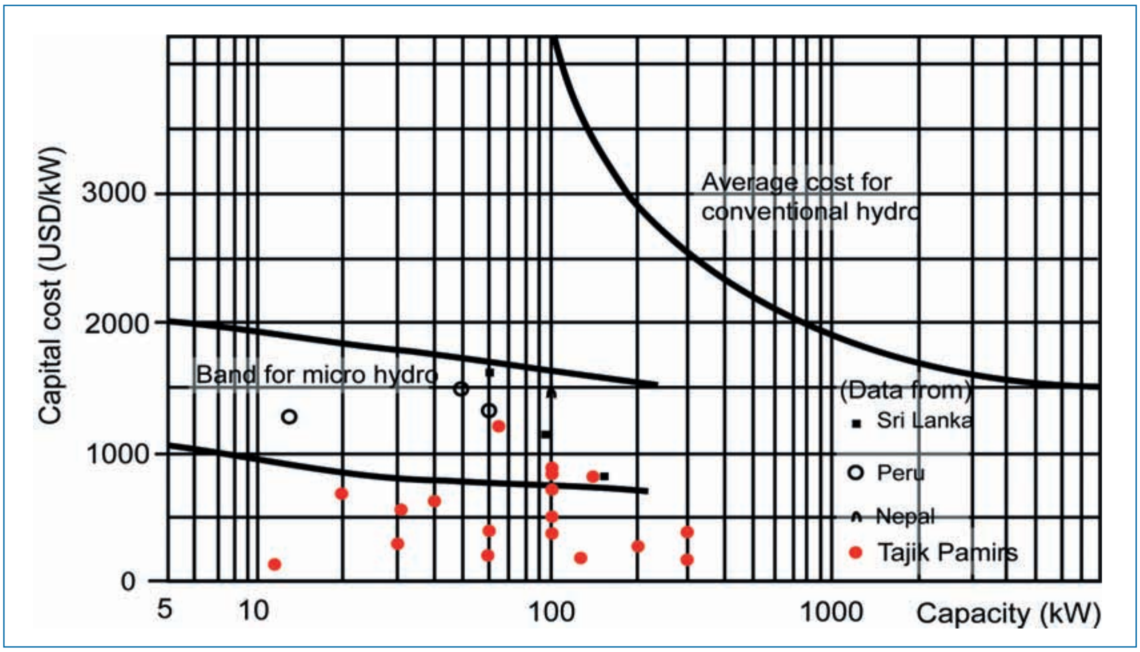



***Figure 2.11:*** *Economy of Scale of Micro and Mini Hydropower Compared to Other Small-Scale Hydropower Plants. The figure was redrawn from Harvey (1993: 3) and supplemented with data from the MHPS in the Tajik Pamirs. Source: Field study 2003 and MSDSP (2002)*

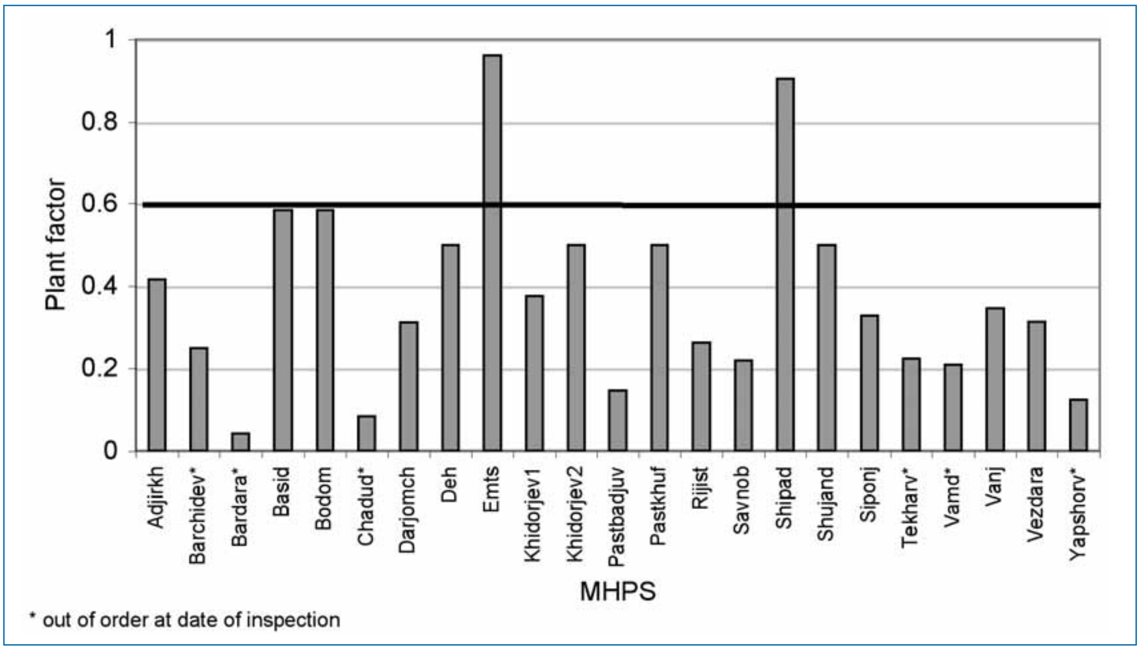



***Figure 2.12:*** *Plant Factor Calculated for 23 Hydropower Stations in the Tajik Pamirs. Source: Field study 2003*

There is a simple rule to be followed when constructing a hydropower plant: "Design for the highest possible plant factor!" Harvey (1993: 8).

***Unit Energy Cost***

It is important to know if power generated with an MHPS is cheaper or more expensive than electricity produced in other ways (from the grid or other power plants). The unit energy cost (UEC) expressed as USD/kWh serves as a helpful indicator to assess the hydro scheme's competitiveness. The UEC is the lower limit in setting the electricity fees needed to cover return and maintenance costs. The unit energy cost is defined as follows:

$$UEC = \frac{\text{annual cost + operation + maintenance cost}}{\text{capacity installed x hours used in a year x plant factor}} = \frac{C_{annual} + (O + M)}{P_{installed} \times h \times PF}$$

***Table 2.6:*** *Five Variants for the Calculation of the UEC Assuming Different Ways of Financing and Different Degrees of Performance.*

| | |
|---|---|
| **Variant A** | Represents the present situation of the community-based MHPS. The only expenses which have to be covered are the costs for O+M. The costs for the installation of the scheme were donated so that no loan repayment has to be performed. In variant A the UEC were calculated while only considering O+M costs and the hydro scheme's present performance. |
| **Variant B** | Assuming that the costs for the installation of the scheme are not donated, but have to be annually repaid over a period of 15 years, the MHPS has to generate more income from the tariffs to also cover the expenses for the loan repayment. In variant B the UEC were calculated based on the present O+M costs, the annual loan repayment of the capital costs and the hydro scheme's present performance. |
| **Variant C** | In addition to variant B, annual O+M costs are assumed to be 2% of the original installation cost as recommended by Harvey (1993). Thus in variant C the UEC were calculated considering O+M costs as 2% of the capital costs, the annual loan repayment of the installation costs and the hydro scheme's present performance. |
| **Variant D** | Since most MHPS have a very low plant factor, representing the scheme's performance and operational period, the tariffs have to be set rather high to ensure a cost-effective operation. Assuming the MHPS to have an economically viable plant factor of 0.6 and an operational period of 18 hours daily or 6750 hours annually, the UEC can be considerably reduced. In variant D the UEC were calculated considering O+M costs as 2% of the capital costs and an assumed reasonable performance of the scheme with a plant factor of 0.6 and an operational period of 18 hours daily. |
| **Variant E** | In addition to variant D the loan repayment is alsol included into the calculation. In variant E the UEC were calculated considering O+M costs as 2% of the capital costs, the annual loan repayment of the installation costs and an assumed reasonable performance of the hydro scheme with a plant factor of 0.6 and an operational period of 18 hours daily. |

*Source: The variants were created based on an example given in Harvey (1993).*

The annual cost in the UEC-formula represents the original capital cost needed for the installation of the scheme expressed as a constant annual sum for loan repayment over the plant's lifetime, considering the real discount rate.

Table 2.7 and Figure 2.13 show the unit energy costs calculated for five selected hydropower plants assuming five different variants (see Table 2.6) of financing and performance of the scheme.

Considering that hydropower projects in GBAO implemented with support from the MSDSP and international donors do not have to repay their capital costs but only have to bear the costs for operation and maintenance (O+M), the UEC for these hydro schemes are usually very low, around USD 0.001-0.002/kWh (see Table 2.7, variant A). Power plants with very low plant factors (e.g. Bardara) or short operational periods (e.g. Vezdara) generate more expensive electricity (five times or even 60 times higher costs per kWh). A comparison of the UEC of five selected MHPS with power from the main grid, which costs between USD 0.0025-0.0075/kWh, shows that micro and mini hydropower plants can be an economic alternative to grid extensions (see Figure 2.13 and Table 2.7, variant A and D).

The picture looks different if the power plants have not been financed by international donors but are to be installed on credit with expectations of loan repayment (see Table 2.6, variant B, C and E). In this case the UEC are calculated while considering the original capital costs expressed as a constant annual sum throughout the life of the project using the annuity equation[52]. Additionally the following assumptions are made according to an example from Harvey (1993: 310):

1. Annual operation and maintenance (O+M) costs equal about 2% of the capital costs (the present annual O+M costs for the MHPS in GBAO range between 0.2% and 1.7% of the capital costs).
2. The power plant is assumed to have a 15-year life.
3. The plant factor has been calculated according to the hydro scheme's present performance.
4. The real discount rate is set at 12%.

Including annual loan repayment over a period of 15 years and O+M costs as 2% of the capital costs in the calculation of the UEC results in an increase by a factor

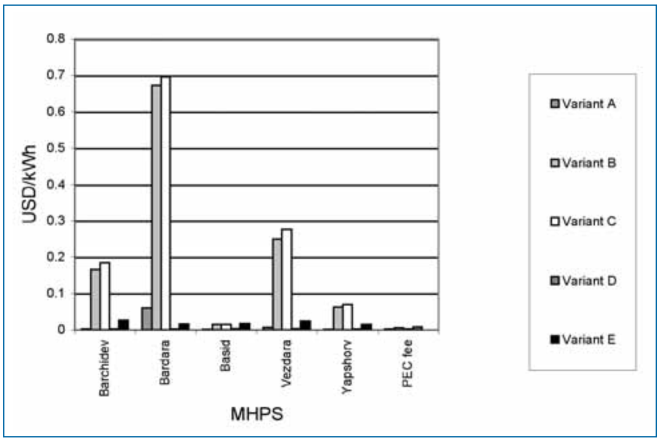



***Figure 2.13:*** *Unit Energy Cost Calculated for Five Selected MHPS in the Tajik Pamirs. The UEC are shown in comparison with the present electricity fees demanded by the PEC. Source: Field study 2003; PEC 2003*

52 $A = C_{annual} = C \times \{ r (1 + r)^n \} / \{ r (1 + r)^n - 1 \}$ with C = capital costs, n = years, r = real discount rate.

***Table 2.7:*** *Unit Energy Costs Calculated for Five Selected Hydropower Plants in 2003.*

| | A | B | C | D | E |
|---|---|---|---|---|---|
| | UEC (USD/kWh) with present O+M costs | UEC (USD/kWh) with $C_{annual}$ and present O+M costs | UEC (USD/kWh) with $C_{annual}$ and O+M costs 2% of C | UEC (USD/kWh) with O+M costs 2% of C, PF=0.6 and 6570 hours | UEC (USD/kWh) with $C_{annual}$, O+M costs 2% of C, PF=0.6 and 6570 hours |
| Vezdara | 0.0070 | 0.250 | 0.276 | 0.0029 | 0.024 |
| Basid | 0.0015 | 0.014 | 0.015 | 0.0021 | 0.017 |
| Barchidev | 0.0021 | 0.165 | 0.185 | 0.0031 | 0.026 |
| Bardara | 0.0598 | 0.673 | 0.696 | 0.0019 | 0.016 |
| Yapshorv | 0.0012 | 0.062 | 0.069 | 0.0017 | 0.014 |
| PEC tariff setting[53] | Summer: Up to 50 kWh/month: USD 0.0025/kWh, over 50 kWh/month: USD 0.0054/kWh<br>Winter: Up to 200 kWh/month: USD 0.0025/kWh, over 200 kWh/month: USD 0.0075/kWh | | | | |

*Source: Field study 2003*

***Table 2.8:*** *Annual Expenses for O+M and Loan Repayment for Five Selected Hydropower Plants According to the Assumptions Made in Variant A, B and C.*

| | A | B | C | | |
|---|---|---|---|---|---|
| | Present annual O+M costs (USD) | $C_{annual}$ and present annual O+M costs (USD) | $C_{annual}$ and annual O+M costs 2% of C (USD) | Present annual income from fees (USD) | Annual O+M costs 2% of C (USD) |
| Vezdara | 76 | 2722 | 3006 | 533 | 360 |
| Basid | 686 | 6712 | 6846 | 1021 | 820 |
| Barchidev | 46 | 3614 | 4054 | 58 | 486 |
| Bardara | 330 | 3714 | 3844 | 111 | 460 |
| Yapshorv | 29 | 1524 | 1698 | 29 | 203 |

*Source: Field study 2003*

of 10-88 to USD 0.015-0.696/kWh, which is too high to be afforded by local customers (see Table 2.7, variant C). If it were possible to improve the power plant's performance achieving a satisfactory plant factor of 0.6 and a reasonable operation period of 18 hours daily, the UEC would be situated within the range of USD 0.014-0.026/kWh (see Table 2.7, variant E), still 10 times the amount that is presently demanded by the PEC for electricity. If an MHPS achieving an economic viable plant factor and steady operation can be constructed with support from donors covering the start-up-costs, the unit energy costs would lie below the present PEC fees and thus would be affordable for almost all customers (see Figure 2.13 and Table 2.7, variant D). Hence a good micro or mini hydro scheme is certainly a viable alternative to expensive grid extensions[54] into remote areas.

A closer look at the actual annual expenses required to operate the MHPS and their potential increase due to loan repayments confirms the picture drawn by the UEC calculations (see Table 2.8). Annual expenses for operation and loan repayment would be about 10 to 60 times higher than the present O+M costs (see Table 2.8, compare columns A, B and C). A monthly electricity consumption of USD 3.5-12.5 per customer[55] would be needed to finance the hydro scheme without contributions from donors. Considering that the regular incomes are in the range of USD 2-10 per month, or even lower in very remote villages, leads to the conclusion that an independent financing of a proper hydropower plant is not likely to be possible. Hence donated capital costs or other sources of income are a precondition to guarantee a long-term operation of a hydro scheme at the village level.

The estimation made in Chapter 11.14 for a single household's electricity demand to cover the energy needs for preparing meals, lighting, TV and radio, gives a guideline of about 315 kWh[56] per month. Assuming sev-

53 The PEC will steadily increase electricity fees to USD 0.03/kWh till 2010 and subsidies on lifeline tariffs will cease.

54 Grid extensions, for example into rural regions in Zambia and Ethiopia, cost USD 79,000 and 57,250 per km. To lay high-tension transmission lines and associated gears demands exorbitant investment. In Eritrea the extension of medium (15kV) and low (400V) voltage lines costs around USD 7000-8000 per km, while the cost of transformers and accessories lies between USD 3000-5000 per village, depending on its size (Habtetsion and Tsighe 2001).

55 Considering higher installation costs for better hydro schemes, these figures can easily double.

56 The PEC data for monthly electricity consumption for all income groups varies between 265kWh and 361kWh (ZERKALO 2000: 3).

en *somoni* (USD 2.20), representing the monthly salary of a nurse or the pension of a retiree, to be an affordable amount to spend on electricity results in a UEC or electricity fee of USD 0.0074/kWh. These costs lie in the upper range of the fees presently demanded by the Pamir Energy Company. Future hydropower projects should be designed while considering these types of calculations to ensure an economically viable power plant, a precondition for lasting operation.

Thus it can be concluded that a community-based hydro scheme in GBAO, which shall provide sufficient electric power at affordable prices to the dwellers of a village, cannot be independently financed by the community, but only with external financial support. Given that the capital costs for the installation of the MHPS are borne by donors, the hydro scheme will be able to generate sufficient income from the electricity fees to cover the costs for operation and maintenance, even considering the population's limited ability to pay.

### 8.2.6 Savnob Micro Hydropower Station

The MHPS in Savnob (Rushan district) is an example of a hydro scheme implemented with external initiative during Soviet time and presently managed by the private energy company PEC. The power plant was completed in 1989 after 1.5 years of construction work and served as an alternative to the already existing diesel power plants[57] in the village. Since the collapse of the Soviet Union it is the only source of electricity for Savnob perennially supplying all households (in 2003: 54 households) and public infrastructures (*hukumat*[58], local hospital, secondary school) with power.

The hydro scheme is equipped with a 50Hz generator (Siemens-Schuckert, Wien 1951) and an 80kW horizontal turbine (VOITH, St. Poelten 1951) from Austria (see Picture 2.17). A flywheel located between the turbine and generator evens out fluctuations in the rotational frequency. Although the power plant runs on very old equipment, no repairs had to be conducted during the last 14 years. Water is diverted from the irrigation channel and led into a very small forebay tank (see Picture 2.18) from where it is released through a 300m long pipe to the turbine. There is only one spring in the village providing water for irrigation, domestic purposes and for the MHPS. Water supply is not adequate to generate sufficient pressure for the 80kW turbine, so that the output capacity is limited to 50%. From May till September, when the croplands need to be irrigated, water is not available for electricity generation. Therefore the hydro scheme's operational period is limited from late afternoon till midnight (17-24h). In wintertime power is provided according to a 14-hour-schedule (5-12h and 17-24h). The MHPS provides each household with an average capacity of 690 W, which is not sufficient for the proper use of electrical cooking appliances.

Two local workers are responsible for the power plant's operation and maintenance. They change shifts every three days and receive a monthly salary of 55 somoni (USD 17.50) from their employer Pamir Energy Company. Technical support and spare parts are available at the PEC head office in Khorog. The electricity bills are calculated according to the meter installed at the MHPS calculating the overall use of the village. As a consequence individual differences in power consumption cannot be considered. In April 2003 each customer received a bill of over 3.46 somoni (USD 1.10) for 234kWh.

The hydro scheme has been operating steadily without major problems since its installation. The only problematic issue is the insufficiency of water supply and

**Picture 2.18:** *Water for the MHPS is diverted from the irrigation channel and stored in a very small forebay tank. Water supply is insufficient to operate the 80kW turbine at full capacity. (Photo: T. Hoeck, June 2003)*

**Picture 2.17:** *Although the MHPS in Savnob has very old equipment it is already running for 14 years without major problems.*

57 The two diesel power plants had a capacity of 18kW each.

58 *Hukumat* is the Tajik word for government. In this context the *hukumat* is the local administration office.

***Table 2.9:** Monthly Winter and Summer Balance for the MHPS Savnob Owned by the PEC. Expenses for maintenance or spare parts and transportation costs for bill delivery are not included.*

| Monthly winter balance (April 2003) for MHPS Savnob | | | |
|---|---|---|---|
| Income from fees: 57 customers | Expenses: salaries for two workers | Financial stock (PEC) | Net return |
| 197.22 somoni | 110 somoni | Not known | 87.22 somoni |
| USD 63.83 | USD 35.60 | Not known | USD 28.23 |
| Monthly summer balance (estimated) for MHPS Savnob | | | |
| Income from fees: 57 customers | Expenses: salaries for two workers | Financial stock (PEC) | Net return |
| 114 somoni | 110 somoni | Not known | 4.0 somoni |
| USD 36.90 | USD 35.60 | Not known | USD 1.30 |

*Source: Field study 2003*

hence low output capacity. The conflict between the two water uses of irrigation and hydropower can only be settled if another source of water can be tapped. PEC is not interested in improving the hydro scheme's performance through the implementation of measures to increase water supply (e.g. large forebay tank, water pump refilling forebay tank overnight, new water channel providing additional water discharge).

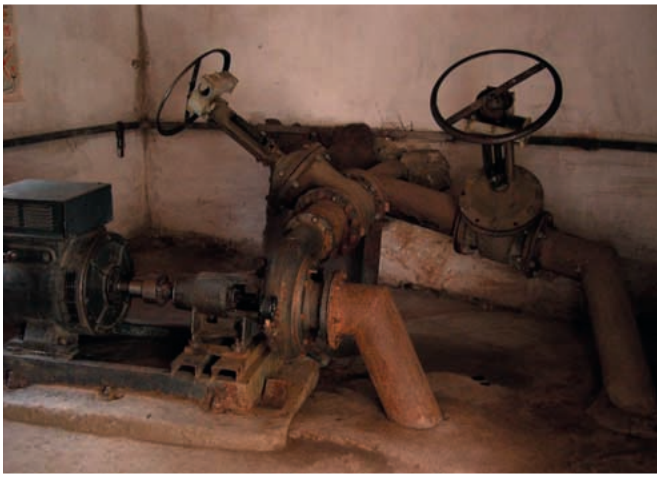
The MHPS reaches a plant factor of 0.146 in summer and of 0.292 in winter. The average annual plant factor is 0.219, far below the economically viable lower limit of 0.6. This poor performance is mainly due to low output capacity and a short operational period in summer. The monthly balance of the hydropower station in Savnob for April 2003 confirms this picture. As seen in Table 2.9 the net return in winter is still positive, but considering that additional expenses[59] for maintenance or spare parts, for administrative work and transportation costs for bill delivery[60] are not included into the balance, the figure may easily drop below zero. Moreover, in summer power consumption decreases due to shorter operation period, reducing the income from the electricity fees. In the best case the MHPS in Savnob can run on a zero balance.

### 8.2.7 Vezdara Micro Hydropower Station

The hydro scheme in Vezdara (Roshtkala district) serves as an example of a community-based project implemented with local initiative and managed by the village organization.

Since 1992 Vezdara has been supplied with electricity from the main grid only in the period from May till October. To fill the supply gap in wintertime the dwellers had the idea of installing a micro hydropower station (MHPS) in their village. Due to lack of funds and donors at that time, the project could not be accomplished. Seven years later the chairman of Vezdara, together with an engineer from the MSDSP, initiated construction of the hydro scheme. Eight months later in November 1999 the MHPS was completed. The project was implemented by the MSDSP and the installation costs of about USD 18,000 were financed with funds from the Swiss Development Corporation (SDC). The entire village - women, men and even children - helped with the construction of the water channel, forebay tank and the hydro scheme's machine room. The workforces were paid on a food for work basis, so that every household received three to four bags of flour for the work performed. There were only male members on the hydropower project committee, and all decision during the planning phase were made without the opinions of the women.

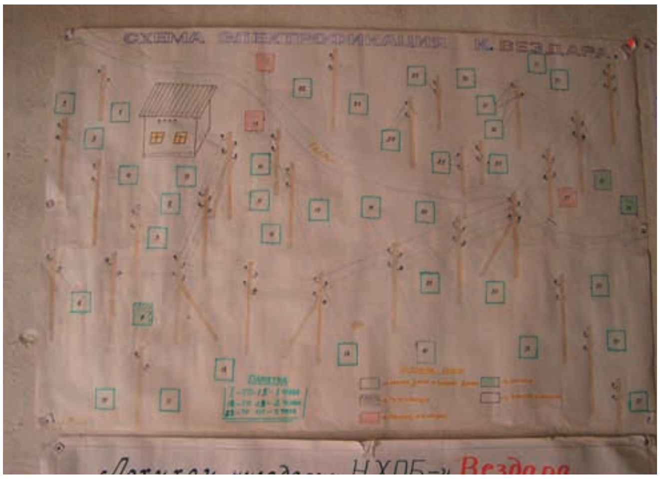
The water for the hydro scheme is diverted from a small river perennially providing sufficient run-off for the 32kW turbine (see Picture 2.8). The unit consists of a former irrigation pump (PAT) horizontally aligned with a synchronic generator (see Picture 2.19). From the forebay tank with a capacity of $9m^3$ the water is released through



***Picture 2.19:** The village organization operates the MHPS in Vezdara. Thanks to very careful maintenance and good financial management, the hydro scheme can independently survive.*

59 No data available.

60 The distance from the PEC administrative office in Khorog to the power plant in Savnob is 175km. The roads in the upper Bartang valley are in bad conditions and demand a lot of petrol.



***Picture 2.20:*** *A good management and careful maintenance enables the hydro scheme to operate steadily without major problems. (Photo: T. Hoeck, June 2003)*

the 115m long pipes to the turbine losing 47m of altitude. The capacity is manually reduced during peak hours to avoid damages caused by overheating resulting in an average output of 20kW. The hydro scheme operates whenever there is no power supply from the main grid, usually from October till the beginning of May. To begin with, 30 customers (all households and some governmental institutions) in Vezdara were connected to the power plant, thus providing an available capacity of 670W per consumer. In the winter of 2001/2002 the village organization of Vezdara decided to supply additional customers with electricity upon request from relatives and friends living in the neighboring villages of Anjin and Anbav. At present a total of 56 consumers[61] are connected to the micro hydro scheme with an average available capacity of 350W per household (see Picture 2.20). There is no transformer in the village to stabilize the current over longer distances, so that only nearby households have a good capacity.

The MHPS provides electricity during 18 hours every day. In a meeting of the Village Organization (VO) the dwellers agreed on a schedule for power generation from 6 am to 12 pm. The idea is to reduce the scheme's operational period, thus conserving equipment and saving maintenance costs. Two well-trained workers employed by the VO to take care of operation and maintenance receive salaries of 13 and 15 *somoni* (USD 4.10 and 4.80). They change shifts every second day and keep records of regularly performed maintenance activities. Every third day some rubber parts on the axle have to be replaced due to fast wear and tear. Monthly costs for lubricant and spare parts are estimated at 12 *somoni* (USD 3.80). The income from the electricity fees[62] based on a flat rate of 2.5 *somoni* (USD 0.80) per customer is sufficient to cover O+M costs. To cope with severe breakdowns and ensure an ongoing operation of the scheme, the VO decided to introduce an additional source of income and stock for the MHPS. The tradition is to celebrate accordingly the successful accomplishment of the hydropower project and sacrifice livestock in the name of god. Each household contributed one sheep or goat and the MSDSP provided one cow for the celebration. Instead of slaughtering all 25 sheep and goats for the feast, 20 of them were saved and donated to the hydropower plant to be kept as a stock. Over the years the animals reproduced and the stock thus increased in value. Presently three cows and 47 sheep and goats serve as a financial reserve for the MHPS (see Picture 2.21). This management strategy already has proven its worth. There was a need to replace the first turbine due to severe damages caused by stones entering the pipes. To purchase another irrigation pump in Khorog to use as a turbine, some of the farming animals belonging to the hydropower project were sold.

Due to careful maintenance the hydro scheme operates steadily without major problems. However, there are too many customers connected to the power plant. Fuses blow frequently due to overloading. The rubber parts on the axle regularly have to be replaced. But spare parts can easily be manufactured by the staff. Heavy precipitation may cause damage at the water channel, and especially in spring large sediment loads accumulate in the channel and in the forebay tank, so that regular cleaning is needed.

The construction of the hydro scheme demanded capital costs of USD 563/kW. In comparison to the ap-


***Picture 2.21:*** *The MHPS in Vezdara owns 47 sheep and goats, and three cows, which serve as a financial stock and as an additional source of income for the hydro scheme.*

61 Fifty households and six governmental institutions are supplied with power from the MHPS.

62 First, a monthly flat rate of 1.5 *somoni* (USD 0.47) was demanded but as more electric appliances were used the fees were increased to 2.5 *somoni* (USD 0.80) per customer.

***Table 2.10:*** *Balance for the Community Based MHPS in Vezdara. One cow can be sold for 630 somoni (USD 200), and one goat or sheep for 189 somoni (USD 60) at the bazaar.*

| Monthly balance (April 2003) for the MHPS in Vezdara | | | |
|---|---|---|---|
| Income from fees (2.5 somoni x 56 households) | Expenses: salaries for two machinists, spare parts | Financial stock: 3 cows and 47 sheep or goats | Net return |
| 140 somoni | 40 *somoni* | 10773 *somoni* | 110 *somoni* |
| USD 44.40 | USD 12.70 | USD 3420 | USD 31.70 |

*Source: Field study 2003*

proximate band of USD 800-1800 for a 30kW MHPS presented in Harvey (1993), the installation in Vezdara could be accomplished with a low budget. Low labor costs and the use of second hand equipment considerably decreased the start-up costs. The scheme has a plant factor of 0.313 which is well below the viable limit. This is mainly due to the power plant's short operational period and its reduced output capacity. Considering only the present O+M costs for the calculation of the unit energy costs, the MHPS can generate electricity at USD 0.0070/kWh. The demanded monthly flat rate of 2.5 *somoni* (USD 0.80) equals an electricity fee of USD 0.0099/kWh. The resulting net return can be thus accumulated and used to cover further expenses for repairs (see Table 2.10). The MHPS also owns a considerable stock of farming animals that can be dispersed if needed. Despite the low plant factor the hydro scheme can survive independently thanks to appropriate financial management.

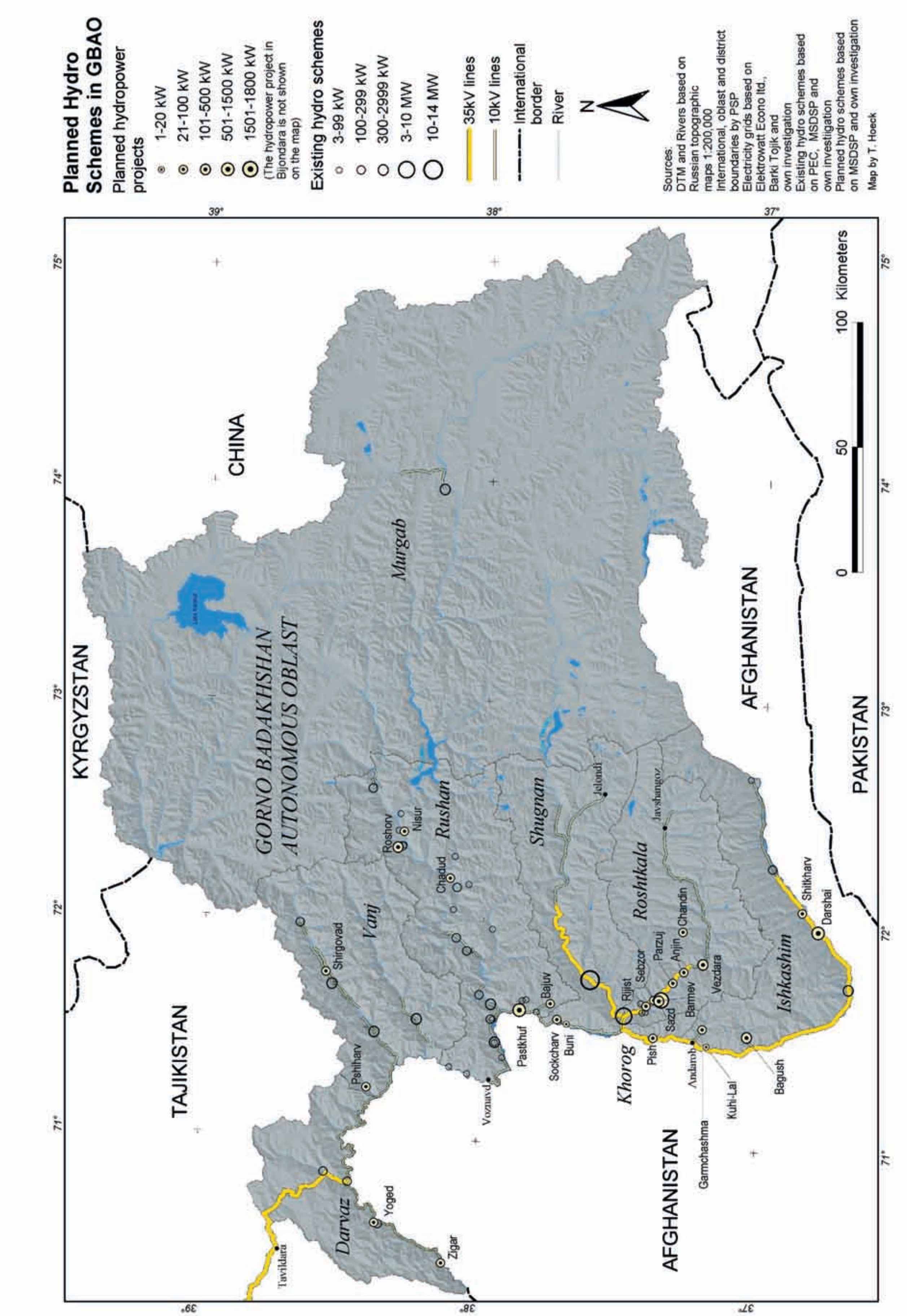
This successful hydropower project motivated other villagers to take the initiative and realize further plans. The dwellers of the neighboring village of Midenved, which is not supplied with electricity during wintertime, started a new hydropower project in 2003: The installation of a 200kW-MHPS in Vezdara supplying four villages[63] with power in winter. Since the first feasibility study performed by an engineer from the PEC, money and livestock has already been collected from future beneficiaries.

### 8.2.8 Future Micro and Mini Hydropower Projects[64]

A total of 26 further hydropower projects are planned in the districts of Darvaz, Vanj, Rushan, Shugnan, Roshtkala and Ishkashim (see Map 2.2). The village organizations submitted requests to the MSDSP with a project proposal demanding technical assistance and financial support to install a hydro scheme. Four mini hydropower plants in the range of 400-1800kW and 22 micro hydro schemes with capacities of 10-200kW are projected. The completion of all planned hydropower stations adds 6.22MW to the electricity supply in GBAO. That means micro and mini hydro schemes would provide an overall capacity of more than 15MW to their customers. Six projects were proposed by village organizations already owning an MHPS. The new scheme should replace the existing power plant, which is either not operating, severely damaged or providing too low capacity to satisfy the demand for electricity (see Picture 2.22). Another reason for initiating a hydropower project is to gain year round electricity supply in villages connected to the main grid supplied from the Pamir 1 and Khorog power plants in summer. Hence 16 hydropower stations are planned as an additional source of electricity operating only in winter. The MSDSP does not give priority to these projects, because the PEC promises to provide perennial electricity supply to all customers after the completion of the Pamir Private Power Project[65]. The main grid would thus provide about 36.7MW to more than 15,900 customers (equal to almost 100,000 dwellers), resulting in an average available capacity of 2200W per household.

***Picture 2.22:*** *The construction of new MHPS in remote regions with presently no power supply is an adequate option, since an extension of the main grid in GBAO is not planned. (Photo: T. Hoeck, July 2003)*

63 These are Vezdara, Midenved, Anjin and Anbav.
64 A complete list with planned hydropower projects is found in Appendix 2.
65 The reader is referred to Chapter 8.1.3 for detailed information about the Pamir Private Power Project.




*Map 2.2: Hydropower Projects Submitted to the MSDSP. The MHPS in Bijondara could not be located and is thus not shown in this map. Map by T. Hoeck*

The need for further MHPS in villages connected to the main grid must be carefully considered. On the one hand there seems to be no necessity for the construction of additional MHPS because a year-round grid supply will be guaranteed. On the other hand, an average capacity of 2200W per customer is insufficient considering higher consumptions in the district centers where the demand of economic activities has to be met. Moreover, the PEC will increase electricity fees from the present upper limit of USD 0.0075/kWh to USD 0.03/kWh in 2010. It is questionable whether all customers will be able to afford these tariffs. For that reason, existing or future MHPS could provide cheaper electric power directly to the dwellers or sell their outputs to the PEC, generating an income for the village with which the fees could be subsidized. There is also a need to think about the future of the 19 existing hydro schemes located in villages connected to the grid. As they are presently operating when there is no supply from the grid, one can conclude that they will be out of commission as soon as perennial provision from the PEC is guaranteed.

### 8.2.9 Conclusion

Most hydro schemes have to cope with major problems not allowing continuous and reliable operation. The inadequate, old and second-hand equipment is prone to damage and requires careful and cost-intensive maintenance. Lack of know-how to perform proper maintenance and repairs as well as insufficient financial management of the MHPS make it impossible to guarantee long-term operation. Moreover, community-based hydro schemes cannot count on external technical assistance, as all responsibilities were transferred to the village after the completion of the project and no backstopping institution was established to provide further external support. There is a great need for additional training of staff, for maintenance and operation instruction manuals and for a competent institution to provide technical assistance to the community-based MHPS.

Virtually all MHPS have too low an output capacity (far below 1500W per customer) to provide customers with sufficient power to cover their basic domestic needs. Thus electricity usually only meets the demand for lighting and to some extent for heating water or preparing meals. It can therefore be concluded that micro and mini hydropower plants make only a minor contribution to relieve pressure on renewable natural energy resources in the Tajik Pamirs. With the present hydropower infrastructure and its performance, a substantial substitution of electric power for biomass fuels, such as firewood, shrubs and dung, is impossible. However, it also has to be considered that MHPS have positive impacts on the socio-economic level: They offer employment to several villagers and provide a cheap resource for lighting and other purposes, thus improving the people's livelihood.

Micro and mini hydro schemes are certainly an economic alternative to grid extensions into remote areas. Assuming that capital costs are borne by donors, the MHPS provide affordable power to the villagers, as shown in the financial analysis. Given improved financial management, the hydro schemes can independently survive, allocating sufficient financial means to cover operation and maintenance costs. MHPS have further advantages compared to grid supply: Major losses and high maintenance costs on extensive transmission lines can be avoided, electricity supply can be adjusted to the village's specific temporal demands and a successful community-based hydropower project can initiate a take-off of further project or economic activities at the village level.

### 8.2.10 Recommendations

The authors recommend considering the following aspects for the rehabilitation of existing MHPS and for the installation of new hydropower projects in GBAO:

*Project implementation*

- Allow sufficient financial means for training and implementation of an operation and maintenance system.
- Carefully design the hydropower project (considering low water discharge in winter and conflict with irrigation) and allow sufficient financial means to install adequate equipment.
- Design for the highest possible plant factor.
- Install vertical (instead of horizontal) units, which cause fewer problems with axles and bearings.
- Consider a needed capacity of 1500W per household and a monthly demand of around 315kWh per customer to ensure sufficient power supply to cover the basic domestic needs (room heating not included).
- Consider the households' ability to pay for a consumption of 315kWh and calculate the tariffs accordingly.
- Implement the project with a participatory community-based approach, where especially women, as the main energy resource procurer and user, are integrated into the planning process and into the project committee.
- The bulk of the installation costs shall be borne by donors, but the beneficiaries shall also contribute labor, financial means, agricultural products or livestock to ensure their long-term interest in the MHPS. It is important that the community considers the hydro scheme as their "baby".

*Operation and maintenance*

- Carry out intensive and repeated training of the staff, provide operation and maintenance documentation and instruct the staff when to call for external assistance.

- Establish a centre of competence in hydropower assisting the community-based hydro scheme with spare parts and technical support.

*Financial management*
- Introduce an adequate tariff setting while considering the scheme's running costs and the households' ability to pay.
- Establish an additional source of income for the MHPS to ensure the independent long-term operation of the scheme. A possibility is to donate livestock to the hydro scheme (as it was done in Vezdara) serving as a reproductive stock.

***References***
AKF [Aga Khan Foundation] (ed.) (2003) Lighting up Communities. A Case Study of the Mountain Societies Development Support Program's Mini-Hydel Projects in Gorno Badakhshan Autonomous Oblast. Evaluation Learning and Communication Unit Tajikistan: Dushanbe.
Breu, Thomas and Hurni, Hans (2003) The Tajik Pamirs: Challenges of Sustainable Development in an Isolated Mountain Region. Bern: Centre for Development and Environment, University of Berne.
Habtetsion, Semere and Tsighe, Zemenfes (2001) Renewables and Energy for Rural Development. Current Energy Utilization and Future Options in Rural Areas. Second Draft Report. African Energy Policy Research Network (AFREPREN). Energy Research Programme 2000-2002.
Harvey, Adam (1993) Micro-Hydro Design Manual. A Guide to Small-Scale Water Power Schemes. London: Intermediate Technology Publications.
MSDSP [Mountain Society Development and Support Programme] (ed.) (2002) List of Accomplished Micro and Mini Hydropower Projects in Gorno Badakhshan. MSDSP Khorog.
ZERKALO [Sociological Research Centre] (ed.) (2000) Social Research Report, GBAO October 2000. Dushanbe: Sociological Research Centre.
Zibung, Daniel (2002) Eine integrale Analyse der Infrastrukturausstattung und Energieversorgung in der Grossregion Gorno-Badakhshan, Tajikistan. Diplomarbeit. Bern: CDE.

## 8.3 Local Biomass Fuels

As mentioned in Chapter 8.1 perennial and reliable electricity supply is limited to the *oblast* and district centers in GBAO, whereas power in rural areas is provided at low capacities or on an irregular basis. Especially in winter, when energy demand is highest, many villages lack electric power. Moreover, in very remote areas the electricity infrastructure is deteriorated or non-existent. Due to the unsatisfactory power supply the majority of the inhabitants are forced to rely on other resources to meet their demand for energy. Despite the general scarcity of vegetation, biomass fuels play a major role in satisfying energy needs in the Tajik Pamirs. In rural regions, where power provision is limited or inexistent, firewood, *teresken* shrubs and manure cover the bulk of the energy demand. Even in villages with perennial electricity supply, biomass fuels may cover up to 90% of consumed energy (see Chapter 11.5).

### 8.3.1 Firewood

Forest cover in Tajikistan amounts to only 2.3% of the country's territory, as compared to 16-18% a hundred years ago. Land has been mainly deforested for gaining agricultural areas. In recent years, however deforestation has considerably increased due to the lack of sufficient energy resources. The forest authorities in Gorno Badakhshan manage an area of 78,400ha, of which about 10,000ha[66] are actually covered with forest-like vegetation[67]. Thus forests constitute about 0.16% of the area of GBAO (IFC 1999: 5/4)[68].

Due to the arid climatic and harsh bio-physical conditions in the Tajik Pamirs forests are limited to areas

***Picture 2.23:*** *Children from Vezdara in the Roshtkala district collect dry branches from a nearby willow-tree forest to store it for wintertime. (Photo: T. Hoeck, June 2003)*

[66] This figure was confirmed through personal communication with a representative of the national forestry authority in Dushanbe in May 2003. It should be added that during the past decade there has been no forest management in the Tajik Pamirs, as mentioned by the representative. Thus the above-mentioned 10,000ha represent the forest area of the late eighties. Due to considerable deforestation in recent years, the present forest area is certainly much smaller than 10,000ha.

[67] The majority of the classified forest area would not be qualified as forest in Western European countries, since a considerable part of it is bushy vegetation (IFC 1999: 5/4).

[68] The information on the situation of forests and forestry in Tajikistan and GBAO, available in IFC (1999), was provided by *Tajikles*, the national forestry authority in Dushanbe.

**Picture 2.24:** *A women from Savnob in the Upper Bartang Valley collects teresken shrubs for cooking and heating since there is no other energy resource available. (Photo: T. Hoeck, June 2003)*

**Picture 2.25:** *To fill the energy gap caused by the cessation of coal provision, the peasants use animal dung as a heating resource. The dung cakes are placed on the roof of the traditional Pamiri houses, as is practiced in Nisur (upper Bartang valley). (Photo: T. Hoeck, June 2003)*

alongside rivers and brooks (see Map 1.2). The so-called gallery forests or *tugais* consist of different species of willow (*Salix shugnanica* and *Salix turanica*), Russian olive, (*Elaeagnus augustifolia*), sallow thorn (*Hippophae rhamnoides*) and poplar trees (*Populus pamirica*) (Wennemann 2002: 85).

Firewood is scarce and the existing resources are heavily exploited. Especially during the years of civil war (1992-1997) forest areas were thinned out or completely cleared to a great extent. The most common firewoods in the Tajik Pamirs are willow trees and thorn bushes, whereas poplar trees are usually not burned but saved for construction purposes. Firewood is used widely in all villages, and even in the capital of Gorno Badakhshan inhabitants use wood for cooking and heating if there is no electricity supply. The *leskhoz*, the governmental forestry office, manages the forest areas and controls the cutting of firewood in GBAO. Officially a license[69] is required that allows the acquisition of firewood, although there is frequent illegal cutting. Moreover, collecting dry branches from forests is not liable to be fined, so that fresh boughs are broken and later legally collected when they have dried (see Picture 2.23). Usually several hours are spent every day collecting and carrying heavy backloads of firewood. Where forest vegetation is too distant to be reached on foot, trucks are hired to allocate fuel wood. In addition to the expenses for the license, high transportation and labor costs have to be covered, resulting in prices as high as 200-300 *somoni* (USD 63.50-95.20) for one truckload[70]. An average household in the Tajik Pamirs cannot afford such high expenditures. In remote regions with very sparse vegetation fruit trees are cut to survive exceptionally hard and prolonged winters. It was reported that some households even used wood from the roof of their barn to heat in winter (AKF 2003).

### 8.3.2 Teresken Shrubs

Where natural forests are scarce or have already been cleared, small shrubs covering the arid slopes of the Western and the high plains of the Eastern Pamirs constitute the only woody energy resource for the population (see Picture 2.24). *Teresken*[71] shrubs (*Eurotia ceratoides*) and wormwoods (*Artemisia species*) grow very slowly under arid conditions in scattered mosaic patterns. The small leaves of these ring-cushion plants are very nutritious (containing 30% raw protein) and offer a valuable fodder for livestock. Under Soviet rule, the law prohibited use of *teresken* shrubs. At present time, however, it is the main energy resource and fodder plant in the Murgab district in the Eastern Pamirs. *Teresken* is widely collected by car or truck, and even sold at the *bazaar* in Murgab center: One bundle (around 15kg) can be purchased for 5 *somoni* (USD 1.60) in winter and for 3-4 *somoni* (USD 0.95-1.30) in summer. (Domeisen 2002; Kleinn 2003)

### 8.3.3 Animal Dung

Manure is the most important fertilizer for the peasants in the Tajik Pamirs (World Bank 2002: 17), but due to the

69 A license can be purchased at around 35 *somoni* (USD 11) from the *leskhoz*.

70 One truckload of firewood equals about 5m$^3$.

71 *Teresken* shrubs belong to the family of *Chenopodiaceae* and have several scientific names. They are known as *Eurotia ceratoides*, *Ceratoides papposa* and *Krascheninikovia ceratoides* (Wennemann 2002: 68). In the Western Pamirs these shrubs appear at altitudes of 2000-3400m, and in the Eastern Pamirs at altitudes of 3500-4200m (NABU 2002: 10).

scarcity of energy resources it is also used as a valuable fuel. Dung is also a scarce resource: Depending on the size of livestock and arable land, farmers can allocate sufficient manure to use it as fertilizer and as an energy resource. Manure is commonly used as heating fuel in combination with wood or shrubs in winter. Households with limited livestock or relatively large plots do not burn dung because providing the soil with new nutrients has first priority. Dung is a very important heating resource where firewood cannot be obtained. The manure is cut from the stables, compacted to cakes and set out to dry on the roof of the traditional Pamiri houses (see Picture 2.25).

***References***
AKF [Aga Khan Foundation] (ed.) (2003) Lighting up Communities. A Case Study of the Mountain Societies Development Support Program's Mini-Hydel Projects in Gorno Badakhshan Autonomous Oblast. Evaluation Learning and Communication Unit Tajikistan: Dushanbe.
Breu, Thomas and Hurni, Hans (2003) The Tajik Pamirs: Challenges of Sustainable Development in an Isolated Mountain Region. Bern: Centre for Development and Environment, University of Berne.
Domeisen, Michael (2002) Marginalized by the Impacts of Transformation. A Study of Post-Soviet Livestock Breeding in the High Mountains of the Eastern Pamirs. Diplomarbeit. Bern: Centre for Development and Environment, University of Berne.
Kleinn, Eva (2003) Unpublished Report on Teresken Acquisition in Murgab Center (Eastern Pamirs). GTZ.
NABU [German Society for Nature Conservation] (ed.) (2002) Biodiversity Assessment and Overview. A Subproject of the Pamir Strategy Project, Centre for Development and Environment. German Society for Nature Conservation. Edited by Eva Kleinn.
Wennemann, Mathias (ed) (2002) Pamir Expedition 2002. Bielefeld – Bonn – Dushanbe 27.07.-24.08.2002. Expeditionsbericht. Universität Bielefeld.
World Bank (ed.) (2002) Tajikistan Pamir Private Power Project. Environment and Social Impact Assessment. Executive Summary.
Zibung, Daniel (2002) Eine integrale Analyse der Infrastrukturausstattung und Energieversorgung in der Grossregion Gorno-Badakhshan, Tajikistan. Diplomarbeit. Bern: CDE.

## 8.4 Imported Fossil Fuels

Tajikistan has only negligible deposits of fossil fuels (oil, gas and coal). The coal found so far, though of reasonable quality, is located in regions difficult to access and thus not viable for quarrying. Hence oil, gas and coal have to be imported to a large extent, e.g. from the neighboring countries of Uzbekistan and Kyrgyzstan. The fuels have to be conveyed by truck over high passes and roads in poor condition to supply the population of Gorno Badakhshan (see Picture 2.26). The high transport cost considerably increases the prices of diesel oil, petrol and coal. (World Bank 2002; Zibung 2002)


***Picture 2.26:*** *Petrol station in Khorog, the capital of Gorno Badakhshan Autonomous Oblast. Diesel oil and Petrol have to be transported by trucks over long distances to reach the economic centre of the Tajik Pamirs. (Photo: T. Hoeck, July 2003)*

### 8.4.1 Diesel Oil and Petrol

Prior to Tajikistan's independence in 1991 subsidies on fossil fuels allowed an extensive use of diesel oil and petrol. Several diesel power plants provided electricity to the dwellers of the Tajik Pamirs. At the present time fuel prices are prohibitive to run diesel generators or to allow frequent transportation for the population.

In Khorog one liter of petrol cost 1.4 *somoni* (USD 0.44) in July 2003. Diesel oil is cheaper: It was available at the *bazaar* at 0.8 *somoni* (USD 0.25) per liter and in remote areas at 1 *somoni* (USD 0.32). In the past months, prices for fossil fuels severely increased, so that in March 2004 one liter of petrol was sold in Khorog at 3.5 *somoni* (USD 1.11) and one liter of diesel oil at 2 *somoni* (USD 0.63). In villages without electricity supply diesel oil is commonly used for lighting and occasionally for cooking.

### 8.4.2 Coal

During Soviet time large amounts of coal were imported to the Tajik Pamirs and made available to the population at affordable prices. With the collapse of the Soviet Union coal provision stopped and the inhabitants lost their main heating resource. Nowadays transport costs for coal importation from Osh (Republic of Kyrgyzstan) are exorbitant: Around USD 100/ton (World Bank 2002). As a result, coal is hardly used anymore in the Tajik Pamirs. There are two coal deposits in Gorno Badakhshan, which have not yet been exploited. One site is located in Ravnou in the Darvaz district with an estimated volume of 4.45 million tons. Poor and intermittent access to this remote deposit severely limits the potential for quarrying. The second coal site is situated in Cheshtebe (Murgab district) on the high plains of the Eastern Pamirs. The commercial mining of this smaller deposit with reserves amounting to 750,000 tons was under preparation since 2002. The project was closed recently due to insufficient coal quality and for security reasons. Coal from the Cheshtebe mine could have been delivered to Murgab at 36 *somoni* (USD 11.40) per ton, a reasonable price even compared to *teresken* shrubs offered at market. (Breu & Hurni 2003; Zibung 2002)

### 8.4.3 Kerosene

Kerosene was widely used for lighting and cooking purpose in areas which were not supplied with electric power prior to independence. At the present time, households equipped with kerosene lamps run their appliances with diesel oil, as kerosene is no longer provided and diesel oil is the cheapest alternative. Former kerosene cookers have been transformed into electric cookers by lining the inside with coils and wire and connecting them to the socket.

***References***

Breu, Thomas and Hurni, Hans (2003) The Tajik Pamirs: Challenges of Sustainable Development in an Isolated Mountain Region. Bern: Centre for Development and Environment, University of Berne.

World Bank (ed.) (2002) Tajikistan Pamir Private Power Project. Environment and Social Impact Assessment. Executive Summary.

Zibung, Daniel (2002) Eine integrale Analyse der Infrastrukturausstattung und Energieversorgung in der Grossregion Gorno-Badakhshan, Tajikistan. Diplomarbeit. Bern: CDE.

# 9. Degradation Assessment of Natural Resources

In the following chapter the questions of triggering factors, processes and consequences of land degradation will be examined. Land degradation processes are complex frameworks of cause-and-effect-interrelations. Their visible consequences are always linked with a negative change in the natural functions of the resources (vegetation, soil, water, air, rocks). The persistence and the intensity of change are crucial factors regarding impact on the environment. Land degradation is generally defined as the temporary or permanent decline of the land (UN/FAO definition). Stocking et al. (2001: 9) describes land degradation as "the aggregate diminution of the productive potential of the land, including its major uses (rain-fed, arable, irrigated, rangeland, forest), farming systems (e.g. smallholder subsistence) and its value as an economic resource." This interrelation between degradation, which is mainly caused by inappropriate human activities, and its consequences on the land use system, is a crucial point for the peasant's livelihood.

Since especially biomass and arable land are stinted resources in Gorno Badakhshan the assumption stands to reason that these resources are prone to be overused and thereby degraded. Local people may assess the 'degradation', which is in fact a social construction, quite differently than the researchers, or do not (yet) consider it as a problem, because they are not directly affected by it. For example, a woman collecting *teresken* bushes is mainly threatened by the scarcity of this natural resource and its backbreaking labor. This fact calls for a field method which involves local people in the identification of issues. The authors applied therefore methods from the participatory land degradation assessment (Stocking 2001. 35 sqq.) to collect data and information.[72] By interviewing the land users directly, on-site information about different forms of degradation was collected in 25 villages.

## 9.1 Endangered Forestlands

Degradation of woodland and forest areas is the predominant degradation form all over the territory of GBAO.


***Picture 2.27:*** *Progression of forestland depletion. Many easily accessible and poorly preserved forests disappeared in the Pamirs. Usually people first collect dead wood. With increasing scarcity, the wood may be lopped off from the trees and bushes [2]. Since the coppice can be collected with less effort than the bigger logs, trees remain longer than the brushwood [3]. With increased pressure on fuel supplies the firewood is commercialized and legally or illegally chopped down [4]. The remaining stumps are gradually cut, so that finally the area is entirely cleared and used as pastureland [5,6] which is likely to be salinized. (Photos: T. Hoeck and R. Droux)*

72 This method is discussed in the Chapter 5.3

Not only the number of trees in the village mainly decreased during the last ten years[73], but also large areas of forestland disappeared. The once dense and rich primeval forests which used to be widely spread in all the floodplains of the main valleys are virtually non-existent nowadays.[74] Local informants estimate the **loss of forestland** within the last 20 years at 70-80%. The principal reason for the disappearance of these riparian forests, called *tugai*, is the high shortage of energy resources since the cessation of Soviet fuel provision. Due to the sudden cut in the supply service, the non-existent controlling body[75], the lack of knowledge regarding sustainable forest management and, the peasants' daily struggles for survival, the 'tragedy of the commons'[76] first appeared. The common forestlands were considerably derogated by illegal cutting during the civil war. Already in the Soviet era a great deal of forestland was stubbed to gain agricultural land and to harvest firewood for public institutions. The village scenery is dominated by poplar trees which are used exclusively for construction purposes. Generally peasants avoided and retained from chopping down their own trees to use as firewood. In recent years, cut or half-cut fruit trees are, due to the increasing energy situation, increasingly numerous[77], especially in the Bartang Valley. Since the fruits –mainly apricots, mulberry and apples – constitute an essential foodstuff, the peasants derogate their own nutrition base by cutting the fruit trees.

Not only excessive cutting exerts pressure on the fruit trees, but also the different **blights** that are often observed. Apricot and apple trees are infected with different fungal decay (powdery mildew, scurf) and parasites such as the apple ermine moth spinning communal webs that cover the entire tree. The consequences of these afflictions are reduced or even absent yields. These incidents are scattered all over GBAO, to different extent. However, the peasants' financial means do not allow purchasing insecticides and fungicides, and they do not have the knowledge to take appropriate measures.

The energy resource base varies from one to another village. Depending on the different accesses of the remaining forests, and the distance to the route for commerce and electricity supply. Nowadays peasants are forced to walk to distant forestlands situated up to a one day's journey from the village.[78] Due to steep and dangerous trails, accidents and casualties frequently occur on collection walks. In villages where forests can no longer be reached by foot within one day, peasants are forced to collect *teresken* shrubs with extremely unfavorable heating characteristics. Given how, with today's energy demand, sustainable use of *teresken* as a major fuel is no longer possible, large areas of pasturelands were depleted and are still being depleted. This results in deserted wasteland, which also becomes unusable as pasture. Consequently, the present rate of harvesting *teresken* shrubs not only ruins the woody resources but also the biodiversity and the forage base for the livestock.

Consequences of this vegetation loss appear in the form of higher wind erosion, producing large smothers. On sites exposed to the wind, where the vegetation is

***Picture 2.28:*** *Afflicted apple tree. Different blights are widespread parasites that considerably diminish the fruit yield. (Photo: R. Droux, June 2003)*

***Picture 2.29:*** *Trampling damage and traces caused by teresken bundles sliding down remarkably reduce the vegetation cover on the slopes. (Photo: R. Droux, June 2003)*

73 According to statements by peasants some villages have lost between 30 and 40% of their trees since the Soviet times.
74 The vegetation base before and during the Soviet era is discussed in Chapter 10.15 and in Chapter 7.
75 As mentioned by the representatives of the Tajik forest department in Dushanbe, there has been virtually no forest management in GBAO during the past decade.
76 The first tree to be cut were those that were not privately owned.
77 In certain villages peasants are even forced to take timber from the stable for heating during a harsh winter.
78 The longest time needed for wood collection was 16 hours per day.

gone, a pavement of pebbles remains, known as armour layers (Stocking et al 2001: 51).

It is actually distressing how few counteractive measures have been taken to mitigate the alarming proportions of forestland degradation. Reforestation projects have been implemented in several villages, but the number and the species of trees and the purpose of reforestation are often inadequate. In many places the tenure of land, the area of responsibility and the future harvest of the wood is too vaguely defined. In addition, it is predominantly poplar trees that have been replanted, which will certainly not be used as firewood. According to the peasants living in a village which was recently electrified by a small scale hydropower scheme, the electricity has reduced the consumption of woody resources and the forest near the village is recuperating. In terms of rehabilitating pasture land no measures have been taken at all.

The consequences of disappearing forestlands and depleted pastures are also affecting the wildlife. Since the period of civil war a large number of peasants were armed and foodstuff provision was disastrous. A large part of the wildlife was hunted and Siberian ibex (*Cepra [ibex] sibirica*) and Marco Polo Sheep (*Ovis ammon polii*) in particular disappeared in many regions. Hence, nowadays very few game is seen by the peasants around the village, even during winter, when the animals used to come further down into the valleys. Additionally, habitats for other wildlife such as foxes, snow leopards, marmots, sandpipers, ptarmigans, etc. were destroyed and are still being destroyed, as was the case during height of the civil war. The hardships at that time were aggravated by refugees[79] from the lowlands, additionally straining the precarious energy and foodstuff situation and increasing pressure on the scarce forestlands.

## 9.2 Soil: The Major Asset for the Land User's Livelihood

The soil is the most important resource for the peasants in the Pamirs, given how their livelihood basically relies on the crop yield.[80] Due to relatively few experienced land users[81] are quite often not aware of the origins, the processes and the consequences of soil degradation. Degradation of soils is a very common problem in Gorno Badakhshan. It is very often caused by human intervention in the environment and inadequate land use management.

***Picture 2.30:*** *Worn mound of crop rows, irrigation rills with sedimentation of silt and sand, and washed-out pebbles indicating topsoil erosion. (Photo: R. Droux, June 2003)*

The fields situated on the hill slopes are watered by furrow irrigation so that the water, which is mounted at the inlet coming from a subordinated channels, meanders through the furrows, watering the plants. For the most part the furrows stretch horizontally in sinuous lines so that the water easily reaches all the plants. Nevertheless, **topsoil erosion** is occurs frequently. Since all agricultural plots need to be irrigated and the vegetation cover is scarce, soil erosion by water is one of the main causes of degradation. Land users often underestimate the consequences of soil erosion or are unaware of accelerating soil degradation processes. The peasants' ma-

***Box 2.1: From Soil Creeping to Landslide***

A striking example of inadequate drainage of irrigation water and its consequences for land users occurred in the village of Barmev (Tusyon, Roshtkala). A 50° steep slope (70m wide and 40m long) situated underneath cultivated land is completely soaked by irrigation water. The entire slope moves 15-20cm annually, as indicated by the hooked willow trees (see Picture 6). In the upper part cracks several meters of length emerge. The water logging in the soil has already triggered a mudflow, nearly destroying the public mill situated at the bottom of the slope. The land user cultivating this plot as a hayfield on the one hand relies highly on the fodder mowed from this plot and on the other hand has to pay a rental fee to the community, which he can hardly afford. However, due to this inappropriate cultivation it is only a matter of time before the whole slope slides down as a huge mudflow destroying the mill and the highly necessary fodder source as well.

79 In certain villages the population increased to up to 50% during the period of civil war.

80 Only 40% of the peasants still receive humanitarian aid in the form or flour and oil. According to the MSDSP coordinator the food aid will be stopped within the next years.

81 During the Soviet era crop cultivation was done exclusively by the *kolkhoz* and the *sowkhoz* controlled and managed by the governmental apparatus. Intensified self-supply started with the privatization of the arable land and support starting in 1996 in the field of cropping systems by international organizations.

**Picture 2.31:** *Leaking irrigation channels are frequently observed. They can cause gully erosion, destroying arable land and houses. (Photo: R. Droux, June 2003)*

**Picture 2.32:** *Inappropriate irrigation caused a mudflow affecting the public mill (arrow) and soil creeping indicated by trees growing at an angle (top left). (Photo: R. Droux, June 2003)*

jor concern is the yield that they can achieve from their land to ensure sufficient food supply for their families. Thus land degradation is mainly perceived as a loss in productivity. Local awareness of the triggering causes for soil degradation is considerably low.[82] However, the statements of several land users that they have to remove stones from their fields every year show that they perceive not the degradation[83] itself as a problem but rather its consequences (mainly indirect consequences in this example). In villages where the water is scarce and its availability is regulated by a schedule, the peasants tend to hurry with irrigating the fields, resulting in a higher flow rate. This causes increased removal of the topsoil visible in the washing out of small mounds on which the crop grows.

Besides the quantity of the irrigation water, its quality and especially its suspended load[84] considerably influence the soil's nutrient cycle. Other frequently observed phenomena in GBAO indicating soil loss are silt sedimentation in drainage furrows or exposure of power poles situated on steeper slopes. Improper drainage of irrigation water leads to waterlogging, resulting in saturated root zones or causing **soil creeping** or even **mudflows** (see Box 2.1).

Since all the croplands are situated on slopes and have to be irrigated, channels bring the water over several km to the fields. They are often drawn through steep and instable slopes and are likely to burst and destroy arable land and even houses. Gully erosions starting orthogonally downwards from the water channels are often observed on loose slopes (see Picture 2.31)

In villages located on steeper hillsides, land users constructed stonewalls for terracing the farmland. But extensive terrace areas are not common in GBAO[85] because the Soviet agriculture system replaced many of the traditional cultivation methods.

Land users are mainly desirous of having a good yield in autumn. Hence the productivity and the final harvest is an indirect indicator for the land user of how 'good' his land is. This issue depends mainly on the organic matter (structure, aeration and water-holding capacity), the biological activities, and the nutrition content (Stocking 2001: 12) of the soil. Although the arable land has been continuously extended in the last years, a considerable number of peasants complained about decreasing crop yield and increasing fertilizer demand. One explanation for this problem is that the common crop rotation is limited to a two year cycle, with one year potatoes and one year wheat. If the soil has no fallow period and is cultivated perennially only with two different species, it is liable to be sapped within a few years. Since all of the agricultural residues are used as fodder and dung is scarce, organic matter in the soil is very low. Because virtually only two species are cultivated, vulnerability to parasites and pests is quite high.

Degradation of cropland caused by **wind erosion** is

82 During conversations conducted in the field, peasants stated that they know how to irrigate and that they have no problem with soil erosion. Meanwhile coeval irrigation was frequently observed, so that the topsoil was eroding and the water turned the same color as the soil.

83 Continuous cleaning of the plots of stones is explicit evidence of increased top soil erosion.

84 Irrigation water sourcing from a spring contains less suspended load than water from a mountain river.

85 The differences between Tajik and Afghan terrace cultivation are remarkable. On the Afghan side the terraced crop lands reach a considerable altitude whereas on the Tajik side the hillsides are sparsely terraced. This high level of terrace cultivation on the Afghan side evolved from a centuries-old self-sufficient economy. Meanwhile the cropland extension and its linked conservation technology disappeared during Soviet times in Tajikistan.

***Picture 2.33:*** *Moving sand dunes threaten arable land. Land users replant trees wrapped into branches of thorn bushes (against browsing) as a measure against drifting sand. (Photo: R. Droux, June 2003)*

rather seldom observed because the small-sized plots and the humidity from the irrigation prevent the wind from causing soil drift.[86] The only visible problem in this field is moving sand driven by the wind and menacing arable land (see Picture 2.33).

**Salinization** is another process contributing to soil degradation that frequently occurs in GBAO. There are two main causes of an accumulation of salts on the surface of the soil. On the one hand, evaporating irrigation water leaving salt behind causes increased salinity on the soil surface. This process is mainly influenced by the high evaporation rate and the amount of water and its mineral content. This former phenomenon is frequently observed early in the season, when the cropland is still bare and evaporation is relatively high. On the other hand, on sites where the groundwater is raised by capillary action, the water evaporates on the soil surface and generates a salty crust. Knowledge concerning salinity prevention is considerably low. The only measures taken by the peasants is to elutriate the salt with an increased water flow or to neutralize the salty plots with ashes, mineral fertilizer or animal dung. The riverside plots, where water rises to the surface due to capillary action, are often used as grassland. Owing to the shortly grazed grass, the evaporation is much higher than on soils covered by sound vegetation. Such **overgrazed pastureland** located on former forestlands on the floodplains is highly likely to develop salty crusts.

The general decline of the livestock, emerging over the last ten years, is in fact not a result of animal diseases but rather a consequence of limited fodder availability, since arable land is no longer used as fodder turnout but for staple food production. On the one hand, a considerable volume of livestock was slaughtered or sold during and just after the civil war, in order to tide over the foodstuff shortage. Since that time, the peasants keep their livestock volumes down because of scanty forage stock in winter. Nowadays, due to inexistent livestock medication and the lack of treatment knowledge, livestock suffer from different afflictions evidenced in liver disease, leg inflammation and a kind of cerebral illness. In some villages peasants reported on mass deaths of chickens, so that no poultry survived.

## 9.3 Water: A Clean and Scarce Resource

Due to the low population density, the virtual lack of an industrial sector as a potential polluter, and careful water management at village level, the water in rural regions is extremely clean when it originates from melting snow and glaciers[87]. Although standards of hygiene in the villages are extremely low and the latrines are generally quite dirty, water contamination and epidemics are virtually non-existent. The bulk of irrigation and drinking water in the villages comes from tributary streams or springs.[88] However, the major problem regarding the water is not its quality but its quantitative availability. Since the channel systems within the villages are fed by tributaries or springs, the peasants rely considerably on water runoff. Due to seasonal differences in water discharge, depending on the catchment area and its features (relief, expanse, exposition, mountain lake, glacier, firn basin etc.) many villages are inadequately supplied with water during wintertime. Some tributaries even run dry and freeze so that the peasants are forced to get the water from the main stream. The water availability in many villages is also scarce during summer, so that peasants established water distribution schedules to ensure sufficient water for all purposes such as irrigation, drinking water and hydropower.

## 9.4 Living in the Danger Zone

Though natural disasters are not directly triggered by human activities and thus not ranked in a narrower sense among forms of degradation, their impact on land user's livelihood can be quite high. The potential for natural hazards is owing to the mountainous topography omnipresent: The steep relief which is in general prone to

86 The acute problem connected to wind erosion on pastureland is discussed above.

87 The only indicator for water pollution was unusual algae fouling of a stream, which was an effluent of the village of Roshorv (1000 inhabitants) with relatively large areas of arable land. The presence of algae indicates eutrophication of the water and a washout of the nutrients of the plots.

88 Some springs have too high alkaline mineral content, which makes the water unusable for washing clothes.

***Picture 2.34:*** *An immense debris flow buried the entire village of Dasht. It is one of many natural disasters threatening the Pamiris. (Photo: R. Droux, June 2003)*

rockfalls, avalanches and landslides; the tectonic activity increasing earthquake risk and the great number of small mountain lakes which are a latent source of debris flow are the most common natural disasters occuring in the Pamirs. **Debris flows** or floods caused by overflowing mountain lakes and mudflows induced by intense precipitation or by leaking irrigation channels were observed in a majority of the villages investigated. In particular, the debris flows cause great havoc and fatalities.[89] Flood waters tend to wash away the alluvial riverside lands which used to be riparian forests. Avalanches and rockfalls seldom threaten villages or houses, because of century-old settlement areas are hazard-safe sites. But latter forms of hazards permanently destroy roads and bridges, so that most of the main valleys in GBAO are often cut off from the outside world during winter.

## 9.5 Regional Overview of Degradation

The authors made inspections in five different valleys during the field study in GBAO, to get an overview of the status of the woodlands. This allowed an appraisal of the degree of degradation of forest at a regional level. The examined valleys were the Shakhdara, the Vanj, the Bartang an parts of the Yazgulom an Pandzh valleys.

The **Shakhdara Valley** is one of the few valleys which is still home to larger *tugai* forests consisting of full-grown birch (*betula pamirica*), willows and poplar trees. Mainly at the centerpiece of the valley, where the road and the villages are rather far from the floodplains, the forests have a large extension and are still in quite good conditions. In the side valleys of the Shakhdara there are some detached forests situated on small plains. But the remaining woodlands are partially cut or at least the bushy underwood has disappeared. There are virtually no virgin forests left. It is striking how the forests situated near villages and roads are in a much worse state than forests across the river, where accessibility is limited. The successive disappearance of forestlands is typically shown on some sites in the Shakhdara (see Picture 2.27). The first stage involves cutting bigger trees used as construction material. The second stage involves successive snapping-off or chopping of the coppice, which is additionally marred by browsing of the livestock as forests in the floodplains are commonly used as pastureland for livestock. The forest turns first into a pastureland and in case of overgrazing the terrain is prone to develop a salt-crust preventing even the grass. What remains are sandy, barren sites.

*Teresken* is mainly used in these villages located on higher altitudes and where the distance to the forests is too long. It is assumed that these villages use *teresken* bushes as fuel, thus contributing to the degradation of the pastureland and accelerating the desertification process.

The **Vanj Valley** is quite accessible and was rather well equipped with an infrastructure during Soviet times. This valley has slightly better conditions for growth of riparian forests than the other ones: sufficient precipitation and large floodplains. That means areas with juvenescent brushwood forest are quite widespread in the Vanj Valley. But here also, owing to the insufficient energy supply, forestlands and areas covered with *teresken* are declining because of illegal cutting and collecting. The forestlands contain only young undergrowth, full-grown trees are very rarely observed in the riparian forest. *Teresken* slide tracks are often observed on the hillsides. Owing to the higher precipitation, the slopes are more likely be eroded. On several spots rills were observed, which were perpendicularly aligned to the slope and indicate the erosive impact of water. In the **Yazgulom Valley** local peasants reported that the *teresken* bushes are mainly gone. The unsustainable energy resource management becomes clearly manifest in the high number of *teresken* slide tracks marking the hillsides.[90]

Generally speaking, the forestlands which used to grow in the **Bartang Valley** have virtually disappeared. Due to the predominant narrow floodplains, the potential

89 An enormous debris flow wiped out the entire village of Dasht in the Roshtkala district in autumn 2002. An overflowing mountain lake situated underneath a glacier triggered this mass erosion (see Picture 8). A similar event killed two people, 20 cows, 78 sheep and goats and destroyed the intake of the future small hydropower plant in Poimazor (Vanj district) in summer 2003. Another debris flow occurred in the village of Khidorjev (Roshtkala) in 1997, destroying settlement areas, meadows, cropland, five houses and the new school.

90 The authors observed peasants from Andarbak collecting firewood at a distance of more than five hours from the village.

areas for riparian forestlands are extremely limited. Since virtually all the woodlands in the lower and the middle parts have been cut by overuse of biomass fuels the bulk of the land users nowadays rely on *teresken* shrubs to satisfy their demand for energy. Hence degradation of pastureland in the whole Bartang Valley is one of the major problems. Although the far end of the valley is populated by some distant larger forests, the energy crisis is still dramatic, as the forests are accessible only to a limited extent.

***Conclusions***

The present base of natural locally available resources and its management is highly inadequate when it comes to the present population's demand in the Tajik Pamirs. The carrying capacity of the soil and of the locally available biomass energy resources has been exceeded. Thus the pressure on these resources is extremely high in Gorno Badakhshan, causing various forms of degradation. The most frequently recognized main causes of land degradation in GBAO include deforestation of woodlands and clearance of *teresken* terrains, both triggered by the overuse of woody biomass used as fuel and additionally worsened by livestock grazing. This conjuncture of an inroad on pastureland causes large deserted areas subject to wind and water erosion. The degradation of forest and pastureland has already had consequences in the social sphere, and mainly in very remote and undersupplied regions. In most regions women, sometimes helped by children, are responsible for fuel wood collection. Due to the overuse of woody fuel, the allocation patch has had to be successively enlarged. In certain regions, where the fuel scarcity is extremely high, virtually all the women suffer from severe health problems caused by the drudgery of fuel wood collection.

Although the land users are aware of consequences of the degradation. For the most part they do not adapt their management because of a lack of meaningful and affordable alternatives. Especially in the field of energy resources, affordable alternatives are virtually non-existent. For the most part economic reasons prevent peasants from purchasing needed goods. Furthermore, knowledge in terms of adequate land and resource management is lacking. Nowadays, one auspicious mean for mitigating the depletion of the vegetation is electricity, only having a great potential to reduce the pressure on biomass fuels under certain conditions (see Chapter 15.).

Inadequate irrigation is another main cause of land degradation. Mainly owing to overly intense irrigation the top soil becomes eroded, the soil surfaces are salinized and landslides are triggered by waterlogged slopes or leaking irrigation channels. The most frequent indicator of inappropriate cropland management are decreasing yields and increasing demand for fertilizer. On the other hand, inadequate crop rotation and missing organic matter in the soil[91] diminish the soil fertility. To mitigate these problems the peasants should first become aware of the reasons, the processes and the consequences of soil degradation. This lack of knowledge can mainly be met by practical agricultural education. Moreover, affordable means and goods must be available to foster the self-sufficient agriculture. But without yield increases the land users will be unable to meet foodstuff demands. Consequently, either the output per acreage must be improved or the cropland enlarged, implicating a higher expenditure of human labor.[92] However, the idea of a self-sufficient and self-supplying GBAO is on the one hand totally unrealistic, because of the biophysical potential regarding the amount of inhabitants, and on the other hand a preventive factor for general development of the Tajik Pamirs, where the highland-lowland interrelation must be fostered.

Although natural hazards are not considered as a degradation, they are latent threat and sudden natural calamites aggravate the inherently hard livelihood of the land Pamiris.

***Reference:***

Stocking, Michael and Niamh Murnaghan (2001) Handbook for Field Assessment of Land Degradation. London: Earthscan Publications Ltd.

91 Dung is insufficient to feed the plots, artificial fertilizer is used if it is affordable. Additionally, virtually no organic matter remains on the fields because agricultural residues are all used as fodder.

92 In regions like the Pamirs with scarce arable land, the improvement of the output per acreage seams to be the more appropriate strategy. But the yield is already considerably high: on average 30kg per acre (Field study 2003).

# 10. Vezdara: A Village with Electricity from the Grid and a Micro Hydropower Station

## 10.1 Introduction to the Village Studies

For investigation of energy resource use and consumption, three case study villages with contrasting energy resource bases were selected (see Map 2.3):

The first village is **Vezdara,** a small settlement (28 households) located in the Roshtkala district around 47km southeast of Khorog. Regular electricity supply is provided from the main grid in summer and from the community based micro hydro scheme in winter. The middle section of the Shakhdara valley still has a relatively dense vegetation cover, characterized by riparian forests, which serve as a firewood source.

**Savnob,** the second village is located at the far end of the Bartang valley in the Rushan district and is home to 56 households. A micro hydro scheme managed by Pamir Energy Company (PEC) supplies the village year round with power. Remains of small forests (willow and thorn bushes) in the floodplains and shrubby plants covering the slopes of the mountains characterize the vegetation in this remote region.

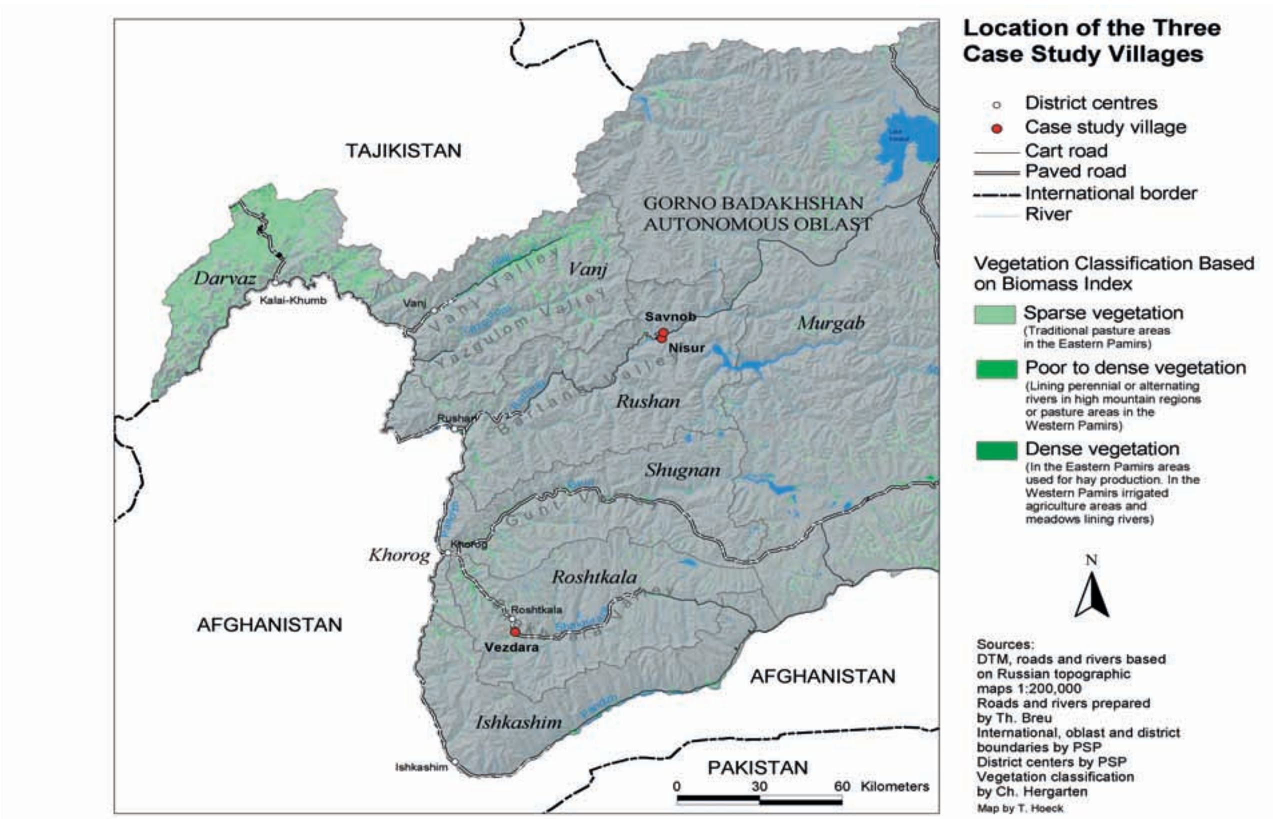
The third village is **Nisur,** a neighboring community of Savnob, has a more or less identical energy resource base except that it has never enjoyed electricity supply. Nisur is home to 35 households.

The research procedure performed in each village, and the different methods applied for data generation are described in (chapter 5.1).

The following three chapters, each of it dedicated to one case study village, have a similar form: A short overview of the village and its energy resource base is provided, energy consumption at household and village levels with a focus on resource degradation is discussed, and a possible scenario towards a sustainable energy resource use is suggested. The investigation focuses on the household sector and does not consider energy expenditures for mobility and activities in the agricultural or industrial sector. In Chapter 13 the findings from the three case studies are compared and analyzed.

## 10.2 Vezdara – the First Case Study

Vezdara is situated in the Rostkala district 47km or 1.5 hours drive from Khorog at an altitude of 2800m above sea level. The site is a confluence of a side valley actu-




***Map 2.3:*** *The Location of the Three Case Study Villages Vezdara, Savnob and Nisur in the Western Pamirs. Source: T. Hoeck*

ally named Vez-dara[93] and the main valley called Shakhdara. Vezdara is home to 28 households, a school, a library owning mainly Soviet books, a medical point, the *hukumat*[94] office and a private shop selling products varying between imported foodstuffs (for example US and Kazakh flour) and basic products such as light bulbs and matches as well as cheap Chinese articles such as rubber boots and toys. Three traditional well-lit watermills are located in Vezdara grinding 30-40kg of grain per hour. The river coming down the Vez-dara feeds a total of eight water channels supplying four other neighboring villages. The availability and the quality of Vezadra's water is very good. Due to the 140km dead-end road leading up the valley, no interregional transit traffic passes through the village. The next larger bazaar is located in Roshtkala center (10km away from Vezdara), where local and international products are sold and a quite well-equipped hospital as well as other important infrastructures are situated. Thus major shopping and trade is done mainly either in Roshtkala or even in Khorog. A regularly scheduled bus shuttles in summer every day between Vezdara and Khorog and is mostly used by traders selling agricultural products at Khorog's bazaar.

During Soviet times a slaughterhouse was located in the village. At that time people chiefly grew grass as fodder. Most of the livestock belonged to the *kolkhoz* and was brought by truck to the high pastures (Javshangoz) situated at the very end of the main valley during summertime. Most of the villagers used to be employed by the government, earning a reputable salary. An average teacher's salary was 147 rubles (USD 150), a great deal of money compared to the present salary of 25 *somoni* (USD 7.94). There was no real need to cultivate the lands for self-supply, and most people earned enough to purchase goods in the shops.

| |
|---|
| Village: Vezdara |
| Jamoat: Barvoz |
| District: Roshtkala |
| Altitude: 2800 m asl |
| Households: 28 |
| Inhabitants 2003 (1992): 197 (217) |
| Average members per household: 7 |
| Female/male ratio: 70%/30% |
| Sheep and goat 2003/1995 (per hh): 100/485 (18) |
| Cattle 2003/1995 (per hh): 54/135 (5) |
| Village territory: 1606ha |
| High pasture: 10ha |
| Average arable land per hh: 2500m$^2$ |
| Arable land per cow dung unit: 484 |
| Forest: 4ha |
| Nonproductive land: 110ha |
| Heated space: 40-160m$^3$ |
| Mean annual precipitation: ~300mm |
| Minimum winter temperature: -23°C |
| Distance to Khorog: 47km |
| Distance to Rostkala (district center): 11km |
| Public infrastructure: school, medical point, library, *hukumat*, shop, 3 mills, mineral water spring, MHPS |

***Picture 2.35:*** *Vezdara is situated on a tributary of the Shakhdara (main valley in the background) and is home to 28 households and a small hydropower scheme (mid: water channel and forebay tank). (Photo: R. Droux, June 2003)*

The Soviets started to establish a sanatorium fed by the slightly warm mineral source located 7.5km from Vezdara further up the side valley. They installed iron tubes leading down to the village, which, due to the high amount of diluted minerals in the water, corroded and became damaged within a few years. Owing to this particular mineral compound and the tepid temperature, the water features a perfect ecosystem for red algae, so that it looks like blood.

Between 1993 and 1999 Vezdara was supported by the Aga Khan Foundation (AKF) with humanitarian aid such as wheat, flour, vegetable oil and a corn-soya blend. In 1996 the arable land and the livestock was equally distributed among all inhabitants.[95] Each year the cultivated area was extended so that today the average household owns 2500m$^2$, which is not sufficient for a total self-supply. Nowadays villagers mainly cultivate wheat and potatoes, and a few have a small kitchen garden. Due to this self-supply, they rely highly on their own harvest. The majority of the households have an external income resource such as relatives living in Dushanbe or abroad, sending money back home or husbands earning money as taxi drivers for example. Hence the gender ratio of

93 In Tajiki "Dara" is the word for valley.
94 The hukumat is the local administration office (Tajiki word for 'government').
95 Each family member received 300m$^2$ of arable land.

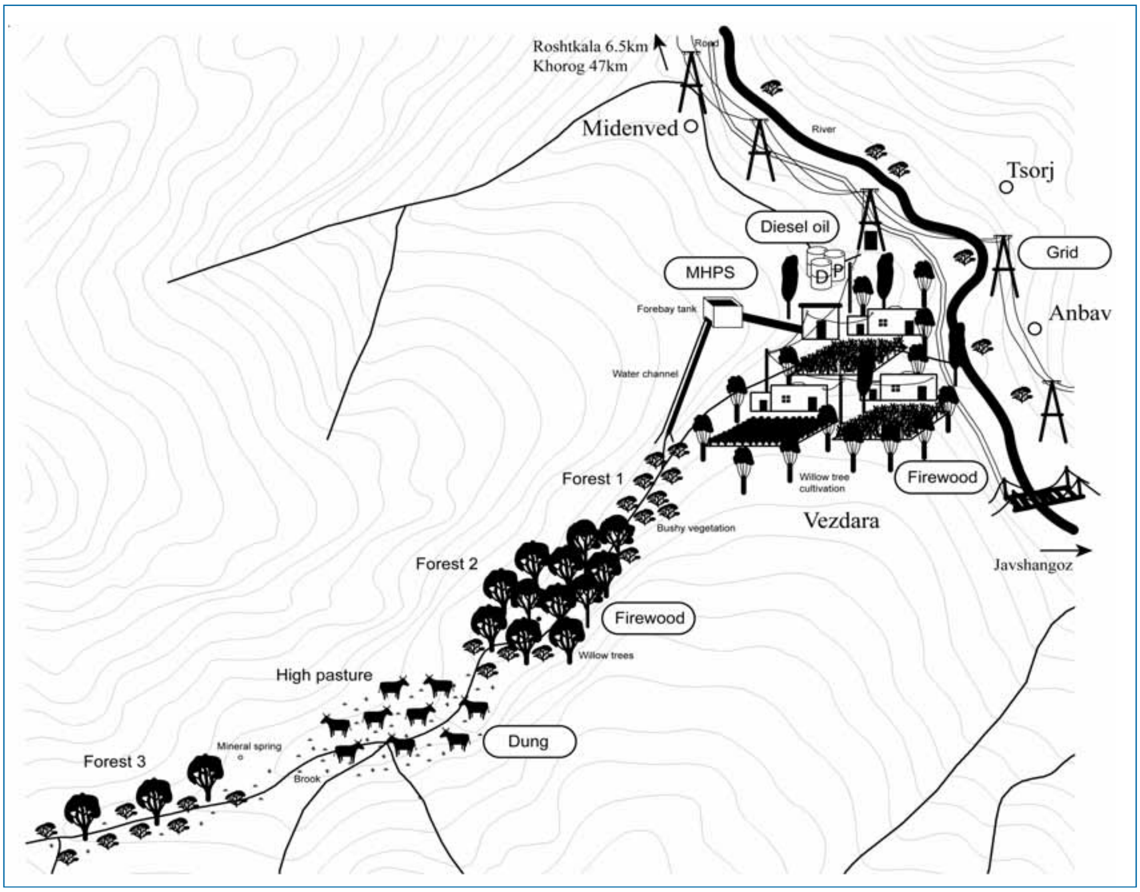



***Figure 2.14:*** *Scematic Sketch of the Village of Vezdara Depicting the Major Assets and Energy Resources. Source: Sketch by T. Hoeck*

70% female and 30% male person is not surprising. Due to the fact that in the last five years mainly young men emigrated in hope of finding a job, earning money or studying, the women's livelihood in the village worsened appreciably. Although the following derogatory statement, is somewhat exaggerated, it reflects the aggrieved feelings of many women:

*"The only man who did not leave our village is the chairman of the VO. If we had the money we would also leave."*[96]

This additional income is insufficient to relieve villagers daily backbreaking labor such as cultivating crops, harvesting and collecting firewood, with paid services, so that it has to be done from now on by the women and children.

In 1999 the villagers of Vezdara established their own village organization (VO), supported by the Mountain Societies Development Support Programme (MSDSP).[97] The first major project initiated and realized by the VO was the MHPS, completed in 1999. Each VO member has to contribute a quarterly fee of 0.45 *somoni* (USD 0.14), mainly paid in cash. The largest incomes for the VO are generated by the electricity fees and by the livestock belonging to the mini hydropower station (MHPS). These funds are used as credits for students, for weddings and funerals or to establish a commercial enterprise. In addition, the chairman and the accountant are paid monthly with twelve and six *somoni* (USD 1.90) from this cash. Another element of expenditure is the MHPS, which sometimes has to be repaired. In 2001 the VO started new projects such as a chicken farm and a guesthouse, both of them under construction at the time of investigation. In accordance with Vezdara's VO, four neighboring villages agreed to establish a new 200W hydropower scheme in Vezdara, whose construction started in summer 2003. Another future project is to rehabilitate the tubes and establish a mineral water enterprise or a sanatorium, although funds are still lacking.

One branch of the VO is the women's committee, which holds monthly meetings where gender-specific issues are discussed. In 2001 they implemented a small reforestation project, and a year later they initiated a vegetable growing project, followed by distribution of flowerbed covers for the kitchen garden. Thanks to the

96 This statement was made during a group discussion with the women's committee, where men were absent.

97 MSDSP is the implementing branch of the Aga Khan Foundation (AKF) in Gorno Badakhshan (GBAO). They realize projects in the fields of humanitarian assistance, infrastructure, credit and marketing, social organization development, agriculture and agricultural diversification.

initiative of the VO chairman and the commitment of the villagers, the livelihood in Vezdara has noticeably improved.

## 10.3 Energy Resource Base

The only ten kV power line still existing in the Roshtkala district was drawn up the entire Shak-dara in 1974. During thirteen years Vezdara was regularly supplied with electricity from the main grid. In that period each household additionally received five tons of coal per year. Regarding energy provision two momentous events happened nearly simultaneously, just after the collapse of the USSR: Cessation of the coal provision (all the fuels were no more subsidized and unavailable) and disconnection of electricity during winter. Due to this tremendous cut in the energy supply villagers were suddenly dependent on local available resources such as wood and animal dung. The pressure on these resources increased rapidly within the next few years, additionally heightened by the immigration of refugees during the period of civil war. In 1996 the village counted 365 inhabitants, of whom more than 40% were refugees.

From the five primary forests that surrounded the village only two still exist. Two of them disappeared completely within the last ten years due to overuse of woody resources. Two forests used by the villagers are located further up the Vez-dara on the way to the high pasture where 520 sheep and goats and 350 cows graze, herded by a family from Vezdara living there in summer. Due to the distance to the village, forest 3 (see Figure 2.14) is almost in its original state and used extensively by grazing cows. Officially, all forests belong to the governmental forestry office (*leskhoz*) and people would require a permission for cutting trees. In fact, forests 1 and 2 serve freely as a source of firewood. Mainly dry fallen-off branches are collected by children. However, villagers remove verdant branches from the bushes in order to collect them later when they have dried.

***Picture 2.36:*** *Children carry dead wood from forest 2 down to the village. The branches were lopped off, dried and then collected. This is the common way to legally obtain firewood free of charge. (Photo: T. Hoeck, June 2003)*

Within the village territory the density of willow and poplar trees is relatively high, but there are virtually no fruit trees. Some households are able to purchase firewood from other *leskhoz* forests in the Shakhdara.

Beside usage of manure as fertilizer, virtually all households in Vezdara use dried dung cakes as burning material only in winter. The manure is cut by a spade from the stables, sometimes molded manually, mostly dried in the backyards, and stored on the flat roofs of the houses.

The only fossil fuel regularly used for lighting is diesel oil. Some households still have the old kerosene lamps which nowadays have all been converted into diesel lamps and used in case of an electrical power outage.

Since the village is only supplied with electricity in summer, the villagers initiated a project to establish an MHPS. In 1992 the dream of having electricity in winter came true. Owing to Soviet second-hand equipment, power production has declined in terms of time but is fairly reliable. The small grid was gradually extended by connecting two neighboring villages. Hence the capacity per household decreased dramatically so that nowadays the villagers use electricity mainly for lighting. Further information about implementation, management, operation and impacts of the MHPS in Vezdara is discussed in the following section or in the Chapter 8.2.7.

***Box 2.2: Background of the Energy Supply***

| | |
|---|---|
| 1974: | Connection to the electric grid from the hydro power plant in Khorog, with no prior supply of electricity |
| 1991: | Cessation of coal provision |
| 1992: | Disconnection of electricity during winter time |
| 1995/96: | Immigration of more than 140 refugees to Vezdara (due to the civil war) |
| 1999: | Construction of the small hydro scheme in the village |
| Since 1999: | The villagers have not been billed by the hukumat for the electricity |
| 2002: | Connection of 10 new households to the MHPS (from the neighboring village) |
| 2003: | Establishment of the Pamir Energy Company (PEC) |
| 2003: | Construction of a new 200kW hydropower scheme |

## 10.4 Mini Hydropower Station (MHPS)

Due to the disconnection in winter of the Roshtkala district from the main grid in 1992, people from Vezdara had the idea of constructing an MHPS already at that time, although no donor was found. In 1999 the AKF allocated funds, donated by the Swiss Agency for Development and Cooperation (SDC), to establish an MHPS. During eight months the local women, men and even children constructed the water channel, the forebay tank, the engine house and the foundation for the penstock. Each household donated one farm animal to the MHPS for further maintenance and possible repairs. At the time of inspection the MHPS owned three cows and 47 sheep and goats serving as a stock in case of larger repairs.

In November 1999 the MHPS started to generate electricity for all 28 households and most of the public buildings (school, library, med-point, *hukumat* office, mills) but only from 6 am to midnight in winter. The villagers only want to use power when it is really needed, in order to reduce maintenance costs and to increase longevity. In 2001/ 02 two neighboring villages (Anjin and Anbav) were connected to Vezadara MHPS. Due to this grid extension the average electricity ration per household was reduced from 645 to 370W.

The MHPS is equipped with a 32kW generator which formerly served as a Soviet diesel generator, and a turbine, which was dismantled from an unused irrigation pump. The 9m$^3$ storage basin is fed by a 115m long water channel. Even in winter the water never freezes and the runoff is enough to generate the full output. Nevertheless, due to the risk of overheating during peak-periods, the mechanics reduce the MHPS capacity, so that the output averages 20kW. During these periods only households located near the MHPS are supplied with sufficient capacity. With increasing distance to the MHPS the capacity decreases strikingly so that in distant households (more than 500m distance) the bulbs have a reddish and dim light. Two machinists earning 13 and 15 *somoni* (USD 4.13 and 4.76) per month are responsible for maintenance, operation and collecting the monthly fee of 2.5 *somoni* (USD 0.80) er household. This income is enough to cover the usual expenses. In case of bigger damages – an entire turbine once had to be replaced – the VO sells some of the MHPS-livestock to obtain money.

In general, the MHPS runs quite steadily and only small spare parts have to be replaced.

## 10.5 Future Mini Hydropower Station

After estimation of the potential for hydropower in Vezdara, made by an engineer from the Pamir Energy Company (PEC) in the summer of 2003, the neighboring villages started to construct a new road to build a 200kW hydropower scheme in Vezdara. The initiative was taken by the villagers of Midenved, which is not supplied with electricity during winter. The VOs already collected 9450 *somoni* (USD 3000) and 29 sheep, goats and two cows from the future beneficiaries, a 200kW generator and a turbine. The only missing part is the 170m long penstock. It is anticipated that the MHPS will be finished in November 2003 and Vezdara (28 households), Midenved (44 households), Tsorj/ Anjin (26 households) and Anbav (13 households) will be connected. People from all these villages, except for the inhabitants of Vezdara will participate in the construction of the new MHPS. The existing MHPS will serve in cases when the other facility is out of order.

Nowadays each household is supplied with less than 0.4kW. As soon as the new MHPS is established, each household will be supplied with 1.6kW, which can at least cover the needs for cooking, baking and heating water.

The future MHPS will be placed 50m below the existing one, so that no additional channel is required. The forebay tank has to be enlarged to feed the new MHPS with a runoff of at least 300 liters per second. According to the responsible engineer, the minimum runoff in winter should be insufficient to generate the full capacity of the 200kW hydropower scheme.

Potential beneficiaries would be willing and able to pay up to five *somoni* (USD 1.59) per month as an electricity fee. Obviously not every household has the ability to pay this amount but the majority of the households are capable of paying more than the present fee of 2.5 *somoni* (USD 0.79).

## 10.6 Local School

In 1979 the school was supplied with current from Khorog, which was used mainly for lighting. To heat the classrooms during winter the school received a certain amount of firewood and coal from the *hukumat*. Nowadays such governmental resource support is non-existent. Teachers therfore cultivate willow trees in the school's back yard, cut off branches in springtime, dry them during summertime and use the wood for heating purposes in winter. In 1999 when the MHPS was finished, villagers and the MHPS committee first refused to connect the school to its grid. After some VO-meetings they nevertheless agreed to supply the school with power from the MHPS.

During Soviet times each classroom was equipped with a small metal stove. In 2002 the school purchased eight 2000W electric arc furnaces (Souzan 444, made in China) for 432 *somoni* (USD 137) but they only can use four of them because of the hydro scheme's low capacity. One of these electric arc furnaces can heat a small classroom.

## 10.7 Household Energy Consumption Patterns

The basic domestic needs in terms of energy resource use at the household level in summer are: Baking bread, preparing hot meals, heating water mainly for tea, lighting, watching TV and listening to the radio. Heating the accommodation and water for washing and bathing are additional needs in winter. In general warm meals are prepared twice a day and, depending on the number of household members flatbread is baked at least once a day. Box 2.3 shows the importance of bread in the daily diet of the Pamiris. Bread is by far the most important food[98], followed by potatoes, vegetables and rice. Although foodstuff diversity is very limited people do not exercise much variety in preparing it. Most of the meals are cooked or baked and raw nourishment, other than fruits, is generally not the custom. Meat is occasionally prepared, predominantly in winter.

***Box 2.3: Villagers' Daily Diet in Vezdara***

Breakfast: Consists of *shir choi* (tea with milk, salt, oil and soaked bread)
Lunch: Consists of tea, bread and sometimes yogurt
Dinner: Consists of tea, bread, soup with potatoes or other vegetables or rice. Occasionally some meat is added.

Metal stoves, which are furnished with a pipe leading the smoke through the roof opening, were purchased by all households in Vezdara mainly during Soviet times. There are two types of metal stoves: an old one designed for use with coal is made of cast iron, and a newer one is made of sheet metal. These metal stoves replaced the traditional clay fuel stove called *kitsor*. It is embedded in the elevated living area inside the traditional Pamiri house and nowadays used only for weddings or funerals. The traditional half-round outdoor standing stove used for cooking and baking is virtually non-existent in Vezdara. It has been completely replaced by electrical appliances and metal stoves. In winter, the metal stoves serve as a heating source for cooking, baking, heating water and room heating. During the nineties some households purchased a handmade metal stove made out of oil barrels. Depending on use, this type of metal stove is more efficient for cooking and heating water than the old Soviet stove which was designed for coal. The thick-walled Soviet stove emits the warmth somewhat slower but also keeps the warmth longer, making it better for room heating.

Due to the low capacity of the MHPS, no household is able to use electric arc furnaces. In Vezdara all households are connected to the electricity grid so that electrical appliances are used in every household. There are few families that still have and use kerosene lamps which are fueled nowadays with diesel oil. Normally lighting is done with electricity. Bulbs are used in a range of 75 to 500W with 100W as most common. Nearly all households have an electrical coil cooker, mainly a hand made version consisting of a drainage tube in which a spring is placed that becomes red-hot due to contact resistance (see Picture 2.37). The capacity depends very much on the availability of electricity. Wealthier households have an additional single hot plate. There are different types of electric ovens used in Vezdara, with the majority of the households possessing one and using it for baking. Most of the electric kettles (2500W) made of aluminum were purchased already during Soviet times. Some wealthier households have a constantly running refrigerator (130W), a relict from the Soviet era. Many households own a TV set and use it several hours a day. Nowadays only richer household are able to purchase consumer electronic devices.

The villagers' energy consumption patterns vary noticeably between summer and winter, because of the uneven seasonal availability of electricity and the higher demand for energy resources during winter.

Wood, especially from the willow tree and collected

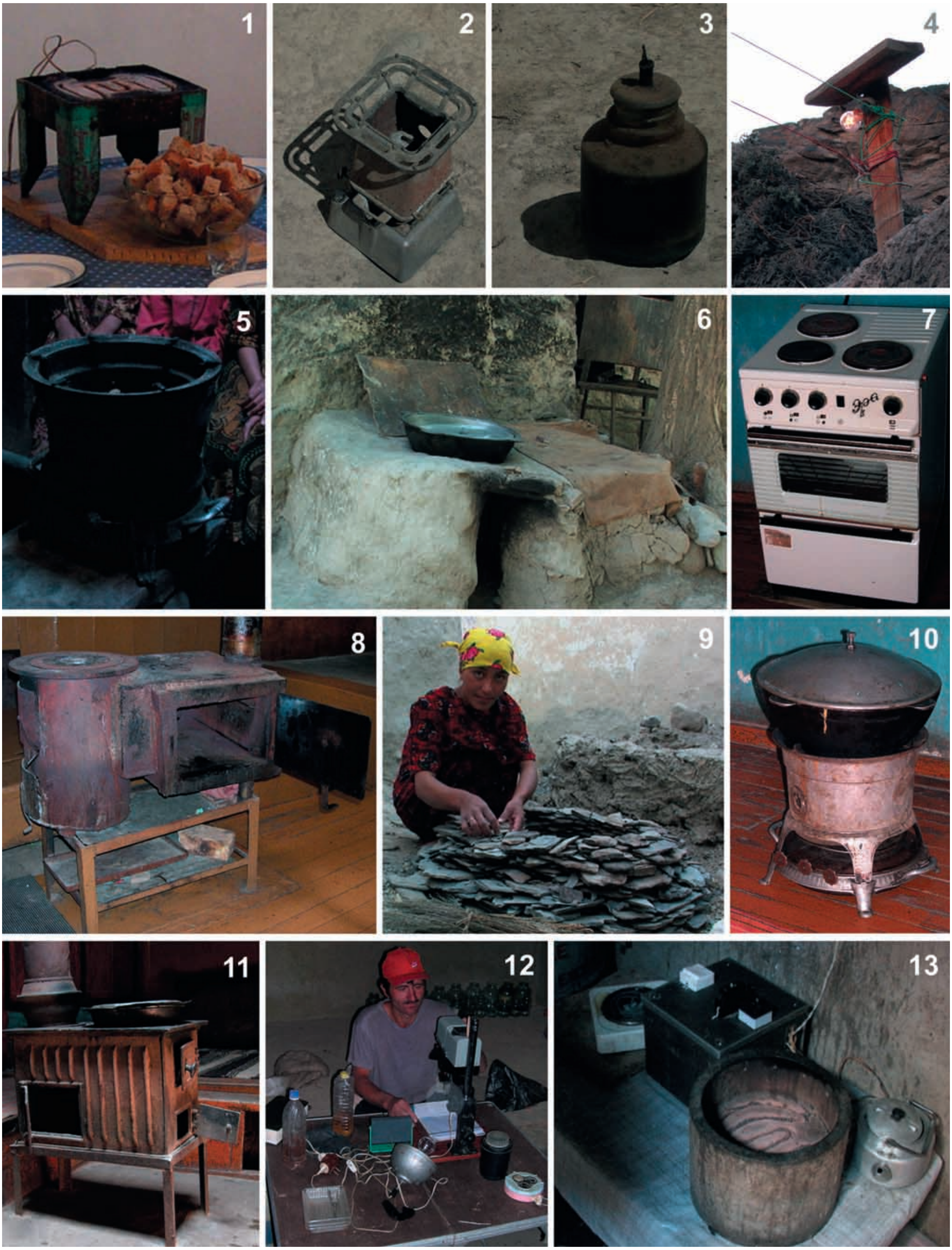
***Table 2.11:** Energy Resource Consumption for Different Purposes.*

| Domestic demands | Firewood | Dung | Electricity | Diesel oil |
|---|---|---|---|---|
| Cooking | ○ ❄ | ❄ | ◯ ⁕ | ⁕ |
| Heating water | ◦ ❄ | ❄ | ◯ ❅ | |
| Baking | ◦ ❄ | ❄ | ◯ ❅ | |
| Room heating | ❄ | ❄ | ⁕ | |
| Lighting | | | ◯ ❄ | ⁕ |
| TV, radio | | | ◯ ❄ | |
| Refrigerator | | | ◯ | |

◦ ○ ◯ Degree of application in summer (low, medium, high)
⁕ ❅ ❄ Degree of appliaction in winter (low, medium, high)

*Source: Field study 2003*

[98] There is an apposite saying characterizing the Pamiri's predilection: Their side dish for bread is bread.




***Picture 2.37:*** *Compilation of Electrical and other Appliances. (1) Coil cooker, (2) kerosene cooker, (3) oil lamp, (4) light bulb (100W), (5) kerosene cooker, (6) kitsor (traditional stove), (7) electric oven, (8) improved metal stove, (9) kitsor under construction, (10) kerosene cooker, (11) Soviet coal stove, (12) photo laboratory, (13) Improved self-made coil cooker, electric kettle, voltage stabilizer, hotplate. (Photos: R. Droux and T. Hoeck, June 2003)*

either in the forests, on the riverside after being washed ashore, or cut in one's own orchard, tends to be used for heating and cooking purposes. Some families cultivate more than eighty trees around their houses as a firewood source. They cut only the branches at a height of two to three meters (see Picture 2.40) in springtime, using the greenery as fodder and drying the branches during the dry summer months to store it for winter.[99]

Besides using wood as an energy resource, the villagers also use wood to construct their houses, usually three to four rooms. But certain species serve a special purpose: Willow trees, due to their high efficiency, are used mainly as firewood and the branches in rare occasions for making baskets. Poplar trees are used exclusively for construction purposes, because of their upright growth. To aid this process the branches are cut completely up to a certain height. Thus the tree increases the biomass gains vertically and can be cut within ten to fifteen years. About thirty such poplar trees are needed to construct a traditional Pamiri house. Not all the trees serve as firewood or as construction material. The following statement of a villager depicts a spiritual-religious meaning of the laurel tree which has its origin in a pre-Islamic natural religion.[100]

*"Yes, it is forbidden to chop down these trees. They have spirits inside them. If someone chops down a young laurel tree, something bad will happen affecting him personally or his house or the whole family. They might get sick physically or mentally. That is why people do not cut them."*

Almost all households use dung in combination with firewood for heating rooms in winter.[101] Use of dung as fire material competes intensively with use as fertilizer. Every household struggles when partitioning of the manure between application as fertilizer and use as fire material. Because a great deal of the households use artificial fertilizer, up to 80% of the manure can be used as fire material.

Electricity, coming from the main grid, is mainly used for lighting, cooking, baking, boiling water and running the aforesaid appliances during summertime. Due to the inappropriate capacity of the MHPS, people can barely use electricity for cooking and baking in winter. The capacity from the MHPS is far too small so that villagers could heat their houses with electricity.

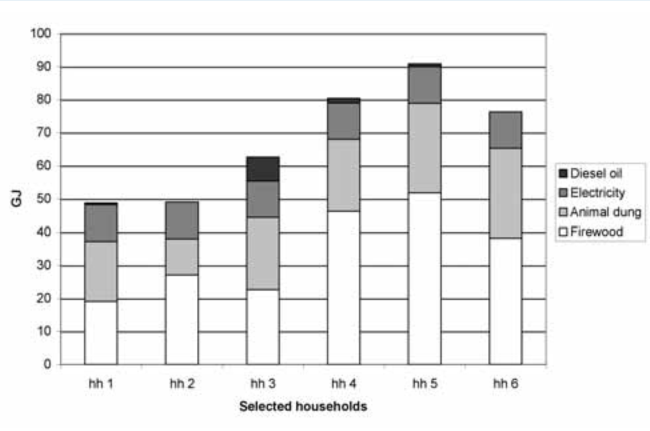



***Figure 2.15:*** *Annual Energy Consumption in GJ of the Six Investigated Households[102] in Vezdara. The data for electricity consumption is averaged across all households, individual electricity consumption data was not available. Hence the amount of consumed electricity in the table is the same for each household. Source: Field study 2003*

In case of electrical power outage, diesel oil is used in old kerosene lamps for lighting. Families with nursing babies often use diesel lamps at night because the MHPS is disconnected then.

Some considerably wealthier households mainly use single-serve and rechargeable batteries for flashlights. Nevertheless, the quantity of consumed energy from batteries is negligible.

Table 2.15 summarizes the energy consumption features of the six households investigated in Vezdara. Energy resource quantification is based on empirically collected data and interview statements from the villagers. The maximum required capacity is the potentially highest electricity demand in these six households, when all appliances are switched on. In fact, this case is unrealistic and simply serves as a theoretical peak value. Based on experience the estimated minimum supply of one household represents an electricity requirement of 1500W. Obviously this capacity is insufficient to run all the appliances synchronically but it is satisfactory to run at least one single powerful appliance. Further information about the monthly minimum electricity demand is discussed in the Chapter 10.16.

To cover domestic needs, people in Vezdara use a combination of firewood, dung, electricity and some diesel oil. Figure 2.15 shows that local available resources (animal dung, firewood) dominate consumption patterns to a remarkable degree. Firewood is the essential energy re-

99 This arboriculture practice is known as "pollarding" and is applied in woodland management. This method is also practiced by removing all minor branches of a tree to leave just the trunk and a framework. The tree is then allowed to grow again over a period of years, after which the process may be repeated.

100 Based on a legend in which Nosir Khusraw, a sage poet and philosopher from the eleventh century, planted a young laurel tree in Bardara (middle Bartang valley, Rushan) nowadays a sacred place is situated. This huge laurel tree is still kept in honor and has attained a height of more than ten meters.

101 A majority of the households restrict dung consumption to December, January and February.

102 For more detailed information about the selected households the reader is referred to the Appendix 3.

***Table 2.12:** Household Energy Consumption Patterns of Six Households in Vezdara. Due to the PEC's flat rate the outlay for electricity is the same for all households though in fact they have a different electricity consumption.*

| | Hh 1 | Hh 2 | Hh 3 | Hh 4 | Hh 5 | Hh 6 |
|---|---|---|---|---|---|---|
| Members | 7-8 | 7 | 4 | 9 | 5 | 13 |
| Category: 1=poor, 2=middle, 3=rich | 2 | 3 | 3 | 1 | 2 | 1 |
| Arable land: $m^2$ | 2000 | 2400 | 2500 | 2500 | 2400 | 6400 |
| Artificial fertilizer (kg/y) | yes | yes | yes (50) | yes | yes | yes |
| Dung used as fertilizer/ fire material | 50%/50% | 20%/80% | 75%/25% | 50%/50% | 50%/50% | 50%/50% |
| Arable land per cow down unit | 324 | 389 | 405 | 405 | 389 | 1037 |
| Sheep and goats*: mean | 18 | 18 | 18 | 18 | 18 | 18 |
| Cattle*: mean | 5 | 5 | 5 | 5 | 5 | 5 |
| Donkey | no | no | no | no | no | no |
| Monthly income: somoni (USD) | 50 (15.87) | 200 (63.49) | 100 (31.75) | 14 (4.44) | 13 (4.13) | 7 (2.22) |
| Size of heated room: $m^3$ | 150 | 40 | 150 | 160 | 137 | 136 |
| Electrical and other appliances | Light bulbs: 3x100W, TV, self-made coil cooker (out of order, used as fireplace), electric oven, traditional stove, metal stove | Light bulbs: 3x100W, new color TV, new radio, video, modern electric oven (2x650W), self made coil cooker, single hotplate, traditional stove, metal stove | Light bulbs: 2x75W, 2x 100W, 1x 150W, Soviet TV, coil cooker, refrigerator (130W), electric oven, electric kettle, traditional stove, metal stove | Light bulbs: 3x100W, 1x 300W, TV (out of order) electric kettle (2500W), electric oven (out of order), tape player (out of order), coil cooker, traditional stove, metal stove | Light bulbs: 5x100W, TV, electric oven, electric kettle (out of order), tape player (sometimes working) traditional stove, metal stove | Light bulbs: 5x100W, TV, refrigerator (not in use), coil cooker, electric oven, electric kettle, traditional stove, metal stove |
| Maximum required capacity**: W | 1340 | 3995 | 5470 | 5440 | 4345 | 5470 |
| **Energy consumption** | | | | | | |
| Firewood: kg/y (GJ/y) | 1273 (19.1) | 1810 (27.15) | 1510 (22.65) | 3083 (46.25) | 3451 (51.77) | 2543 (38.15) |
| Dung: kg/y (GJ/y) | 1510 (18.12) | 906 (10.87) | 1812 (21.74) | 1812 (23.56) | 2265 (27.18) | 2265 (27.18) |
| Electricity: kWh/y (GJ/y) | 3054 (11.00) | 3054 (11.00) | 3054 (11.00) | 3054 (11.00) | 3054 (11.00) | 3054 (11.00) |
| Diesel oil: liters/y (GJ/y) | 15 (0.54) | 0 (0.00) | 200 (7.2) | 40 (1.44) | 25 (0.9) | 0 (0.00) |
| Annual energy consumption | 48.75 GJ | 49.02 GJ | 62.59 GJ | 80.42 GJ | 90.84 GJ | 76.32 GJ |
| Per capita energy consumption | 6.50 GJ | 7 GJ | 15.65 GJ | 8.94 GJ | 18.17 GJ | 5.87 GJ |
| Summer consumption | 22% | 11% | 9% | 14% | 18% | 7% |
| Winter consumption | 78% | 89% | 91% | 86% | 82% | 93% |
| **Expenses** | | | | | | |
| Electricity: *somoni* (USD) per month | 2.50 (0.80) | 2.50 (0.80) | 3.00 (0.95) | 2.50 (0.80) | 2.50 (0.80) | 2.50 (0.80) |
| Wastages***: *somoni* (USD) per month | 1 (0.32) | 1 (0.32) | 1 (0.32) | 1 (0.32) | 1 (0.32) | 1 (0.32) |
| Firewood: *somoni* (USD) per month | 0.00 (0.00) | 0.00 (0.00) | 33.00 (10.48) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| Diesel oil: *somoni* (USD) per month | 2.50 (0.79) | 0.00 (0.00) | 25.00 (7.94) | 7.00 (2.22) | 4.00 (1.27) | 0.00 (0.00) |
| Total: *somoni* (USD) per month | 6.00 (1.90) | 4.50 (1.43) | 62.00 (19.68) | 10.50 (33.33) | 7.50 (2.83) | 3.50 (1.11) |

* Averaged over the total village livestock.
** If all appliances are switched on
*** Bulbs, wires, appliances, heating coils
Conversion factors:
Firewood, *teresken*: 1kg = 15 MJ, dung: 1kg = 12MJ, electricity: 1h = 3.6MJ
Diesel oil: 1 liter = 36MJ

*Sources: www.worldbank.org, www.asystems.ch, www.bioheiztechnik.de, www.worldenergy.org, Rijal (1999: 226); Field study 2003*

**Picture 2.38:** *Firewood and dung are the major fuels in Vezdara. An average household annually consumes 2327kg of firewood and 1762kg of dung. (Photo: T. Hoeck, June 2003)*

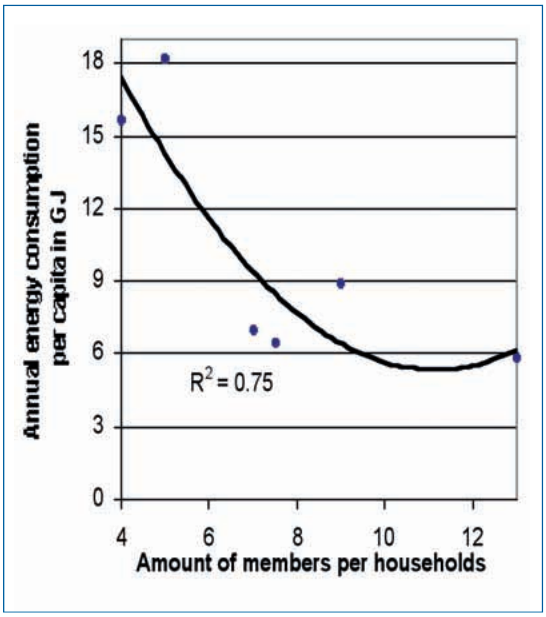



**Figure 2.16:** *Economies of Scales: Energy consumption of households in Vezdara. Source: Field study 2003*

source in Vezdara. Most households procure the needed firewood themselves because they are unable to pay for outside help. Households have their predominant energy consumption during winter: Between 78-93% of all energy resources are used in the winter season. Due to the low temperatures, people are forced to heat their houses, consuming a huge amount of energy resources. The daily wood consumption exemplifies these seasonal differences: 5-15kg of wood is used during winter and two to four kg in summer. This difference results from the fact that during summertime most households cook and bake with electricity whereas these activities are done mainly with firewood and dung in winter. The annual firewood consumption of the households varies between 1273 and 3451kg with the average at 2327kg. Between 906 and 2265kg of dung is used by all of the selected households to improve the heating effect in winter.

The largest amount of energy is spent in winter for heating accommodations. Heating is done mostly with firewood and animal dung on the metal stove where meals are cooked and bread is baked at the same time.

Since figures for individual electricity consumption were not available Figure 2.15 shows the average figure for overall electricity consumption divided by the amounts of individual households. It is obvious that differences regarding electricity consumption occur among households due to unequal availability and use of electrical appliances. Thus Figure 2.15 may show a slight distortion of the actual consumption pattern in terms of electricity consumption.

## 10.8 Economy of Scale for Energy Consumption

Figure 2.16 shows the correlation between the number of household members and annual per capita energy consumption. It shows that annual per capita energy consumption in small households is up to three times higher than in larger households. This effect, known as economies of scale, should be taken into consideration in domestic energy studies. The authors thus identified resource consumption on the household level and analogical data was calculated from that. Meanwhile, the village's civil society is accurately represented because the household is the pivotal organizational unit for the peasants in Vezdara.

The sampling of households has been made by considering the number of members eating regularly in the household, the financial status of the family and the spatial distribution of the houses over the village territory. There is virtually no evidence that one of these three factors decisively influences the quantity of consumed energy at the household level. The investigation is based on the statements and the estimations of the household members.

## 10.9 The Drudgery of Collecting Fuel Wood

As shown in Figure 2.15, firewood constitutes the largest amount of all energy resources. Most of the households collect the wood in forest 2 (see Figure 2.14), on the riverside or around their houses. This backbreaking work is done mainly by the children or the women, because most of the men are out of village. It takes about three to four hours to walk up to forest 2, to collect a back load of dry wood and to bring it down. To meet the daily wood consumption this work must be done nearly every other day. The manner of doing it varies considerably: Some

***Table 2.13:*** *Costs for Energy Resources and its Linked Expenditures in Vezdara.*

| | |
|---|---|
| Diesel oil | Sold in the village: 2 *somoni* (USD 0.63) per liter<br>Sold in Roshtkala center: 1.5 *somoni* (USD 0.48) per liter<br>Sold in Khorog: 1 *somoni* (USD 0.32) per liter |
| Electricity from PEC<br>Electricity from the MHPS | Summer: 0.25 US cents/kWh, over 50kWh: 0.54 US cents/kWh<br>Winter: 2.5 *somoni* (USD 0.79): monthly flat rate |
| Firewood | 3-5 hours per day, only during summertime<br>A truckload of firewood costs 400 *somoni* (USD 127) |
| Dung | 3 days of preparation of dung cakes, 1 month for drying |
| Artificial fertilizer | Reimbursement: 1kg of artificial fertilizer is exchanged with 2kg of wheat |
| Appliances | 100W bulbs: 0.60 *somoni* (USD 0.19): sold in the bazaar in Roshtkala |

*Source: Field study 2003*

households collect it only in summertime, saving 50% of it for winter; others intensively collect it during several days in autumn and others go up to forest 2 even in winter. In case of major snowfalls, the latter group has to cut the trees in the orchard entirely because the stock is insufficient to survive severe winters. A meaningful and popular method of wood acquisition is to cultivate one's own willow trees around the house. Richer households have the means to purchase a truckload of firewood from the *leskhoz*.

Due to the lack of manpower and stiff family structures, even young boys have to collect firewood, which sometimes makes it impossible for them to attend school.

Each resource has its individual costs, either in cash or in expenditure of human labor. The common fossil fuels are available in the district center or in Khorog, whereas the prices in Khorog are less than in Rosthkala because of the freight costs. Wealthier households have the means to purchase firewood and diesel oil in larger quantities so that the expense of energy resources increases with higher income. Between 2 and 62% of a family's income is spent on energy resources. As the PEC tariffs will increase in the next few years the largest outlay for energy will be the electricity fees. In Table 2.13 artificial fertilizer is listed because its application is linked with dung consumption. Although the villagers only have the expenditure of human labor for dung, it has to be taken into account that the villagers are forced to purchased more artificial fertilizer for each dung cake which is not distributed on the fields.

## 10.10 Impacts of Electricity

During civil war the forests were intensively cut down and their territory was drastically reduced within a few years. At that time more than 100 people per day collected wood in forest 1 and 2 (see Figure 2.14), and even people from the neighboring villages used wood from Vezdara. Nowadays the forests are less frequented, but owing to poor management they are still overused. The following statement by a women clearly depicts indications of unsustainable use of woody resources:

*"Before it took much less time to collect the dry wood, as there was plenty of it all around. Now it would take 1.5-2 hours to collect it, depending on the equipment and time."*

Due to the fact that the village was electrified in 1974 and the fossil fuel supply already existed at that time, it is difficult to ascertain electricity's impact on the ecological, social and economic sphere. Primarily, kerosene lamps were replaced by light bulbs, and new electrical appliances such as TV, radios, refrigerators, oven and kettles reemerged in the households. From this time on, villagers started to cook and bake with electricity during summer, thereby slightly reducing the firewood consumption. But that was not really their intention. Since the village was supplied with electricity the traditional outdoor stoves disappeared over the years. This fact indicates a loss of local knowledge and cultural heritage. Electricity was the most convenient energy resource and part of the Soviet progressive zeitgeist.[103] Electricity facilitates certain establishment of institutions: A medical point relies greatly on appliances such as refrigerator or disinfection device.

After the village was supplied with electricity, the villagers changed some of their daily customs. Due to less time used for resource allocation and preparation work. the villagers have more leisure time since they are supplied with electricity. They use this time for making hand-

103 The Soviets intended to 'enlighten' the entire USSR with the *lampochka ilyicha* (lamp of Vladimir *Ilyich* Lenin) which was an emblem for the development of electrification and technical progress. Lenin's slogan was 'communism is Soviet rule plus electrification of the entire country'. This slogan indicated an instrument to free the comrades from the 'darkness'. The first light bulb installed in a household bore the name '*ilyich*'.

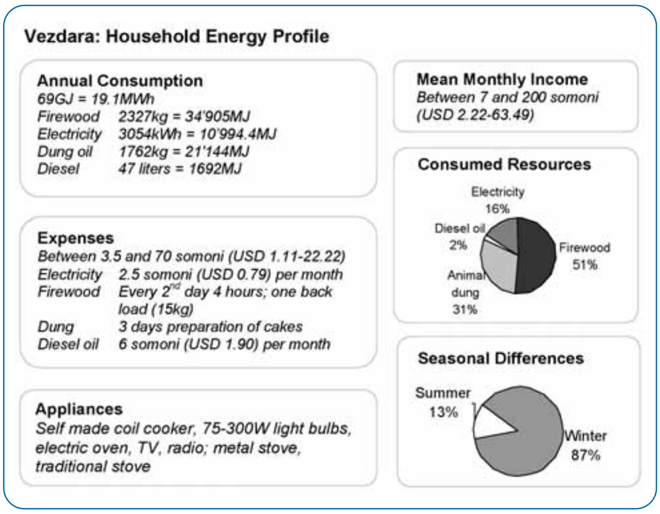



***Figure 2.17:*** *Profile of an Average Household in Vezdara Housing Seven Members: Only the MHPS fees are included in the expenses for electricity because at the time of investigation this was the only payment for electricity. In the future people from Vezdara have to pay at least on additional 2.5 somoni for the electricity bill from the PEC. Source: Field study 2003*

icrafts and do homework. Better lighting and the availability of TV distinctly changed sleeping time. Since supply of electricity the villagers often watch TV in the evenings and stay up longer. Thus sleeping time has decreased since supply of electricity.

Generally speaking, electricity has considerably improved the dwellers' circumstances so that it is hard for them to imagine life today without electricity.

## 10.11 Household Energy Profile

The annual energy consumption of an average household is based on the empirically collected data of the daily energy consumption of the different resources. The different scale units (kilograms, kWh, liter) are converted into Joules (see Table 2.14), whereas the data for the winter season was determined separately. For extrapolation of electricity consumption the year was divided into 213 winter days supplied by the MHPS and 152 summer days supplied by the main grid. Due to the limited amount of livestock and the additional use of the dung as fertilizer, estimation of dung consumption is based on 151 days (see Appendix 3).

To estimate the mean household consumption, the six selected households, comprising 23% of the village population, were averaged and projected on the whole village. The outcome of this is the Vezdara household energy profile compiled in Figure 2.17. Because the expenses and incomes of the six households differ greatly from each other, the ranges of income and expenses are quoted in Figure 2.17. Diesel oil usage is averaged over the overall village consumption. Therefore, the mean households mentioned have an annual diesel oil consumption of 47 liters although not all dwellers use it. The average household is relatively well equipped with electrical appliances. It owns at least one coil cooker, some light bulbs, a rudimentary electric oven and a radio or TV. Seasonal differences in energy resource use can be explained on the one hand by the high energy consumption for room heating and on the other hand by the high efficiency of electricity compared to firewood[104], which is mainly used in winter.

## 10.12 Energy Resource Use During Soviet Times

During Soviet times[105] the energy supply was managed completely by the government. Each household in Vezdara was provided with five tons of coal per year, and regularly electricity generated by hydropower and diesel generators and kerosene: Everything was available at a

***Table 2.14:*** *Domestic Energy Resource Use During Soviet Times.*

| Domestic demands | Coal | Firewood | Dung | Electricity | Kerosene |
|---|---|---|---|---|---|
| Cooking | ○ (summer low) ❄ (winter high) | ○ (summer low) ❄ (winter medium) | ❄ (winter low) | ○ (summer medium) ❄ (winter low) | ○ (summer low) |
| Heating water | ○ (summer low) ❄ (winter high) | ○ (summer low) ❄ (winter low) | ❄ (winter low) | ○ (summer medium) ❄ (winter medium) | ❄ (winter low) |
| Baking | ○ (summer low) ❄ (winter low) | ○ (summer low) ❄ (winter medium) | ❄ (winter low) | ○ (summer high) ❄ (winter low) | ❄ (winter low) |
| Room heating | ❄ (winter high) | ❄ (winter medium) | ❄ (winter low) | | ❄ (winter low) |
| Lighting | | | | ○ (summer high) ❄ (winter high) | ❄ (winter low) |
| TV, radio | | | | ○ (summer high) ❄ (winter high) | |
| Refrigerator | | | | ○ (summer high) ❄ (winter high) | |

○ ○ ○ Degree of application in summer (low, medium, high)
❄ ❄ ❄ Degree of appliaction in winter (low, medium, high)

*Source: Field study 2003*

104 Water boiling tests comparing efficiency of firewood and electricity resulted in 7-14 times higher energy consumption (Joules) to boil one liter of water with firewood than with electricity.

105 In the following chapter the term 'Soviet times' is generally used for the period of highest prosperity of the USSR: from 1950 to the collapse.

relatively low price, so that each household was able to purchase a sufficient quantity. Electricity was used only for lighting and electrical appliances. In general, consumption was higher but costs were lower than today.[106] Diesel oil and petrol were mainly used to run electric generators, irrigation pumps and transportation, which, due to the lower costs and the better living conditions, was used much more than today. Meanwhile, kerosene was used for lighting, cooking and even for heating.

For a small fee firewood could be purchased from the *leskhoz* and was used mainly to light the fire in summer and occasionally as supplement for coal in winter. In fact, coal was more than sufficient for the different heating purposes.

Thus dung was used marginally as fire material and as fertilizer. Due to the fact that neither the livestock nor the arable land was privately owned, people did not assume responsibility for resource management. Besides, the arable land was much smaller and people did not rely on their own harvest. As for the demand of dung, there was a great profusion in comparison with today's situation. Thus at this time there was no incentive to reduce consumption. These behavior patterns still influence present resource use strategies.

Table 4 summarizes an outline of resource use during Soviet times by means of a qualitative comparison of consumption of different resources.

## 10.13 Energy Resource Use Strategies

The peasants in Vezdara are confronted with two main lifetime tasks which they have to accomplish, mainly during summer months: First, to produce sufficient staple food and second to acquire energy resources for winter, prioritized by the peasants in this order. Difficulties linked with these two issues are also seen as the major challenges of the peasants. The main limiting factors hindering the peasants to fulfill these tasks are the financial means, the number of farm animals, the amount of arable land, the household's size, and the availability of fuel and electricity.

Narrow financial resources hinder poorer peasants from diversifying their resource base. The poorest households in Vezdara earning less than ten *somoni* (USD 3.17) per month are unable to purchase diesel oil, thus decreasing monthly expenses to 2.5-3 *somoni* (USD 0.79.- 0.95) in comparison with other households. However, they also own basic electrical appliances, since most of them were purchased during Soviet times. Today their financial means prevent them from purchasing more efficient and sophisticated devices. With a monthly income of 7 to 200 *somoni* (USD 2.22-63.49) most of Vezdara's peasants can cover today's expenses for electricity (2.5 *somoni*; USD 0.79) and diesel oil (six *somoni*; USD 1.90). Due to the inadequate capacity of the MHPS, which runs only in winter, households situated near the power plant are able to use the electricity for cooking and baking. Some families with few children and not owning large pots and having less bread to bake, tend to use electricity for these purposes, too.

Only very few households still cook and bake with firewood in summer. This behavior can be explained by the inability to pay for repairs of damaged electrical appliances, by resisting traditions or individual preferences. However, the most favored energy resource is electricity.

The woody resources, especially willow trees, are in principal used willingly by the people from Vezdara because efficiency is high for both preparing meals and heating purposes. However, it is a scarce resource and collection is a hard and time-consuming task which competes with the labor time for producing wheat and potatoes.

Dung is a favored and relatively efficient resource, especially for room heating purposes, because it burns slowly and keeps the heat much longer. Due to the fact that, on the one hand, dung is only available in a limited quantity and, on the other hand, is a convenient fertilizer, peasants ration it very accurately. Most of the households use half of the amount as fertilizer and the other half as fuel. But they actually would prefer to distribute the entire supply of dung as fertilizer on their fields.

Peasants from Vezdara obtain artificial fertilizer from the VO on a credit basis. They have to repay it with the following exchange rate: One kg of artificial fertilizer has to be acquitted by two kg of wheat which is delivered to the MSDSP, because they actually supply the VO with artificial fertilizer. This means that a peasant with more arable land having a good yield is better able to repay the artificial fertilizer with wheat. Meanwhile, a household with little arable land having less yield is liable to get in debt. Although artificial fertilizer can be bought with money, virtually all the peasants purchase it as credit reimbursed by wheat. Thus, the constraints in terms of artificial fertilizer not only depend on financial resources but are also a matter of output efficiency in the cropping system.

In terms of the energy situation of a household, there are two pivotal elements affecting the balance of the system: the amount of arable land and number of farm animals. In 1996 the land was equally distributed and since then it has not been redistributed, so that large families received much arable land. That means that these families, which used to have a lot of children who have now moved out, have more arable land than used to be assigned to them. Meanwhile young, newly settled families

106 Villagers paid between 0.5 and 1.5 ruble a month (USD 0.49-1.47).

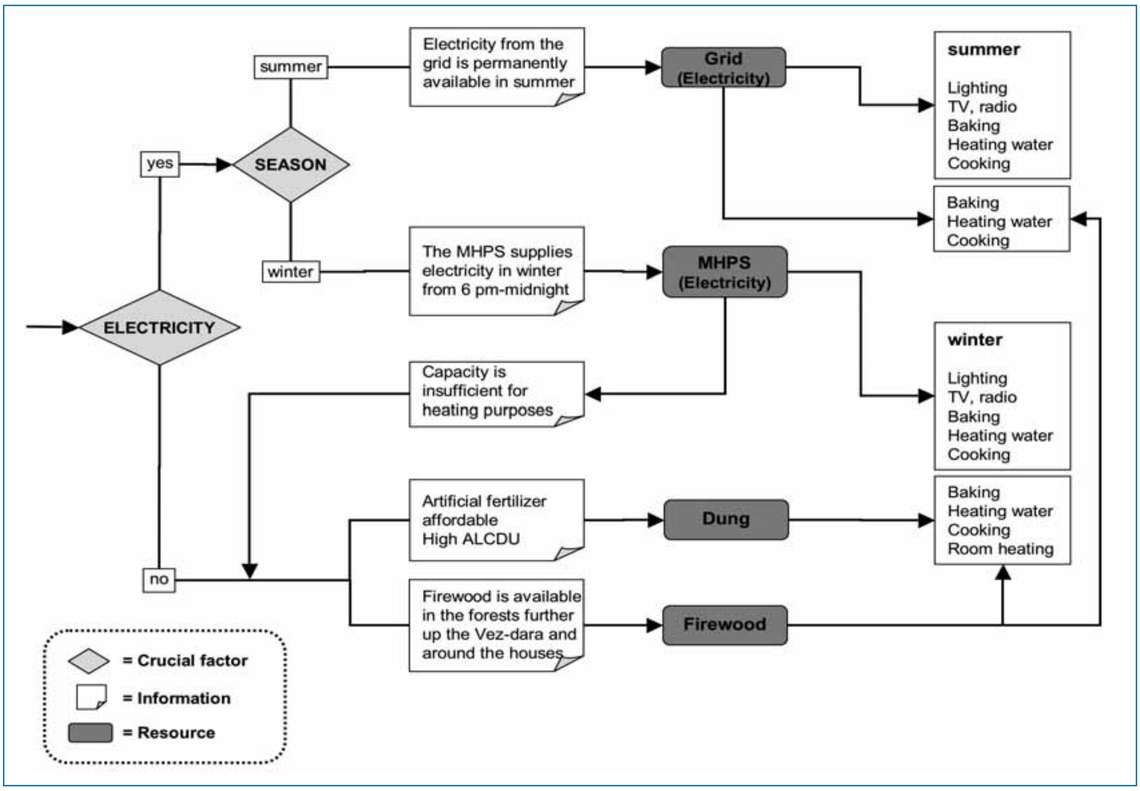



***Figure 2.18:*** *Present Energy Resource Use Pattern in Vezdara. Source: Field study 2003*

with many children and little land struggle for the daily survival. Besides harvesting for staple food the peasants have to produce sufficient forage to overwinter the livestock in the stable. Although some peasants would have the financial means for more farm animals, it is impossible to increase the amount because of limited fodder. However, the number of farm animals determines the quantity of available manure used as fertilizer and as fuel, so that the ratio between the arable land and the number of farm animals should be adequate expressed as arable land per cow-dung-unit (ALCDU).

As mentioned above, some inhabitants follow a type of agro-forestry strategy by pollarding willow trees around their houses. For this they need a sufficient number of trees and land on which the trees can be cultivated. This agro-forestry system competes to some extent with the crop growing, because of the scarce irrigated land and the tree shadows which adversely affect crop yield. This strategy allows the peasants to manage their own energy resource base. Furthermore the agro-forestry plots allow multipurpose usage. Usually the villagers cut the shoots every second year and heap them up beside or on the roof of the house thus considerably reducing the allocation work.

Due to these general restrictive conditions, the peasants are forced to follow a strategy based on local inexpensive resources with a preferably high heating efficiency whereby the poorer households are apt to minimize their expenses while wealthier ones tend to reduce time spent on procurement.

Several responses from the peasants on the scarce energy resource base can be understood as adaptive strategies. On the one hand, they augment the supply by using alternative energy resources, such as dung, or by establishing an MHPS. On the other hand, they reduce the resource demand by moving into smaller rooms in winter or purchasing a sheet metal stove, which burns firewood more efficiently than the Soviet stove.

## 10.14 Village Energy Consumption Profile

Estimation of the village energy consumption profile (see Figure 2.19) is based on the average household consumption. A striking feature is the high consumption of biomass fuel during winter. Though the village is regularly supplied with electricity, it only constitutes 16% of overall consumption. There are two reasons for this: First, during the periods of peak consumption (in winter in the evenings) the MHPS is unabel to supply the households with the required electricity, so that the peasants have to revert to firewood. Secondly, the heat efficiency of wood is much lower than that of electricity, so that much more woody energy expressed in joules is used.

## 10.15 Resource Degradation

Twenty years ago Vezdara was surrounded by dense forests, including at least three forests in the Vez-dara

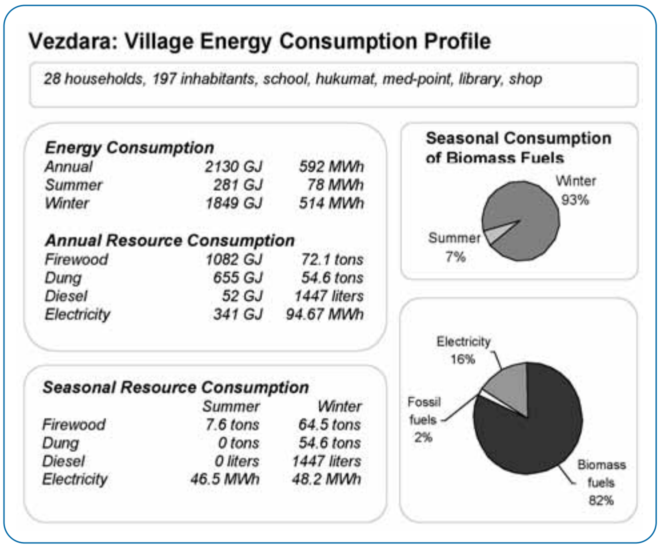



***Figure 2.19:*** *Estimated Overall Consumption in the Village of Vezdara.*
*Source: Field study 2003*

and a large forest down in the Shakhdara. This valley used to be famous for its large and dense forest consisting of tall poplar trees. In 1914 A. v. Schultz (1914: 10) characterized this valley as follows: “Proper woods, consisting nearly exclusively of poplar trees, as humid forests accompanying some rivers (mainly the Shakhdarra). Grove with poplar trees, pastures, wild growing fruit trees, rare species of birch trees on protected and humid sites, sometimes covering an entire alluvial fan which is embedded in the main valley. [...] Wilde roses, pastures and different thorn coppice form an impassable thicket”.[107] Due to the increasing scarcity of energy resources, starting in the early nineties, most of the forests have been thinned out or even entirely cutover.

*“Ten years ago, the meadow area down at the river used to be dense forest, but now there are only puny willow trees left. The largest amount was cut during the period between 1995 and 1998. Before the forest was so dense that when a cow entered the forest, it was lost for the next two or three days.”*

Nowadays only the two distant woods of the village still exist. Forest 3 (see Figure 2.14) is situated 1km above the high pasture, composed a great many of voluminous, high willow trees measuring five to eight meters which are relatively old and untouched. Only a shepherd family spends the summer months in this area, mainly using animal dung as fire material. The wood in forest 3 is too distant to be used by the villagers. Hence the willow trees from forest 3 are in an absolutely primal state.

The grassland on the high pastures is short grazed and, due to the large amount of livestock (870 animals tramping around), browsing damages are evident all around. On a steeper slope a one ha large landslide was triggered by these soil surface injuries (see Picture 2.39). Even at a distance of several km far from the high pasture *teresken* bushes show browsing damage, and are all stunted in growth.

In forest 2 about a quarter of all the bushes are entirely cut and almost all of them show serious chopping damage. Livestock also graze in this large meadow measuring three ha. Due to this double use, the forest has degenerated to a park-like landscape.

Forest 1 is situated on the next flat site further down the Vez-dara. Its vegetation is mainly composed of willow trees, rosehip bushes, sallow thorn bushes and few black current bushes. There are virtually no old tall willow trees, and only the trunks remain from which young branches grow. The remaining trees are small and almost all have chopping marks. The density of the trees diminishes the close one comes to the village until the forest completely disappears some hundred meters above the village, where the dilapidated sanatorium is situated. Even in the early nineties this area used to be a forest where nowadays just meager grassland is left. Nowadays the majority of the forests next to the road and close to the villages show intense cutting.

Apart from some difficulties in cultivating the fields in the wet spring period, degradation in regard to the soil is not identifiable in the village.

According to elderly villagers, wild animals such as Marco Polo Sheep, ibex and snow leopards were sighted around the village in winter even, still twenty years ago. Nowadays it very seldom happens that wild mammals are observed, even on the high pastures. However, owing to the high amount of weapons distributed during civ-

***Picture 2.39:*** *Some insular primary forests still exist on the high pasture (foreground) but trampling and browsing damages are common, which may cause large scale erosion (see trapezoid on the slope). (Photo: T. Hoeck, June 2003)*

[107] Citation is translated from German.

il war, to the famine and the nonexistent controlling body, the most serious depletion regarding wildlife occurred in the times of civil war.

## 10.16 Scenario Towards a Sustainable Energy Resource Use

In this chapter possibilities are highlighted on how to reduce the pressure on locally available biomass fuels and to create a strategy towards a sustainable energy resource management. The aim is to ameliorate today's energy resource consumption patterns so that further generations will have a secure livelihood. To reach this goal either the applied resources have to be used more efficiently, or alternative energy sources have to be enhanced or established. In other words, either the demand can be reduced or the supply can be strengthened.

The challenge of a sustainable resource use scenario is for the peasants to improve their living standard by optimizing their resource use strategy and its linked consumption patterns.

Due to the fact that electricity is eagerly used and seems to be the resource of choice in Vezdara, the following section focuses on the potential of electricity generated by hydropower. However, the price for consumed kWh must be affordable: At the time of this research, the Pamir Energy Company (PEC) had not collected fees for the summer electricity consumption, although it is clear that within a short time they will bill the people from Vezdara, too. Hence, at least three *somoni* (USD 0.95)[108] will be charged during summer for the future monthly electricity fee from PEC. Including some expendable items such as coils for the cooker, light bulbs or repairs of appliances, people will need at least ten *somoni* (USD 3.17) for their expenses in terms of energy. This implies that the poorest households earning seven somoni (USD 2.22) a month (e.g. household 6 see Table 2.12) are barely able to pay all the future energy resource disbursements. Since the PEC charges its customers a flat rate, there is no possibility of reducing the expenses on electricity fee for indigent households. On the one hand, they are forced to spend all of their income on electricity; on the other hand, they will have to abandon diesel oil consumption.

Based on a present estimation[109] of the monthly electricity consumption, the villagers use 318kWh per month, whereas the energy used for room heating is not taken into account because it is utterly impossible to cover this amount of energy with electricity. If a household use a 2000W electric arc furnace five hours per day, the monthly overall consumption would increase to 600kWh.[110] Consequently, due to the limited financial means and the insufficient capacity of the MHPS[111], room heating with electricity is impossible. Assuming that, after the rehabilitation of the Pamir-1 hydropower plant, the village will be regularly supplied with electricity from the PEC the villagers of Vezdara will have to pay 4.76 *somoni* (USD 1.51) with a monthly electricity consumption of 315kWh, which is affordable for everyone. According to the PEC's

***Table 2.15:** Possible Measures to Improve the Energy Situation in Vezdara.*

| | |
|---|---|
| **Decrease the demand for energy resources** | |
| Substitution of energy resources | To use electricity instead of firewood for cooking, baking, heating water (immersion heater) |
| Upgrading the efficiency of the appliances | Improve electrical devices for cooking, baking, heating water and lighting (LED lamps) demanding less watts, use sheet metal stoves for cooking |
| Enhancement of insulation characteristics of the winter rooms | To increase the insulation of the house with local materials: straw; wool; felt; reed, bast fibers from the stipe of the stinging-nettle (*urtica dioica*), of flax (*Linum usitatissumum*) of ramie (*Boehmeria nivea or boehmeria tenacissima*), timber, wooden floors |
| Reduction in the use of biomass fuel | To extinguish the fire immediately after food preparation |
| **Increase supply with local renewable energy resources** | |
| Advancement of the electricity supply | To complete the 200 watt hydro scheme, to supply the village with electricity from the grid during summer and winter |
| Increase of the household's available capacity | To introduce an electricity distribution schedule, to interfere in the user's habits by consumption regulations, to establish a public bakery |
| Enlargement of tree plantation | To plant willow trees or Russian olives to use as a fuel wood resource, to promote household-based firewood cultivation (pollarding) |

*Source: Field study 2003*

108 The estimation is based on 400kWh electricity consumption and a fee of 0.75 US cents per kWh. The maximum authorized average price (in US cents) that can be charged by the PEC is calculated as follows: 2003: 0.88; 2004: 1.10; 2005: 1.37; 2006: 1.17; 2007: 1.97; 2008: 2.27; 2009: 2.61; 2010: 3.00 (PEC 2002: 74).

109 The following premises are made: light: 400W, 5 h/day, electric oven; 1300W, 3 h/day; coil cooker: 1000W, 2 h/day; TV: 40W, 5 h/day; electric kettle: 2500W, 1 h/day.

110 In 2010 this would be a subsidized electricity fee of 39.38 *somoni* (USD 12.50).

111 If all the households in Vezdara would heat their living rooms with electricity during winter the village would need a 90kW hydropower scheme.

***Table 2.16:*** *Firewood Tree Estimation. Biomass growth of 10 and 20 years old trees and the required reforestation area to meet the demand for space heating in Vezdara*

| Forest species | Biomass volume of trees in kg | | Required trees per hh/y | | Required trees per village/y | Annual yield | Required area | Required area |
|---|---|---|---|---|---|---|---|---|
| | *10 y* | *20 y* | *10 y* | *20 y* | *10 y* | *Tons/ha* | *Ha/hh* | *Ha/ village* |
| Poplar (*Populus*) | 182 | 502 | 20 | 7 | 569 | 61.9 | 0.060 | 1.67 |
| Willow (*Salix*) | 49 | 441 | 76 | 8 | 2114 | 16.7 | 0.222 | 6.20 |
| Black locust (*Robinia*) | 105 | 516 | 35 | 7 | 987 | 35.7 | 0.104 | 2.90 |
| Russian olive (*Elaeagnus*) | 205 | 534 | 18 | 7 | 505 | 69.7 | 0.053 | 1.49 |
| **Mean** | 135.25 | 498.25 | 37 | 7 | 1044 | 46 | 0.110 | 3.07 |

*Source: Clemens (2001: 156), Field study 2003, Calculation: R. Droux,T. Hoeck*

concession agreement (PEC 2002: 74) the villagers will be forced to pay 12.44 *somoni* (USD 3.95) for these 318kWh in 2010.[112] Such an amount is only affordable for the wealthier households. Taking this fact into account, it is expedient to follow a strategy of autonomous energy made by an MHPS. Since they already have one 32kW hydropower scheme and will establish a 200kW hydropower plant at the latest in 2004 it makes sense to follow these plans. The new MHPS is designed for four villages housing a total of 115 families. Assuming that there is enough runoff and the MHPS will actually achieve an output of 200kW, each household would be supplied with 1.7kW. This capacity is sufficient to meet basic needs and to replace the wood used for cooking, baking and heating water. However, it is known that the electricity supply regulates its demand and in the course of the village's development the households, the school[113], the planned public bath, the inn (under construction) and the projected electric mills are additional consumers.

One essential question remains: Is it possible to manage the firewood consumption for room heating in winter in a sustainable way? The estimated amount of firewood which is required for room heating purposes averages 3700kg. According to Clemens' model calculation (2001: 156) regarding the potential of farm forestry, a mean household in Vezdara would annually need between 18

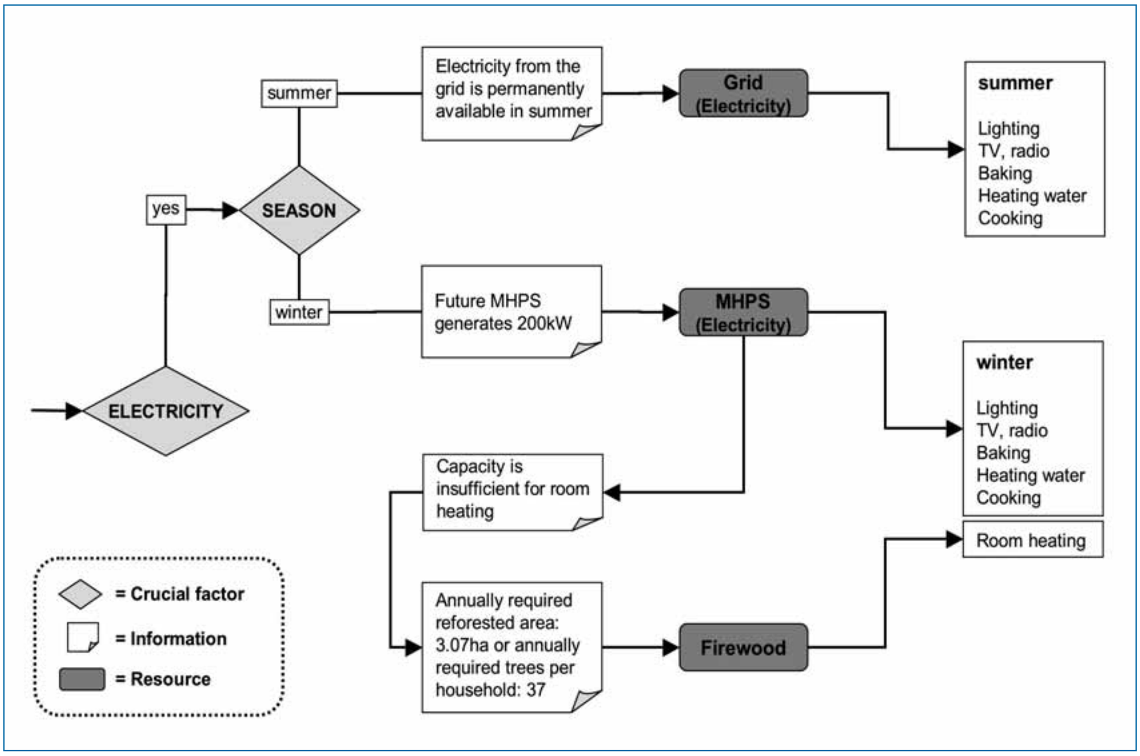



***Figure 2.20:*** *Energy Resource Use Pattern Following the Scenario Towards a Sustainable Energy*

112 According to the PEC's concession agreement, the lifeline subsidies are garneted until 2010. Afterwards the villagers of Vezdara will have to pay 0.94 *somoni* (USD 0.03) per kWh averaging a monthly fee of 29.76 *somoni* (USD 9.45). Exchange rate fluctuations are not taken into consideration.

113 If the school plugs in all electric room heaters (8 x 2000W) it uses 8% of the overall capacity of the new MHPS.

***Picture 2.40:*** *Household based firewood cultivation is commonly practiced in Vezdara by pollarding branches every two to four years. (Photo: T. Hoeck, June 2003)*

and 76 ten year old trees, depending on the species (see Table 2.16). The families should plant an average of 37 trees per year so that they can cut the first ones after ten years. The other option to meet the required quantity of biomass is that the village winnows a farm forestry plot where every year 3.07ha would be reforested so that within ten years the first trees can be yielded. The village territory provides more than these required 30ha of suitable land for farm forestry.

Figure 2.20 illustrates the energy resource use pattern based on the basic preconditions of the scenario. This includes the above-mentioned methods of firewood cultivation and a full capacity of the new 200kW hydropower scheme. It is foreseen for 2005 that the PEC will also supply the Roshtkala district during winter. Thus it may happen that Vezdara's villagers also use electricity from the grid, although they have a new MHPS. However, the scenario illustrated in Figure 2.20 assumes that the new MHPS will be regularly used.

Owing to Vezdara's well-managed village organization (VO) a community based farm forestry combined with a controlled firewood cultivation, on the household level the village could considerably relieve the village's energy problems. For a future implementation of a farm-forestry project, the management, the land tenure and the yield distribution have to be carefully considered.

## 10.17 Conclusions and Recommendations

The sudden collapse of the USSR triggered tremendous changes for the daily lives of Vezdara's dwellers, particularly in terms of energy resource supply. The resource use framework switched from a system based completely on imported resources to a total self-sufficiency economy, dependent on local energy resources. Certain Soviet heritages developing under an externally subsisted economy hamper today's circumstances. Most of the houses were constructed during Soviet times when sufficient heating resources were available, so that the size is absolutely inadequate to the present resource base. Extended families were promoted by the regime, causing a severe supply bottleneck now. Thus, the high pressure on firewood and the major disappearance of forestland triggering several other degradation phenomena was a corollary. Even today the forests are overused and poorly managed, and woody resources are continuously decreasing. Forest rehabilitating measures and other activities which promote the growth of forests are virtually non-existent in Vezdara. The authors thus consider this matter to be extremely urgent and suggest a plan of widespread reforestation. The most expedient and auspicious approach is to enhance a family-based firewood cultivation by pollarding the branches every second year. The advantage of this firewood use method is obvious. Labor time and backbreaking burdens can be reduced, due to the short distance to the source. The trees around the house can be labeled a next-door-resource. The resource is owned by the families, which makes it clear in which quantity the resource is available and when the desired quality has been reached. The authors remarked that, due to the fact that private property is treated with care, the villagers use their trees more carefully than wood belonging to the government.

In addition to improving overall living conditions electricity has vital importance as a substitute for firewood. Generally speaking, virtually all the villagers use electricity for cooking, baking, and heating water instead of wood if the capacity is sufficient. Due to the ample electricity supply during summertime, the villagers are able to accomplish all the activities with electricity which were formerly done with fuel. Consequently 60% of the summer energy consumption is covered by electricity. The biomass consumption during winter is much higher because it is used for room heating, which is combined with cooking and baking. The impact of the MHPS on woody resources is, due to its inadequate capacity, relatively low. Only 10% of the entire winter energy consumption is covered by electricity. It can be concluded that there is a slight relief of pressure on firewood consumption induced by the electricity generated by the MHPS. Moreover, this successful project motivated the villagers of Vezdara to launch new ventures improving the local economy and the living standard. The felicitous hydropower plant became a glorious showcase, due to the well organized VO managed by a reliable chairman and due to the technical knowledge of the local engineer.

The following list of recommendations is the result of the conclusions deduced and the authors' field experiences. The success of such proposals is substantially dependent on its acceptance, so that, without basic resoluteness on the part of the peasants the proposed recommendations will be without effect. Their intention is to serve as a guideline for the peasants and the village organization to make a step towards sustainable energy resource management. The proposed measures are adapted to Vezdara's specific energy situation. They should be considered as possible proposals generated by an aoutsiter's view and should act as a subject for discussion with locals. Due to different implementation approaches, the recommended measures are divided into short-term and long-term initiatives.

***Short-term recommendations with immediate impact***

To increase the electrical capacity per household the villagers should…

…introduce an **electricity user's schedule,** in which alternately the first and the second half of the village is supplied.

…introduce **regulations** on the use of electrical appliances; to unplug devices not in use and to simultaneously use only a limited number of appliances, to restrict the bulk of consuming appliances to a certain number.

…use **light-emitting-diode (LED) lamps or low-watt light bulbs** instead of 100 watt bulbs.

To use electric power more efficiently the villagers should…

…all purchase or make pan shaped **electric coil cookers.**

…invent an electrified traditional clay oven.

To use biomass fuels more efficiently the villagers should…

…make better **use of waste heat** from their metal stoves or heat stones and water as heat storage media.

…promote the **sheet metal stove** for cooking.

To reduce the women's and children's collecting labor the villagers should…

…**enhance firewood cultivation** by pollarding the trees around the houses.

To increase the supply with dung to use as fertilizer and fuel the villagers should…

…collect **manure from the livestock compound on the high pasture** and transport it in autumn on the back of the livestock down to the village. The dung could be used as fuel for public institutions (hospital or school).

To allow the use of electricity for baking bread and cooking in winter the villagers should…

…establish a **public bakery** run on electricity where villagers can bake their own bread (similar to the public mills).

…launch a **'tearoom'** where hot water and tea is available.

***Long-term recommendations with delayed impact***

To reduce energy resource consumption the villagers should…

…better **insulate their homes and buildings** using straw; wool; felt; reed, bast fibers from the stipe of the stinging-nettle *(urtica dioica)*, of flax *(Linum usitatissumum)* of ramie *(Boehmeria nivea or boehmeria tenacissima)*, timber, wooden floors. Lining only a single room with insulating material for use in winter.

…construct smaller living rooms for winter.

To increase the supply of biomass fuels the villagers should…

…**reforest large areas** with willow and Russian olive to use as firewood resource. The villagers should annually reforest 3.07 ha or every household should annually plant 37 trees over a period of ten years. A precondition would be to reorganize the system of ownership.

…cultivate and **manage existing forest areas in a sustainable way** and use them as firewood source.

…promote **firewood cultivation** around the houses by pollarding the branches.

To make available a more efficient heating fuel the villagers should…

…establish **production of briquettes** made of manure, shrubs, agricultural residues and small branches

***References***

Domeisen, Michael (2002) Marginalized by the Impacts of Transformation. A Study of Post-Soviet Livestock Breeding in the High Mountains of the Eastern Pamirs. Diplomarbeit. Bern: Centre for Development and Environment, University of Berne.

Harvey, Adam (1993) Micro-Hydro Design Manual. A Guide to Small-Scale Water Power Shemes. London: Intermediate Technology Publications.

PEC [Pamir Energy Company] (ed.) (2002) Concession Agreement Between Government of the Republic of Tajiistan and Pamir Energy Company. Dushanbe May 24th 2002.

Schultz von, Arved (1914) Die Pamirtadschik. Veröffentlichung des Oberhessischen Museums und der Gail'schen Sammlung zu Giessen (Abteilung für Völkerkunde). 1. Heft. Giessen: Verlag von Alfred Töpelmann (vormals J. Rickmers)

SFOE [Swiss Federal Office of Energy] (2002) General Energy Statistics 2002. Bern. http://www.energie-schweiz.ch/imperia/md/content/statistikperspektiven/gesamtenergie/9.pdf

SFOS [Swiss Federal Office of Statistic] (2003) Press release: Population. According to the census of 2000.

Internet:

www.videncenter.dk/groenne%20trae%20haefte/Groen_Tysk/trae-DE04.pdf

# 11. Savnob: A Village with Electricity from a Micro Hydropower Station

Savnob is one of the last villages in the Upper Bartang Valley in the district of Rushan, located at an altitude of 2700m (see Picture 2.41). The road leading to Savnob is in bad condition, making the 120km trip from Rushan off the Pamir Highway up the Bartang Valley costly and time-consuming. Especially in winter access is under permanent threat of natural hazards (avalanches, rockfalls), sometimes blocking the road for several months.

After the collapse of the Soviet Union the local *kolkhoz* was dissolved, and the land was privatized and distributed equally to all inhabitants. Arable land and livestock are the main assets in this remote region. Wheat and potatoes are cultivated in a two-year cycle of crop rotation. Small patches around the houses yield relatively good harvests of vegetables and tobacco.

A single spring supplies the village with water for domestic use, irrigation and for operating the micro hydro scheme (see Figure 2.21 and Picture 2.42). Water availability is limited and water has to be distributed according to a sophisticated schedule to meet all needs.

Employment possibilities are scarce, with only the public infrastructures (secondary school, hospital, *hukumat*[115]) and the mini hydro power plant offering occupations with rather symbolic salaries of 13-55 *somoni* (USD 4.10-17.50). Thus, survival in Savnob is mainly dependent on the output of the subsistence economy, based on agro-pastoralist activities. About 10-15% of the families receive financial support from relatives working in Russia. The inhabitants still benefit from humanitarian aid from the Mountain Society Development and Support Programme (MSDSP), providing goods once a year in the form of vitamin added vegetable oil and wheat flour.

The traditional Pamiri-house in Savnob consists of one large room and two smaller rooms. Attached to the house is a stable for donkeys, cows, goats and sheep. Construction material is mainly stone, straw and clay, forming thick walls covered with wooden crossbeams and layers of clay. There is traditionally only one window, a quadrangular opening in the ceiling, also serving as an outlet for smoke from the stove.

| |
|---|
| Village: Savnob |
| Jamoat: Savnob |
| District: Rushan |
| Altitude: 2700m |
| Households 2003 (1999): 54 (52) |
| Inhabitants 2003 (1999): 341 (322) |
| Average members per hh: 6 |
| Female/male ratio: 60%/40% |
| Sheep and goats (per hh): 633 (12) |
| Cattle (per hh): 113 (2) |
| Chicken (per hh): 124 (2) |
| Village territory: 1168ha |
| High pasture: 1120ha |
| Arable land per cow-dung-unit[1]: 597 |
| Arable land (per hh): 9ha (0.166) |
| Orchard: 3ha |
| Forest: 34ha |
| Size of heated room: 40-90m[114] |
| Heating period: November to April |
| Mean annual precipitation: ~ 130mm |
| Minimum winter temperature: -35ºC |
| Distance to Rushan, district center: 120km |
| Distance to Khorog, oblast center: 175km |
| Public infrastructure: secondary school, hospital, MHPS, club, store, *hukumat*, radio station, 2 mills, ruins of old fortress, ancient cave, religious site |
| Occupation: 64 peasants, 2 hukumat, 17 education sector, 11 health sector |

***Picture 2.41:*** *The village of Savnob is a green island in the high mountain desert of the Tajik Pamirs. (Photo: T. Hoeck, June 2003)*

114 This factor represents the ration of arable land and available manure from cows, sheep and goats. The cow-dung-unit is calculated while considering the productivity of large (1) and small livestock (0.065). An adult cow contributes around 10kg of wet dung per day, sheep and goats only 0.065kg per day (Kadian & Kaushik 2003: 64). The amount of arable land per cow-dung-unit (ALCDU) is an indicator of the availability of dung as fuel.

115 *Hukumat* is the Tajik word for government. In this context the *hukumat* is the local administration office.

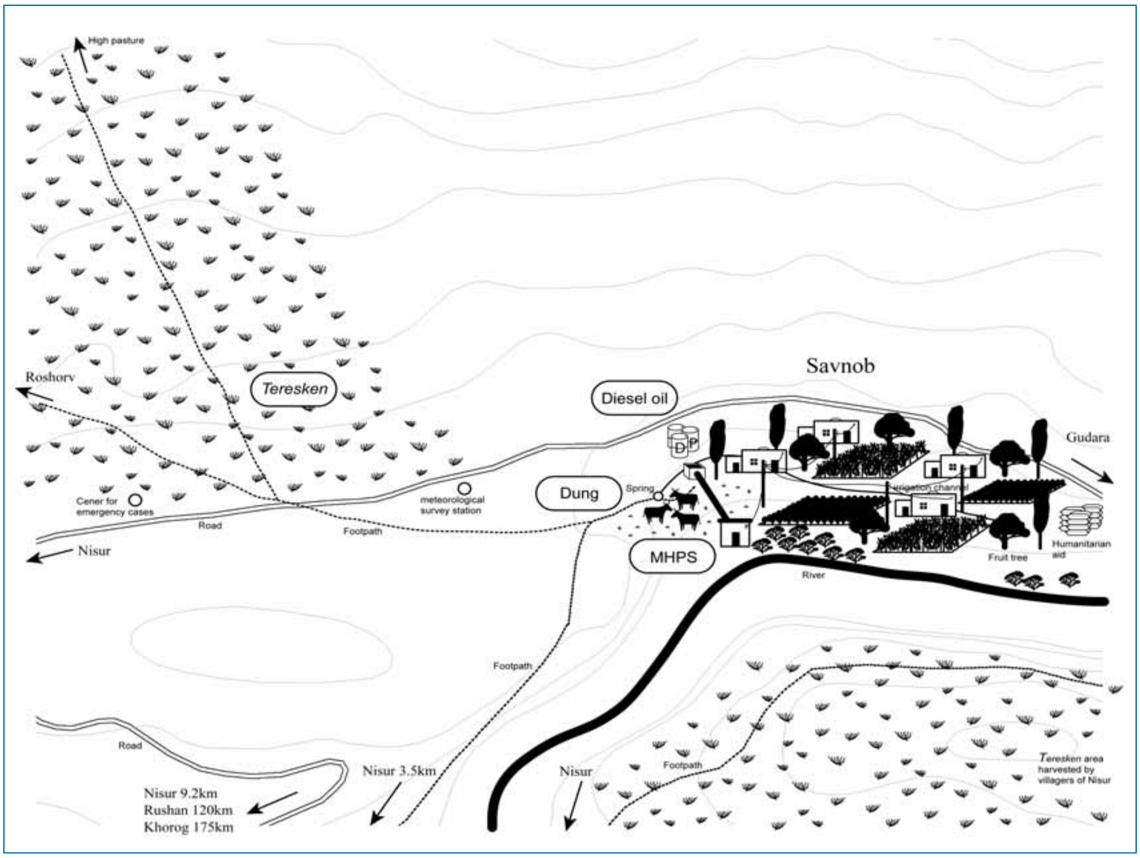



***Figure 2.21:*** *A Schematic Sketch of the Village of Savnob Depicting the Energy Resource Base. Sketch by T. Hoeck*

In 1999, on request from the MSDSP, the Village Organization (VO) of Savnob was founded, representing the village and serving as a platform to discuss and solve problems at the village level. Since then several projects (reforestation, water tap system, water canal construction, vegetable cultivation, traditional Pamiri socks) were completed in cooperation with international donors and non-governmental organizations (NGOs).

***Picture 2.42:*** *Water supply in Savnob depends on a single spring feeding water channel for irrigation, hydropower and drinking water. (Photo: T. Hoeck, June 2003)*

There is a new project to extend the amount of agricultural land to ensure self-sufficiency and even produce surplus yield for trading. The construction of a new water canal would allow the irrigation of an additional 500ha of land, located above the village close to the meteorological survey station and the center for emergency cases. The excess water could be directed down to the village, increasing water availability for irrigation and for the micro hydropower station (MHPS). This also bears a potential of mitigating the conflict between these two water users.

## 11.1 Energy Resource Base

Since the collapse of the Soviet Union and the corresponding cessation of provision with fossil fuels at cheap prices, the villagers in Savnob are completely reliant on locally available energy resources (see Box 2.4). Due to high procurement and transportation costs, imported resources such as coal, kerosene and diesel oil are hardly affordable for the inhabitants. With the installation of the MHPS in 1989 a perennial, although not permanent electricity supply was guaranteed, delivering power for lighting and other purposes. Since 1996 collecting firewood from the nearby forests (willow trees and thorn bushes) is restricted by the *leskhoz*[116] to achieve rehabilitation of

[116] The *leskhoz* is the governmental forestry office (*les* is the Russian expression for forest).

**Box 2.4: The Changing Energy Resource Base in Savnob**

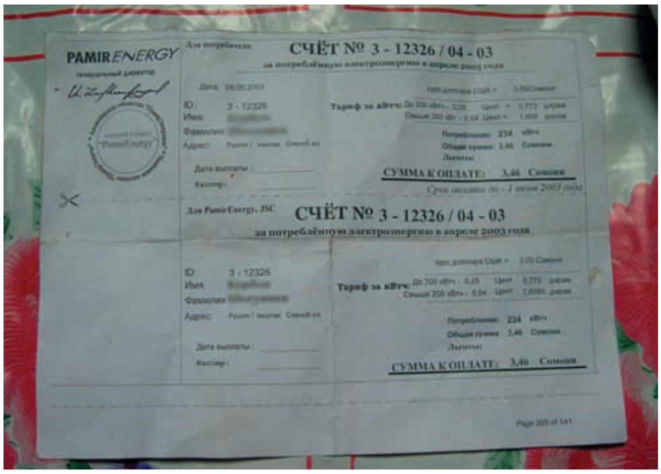
| | |
|---|---|
| Till 1988: | No electricity. |
| 1988-89: | First electricity supply from two diesel generators (18kW each) delivering sufficient power for lighting. |
| 1989: | Completion of the 80kW MHPS with an output capacity of 40kW providing perennial supply to all households. |
| Till 1991: | During Soviet rule fossil fuels (kerosene and coal) for cooking, room heating and lighting were available and affordable for everyone. |
| Since 1991: | Households start collecting *teresken* shrubs and firewood around the village and truckloads of firewood from Gudara are brought to the school and hospital. |
| 1991-1996: | Use of firewood from local forests. |
| Since 1996: | Local forests are officially protected for rehabilitation. |

the vegetation cover, which suffered severely from heavy cutting during the times of civil war following independence. An alternative to the village-own woodlands is found in the forests further up the valley beyond the village of Gudara. In autumn people from all over the *jamoat* hire trucks and drive to the upper forests to collect fuel wood for the cold season. The truckloads of firewood are expensive[117] and can only be afforded by richer households or public infrastructures. Hence most families rely on other energy resources. In contrast to the green plots and orchards surrounding the houses, the area around the village is sparsely populated with *teresken* shrubs (*Eurotia ceratoides*). These small bushes represent the main energy resource for the inhabitants of Savnob. Occasionally a cushion-plant, known by the locals as *tezkan*, is brought from higher altitudes. Cows, goats and sheep provide another important resource: Dung is used preferably for fertilizing croplands but also plays a major role in heating in winter. The radio station established for the Lake Sarez Early Warning System possesses its own electricity supply from a small solar panel installed on the building's roof.

## 11.2 Micro Hydropower Station[118]

The micro hydropower station (MHPS) constructed in 1989 provides electricity to all 54 households, to the school, the hospital and to the *hukumat*. Due to the shortage of water and the resulting conflict between irrigating croplands and operating the MHPS, electricity is not permanently supplied. Priority is given to irrigation, so that from May till September power supply is limited to seven hours per day in the evenings (5 to 12 pm). In wintertime electricity is distributed according to a 14-hour-schedule: from 5-12 am and from 5-12 pm. The installed capacity of 80kW has never been reached so far. Inadequate water availability reduces the hydro scheme's output to an average of 40kW or to 690W[119] per household when equally distributed to all customers. Since 2002 the power plant is owned and managed by the Pamir Energy

***Picture 2.43:** The MHPS in Savnob cannot operate at full capacity due to a water use conflict with irrigation. (Photo: T. Hoeck, June 2003)*




***Picture 2.44:** Since the installed meters do not operate properly, individual electricity consumption cannot be taken into consideration. All households thus receive a bill concerning the same amount of money. (Photo: T. Hoeck, June 2003)*

117 One truckload of firewood costs around 195 *somoni* (USD 62)

118 Detailed information about the MHPS in Savnob is found in Chapter 8.2.6 and in the Appendix 2.

119 An electric kettle for heating water needs 2500W and an electric oven for baking bread has a capacity of 1300W.

Company[120] (PEC). Two workers from Savnob are employed by the PEC and responsible for maintenance and repairs (see Picture 2.43). Technical support and spare parts are available in Khorog at the head office. The PEC defined the electricity fees on a kWh basis in US dollars[121], charging higher rates in wintertime and for consumption beyond a certain limit. The overall consumption of electricity is distributed evenly among all households so that all households receive a bill over the same amount of money[122] (see Picture 2.44). Customers have already complained about the “unfair” billing system, arguing that people using only a few electrical appliances pay the same amount as others with excessive use of electricity.


***Picture 2.45:*** *Since there are insufficient funds to purchase fuel for the school for heating in winter, school children have to bring along teresken shrubs or dung every day to heat the classrooms. (Photo: T. Hoeck, June 2003)*

## 11.3 Local School

The school offers primary and secondary education up to 11th grade for about 120 pupils from Savnob and from the neighboring village of Rukhsh. Only the teachers’ room is supplied with electricity for lighting. Electrical appliances are not available. On rare occasions a teacher brings his private tape recorder to school. The seven classrooms (see Picture 2.45) are equipped with metal firewood stoves from the Soviet era, which serve as the only heating source in winter. The official heating period (a relict of Soviet rule) is set from November 15th to April 12th. The school usually closes for about 20 days of vacation in January, or even 30 days in harsh winters. In summer there is a three-month break from June till the beginning of September. The parents’ committee gathers in autumn to discuss how to supply the school with heating material in wintertime. In 2003 the hukumat allocated funds for one truckload of firewood, which was brought from the *leskhoz* forest about 55km further up the valley. A truckload of firewood, including expenses for petrol, driver’s salary and a license to cut wood from the *leskhoz*, costs about 195 *somoni* (USD 62) and enables the school to heat all seven classrooms and the teachers’ room for a few hours daily over two months. Two to three truckloads of firewood are needed to survive in the winter. But the school’s budget[123] does not allow buying the missing amount of fuel for heating. Hence the supply gap has to be filled by the households, equipping their school children in wintertime with fuel (*teresken* shrubs, dung or dry branches) before they leave for school. This is an additional burden for the families’ scarce fuel stock stored for wintertime. Despite the efforts to heat the rooms, it is usually very cold in the classrooms. The villagers submitted a project to the MSDSP for better insulation of the school building. The plan was accepted, but no concrete activities have been launched so far.

## 11.4 Local Hospital

As Savnob is the center of the *jamoat* it has a hospital (built in 1989) with basic equipment to treat common diseases and illnesses. In winter there are about ten to fifteen patients from all over the *jamoat*, commonly suffering from pneumonia. The hospital is managed by one doctor and eight nurses and can accommodate up to fifteen patients. Electricity is an important commodity in running the hospital: A large electric cooker with integrated oven (requiring 5800W capacity, see Picture 2.37, Photo 7) is used for cooking, baking bread, heating water for tea and boiling syringes for disinfection. The medicine is stored in the refrigerator and put in a cooling box when there is a power supply gap.

Due to the fact that electricity is only available from late afternoon till midnight in summer, the energy demand of the above-mentioned activities must be met by biomass fuels during the daytime. In former years there were sufficient funds to buy several truckloads of firewood from the *leskhoz* forests, thus allowing a perennial

120 The MHPS formerly belonged to *Barki Tojik*, the National Energy Department. After the establishment of the Pamir Energy Company, all energy infrastructures in GBAO were handed over to the new private company. For further information about the PEC the reader is referred to Chapter 8.1.2.

121 The fees are converted into the national currency (*somoni*) on the basis of the current exchange rate.

122 In April 2003 every household received a bill of over 3.46 *somoni* (USD 1.10) for 234kWh.

123 The school owns a fruit tree orchard, poplar trees and some acres of arable land. The plot is rented for 40 *somoni* (USD 13) per year to one of the teachers. In 2003 the school sold 5 medium-sized poplar trees for construction purposes for a total of 80 *somoni* (USD 25). In addition to the school’s own income sources, the VO supports it with 80 *somoni* (USD 25) annually.

supply. But in 2003 the *hukumat* only financed two truck-loads, an inadequate amount to heat the building during wintertime. The staff of the hospital was thus forced to re-organize firewood allocation in terms. From spring to autumn a nurse or the doctor is on duty for a couple of weeks, walking five kilometers and spending three hours daily on firewood collection. One back load of firewood is sufficient for two to three days in summertime.

***Picture 2.46:*** *From spring until autumn huge amounts of teresken shrubs are collected and stored on the roof of the Pamiri houses as a heating resource for winter. (Photo: T. Hoeck, June 2003)*

## 11.5 Household Energy Consumption Patterns

The basic domestic demands for energy resources at the household level are in summertime: preparing hot meals (see Box 2.5), heating water for tea, baking bread, lighting and if available, TV and radio. In winter the needs for heating water for washing and bathing, and room heating also have to be covered.

**Box 2.5: Daily Diet of the Villagers in Savnob**

Breakfast: consists of shir choi (tea with milk, salt and fat) and bread
Lunch: consists of tea, bread and perhaps yogurt
Dinner: consists of tea, bread, soup, rice or potatoes. Occasionally some meat is cooked or grilled.

A household commonly has a traditional stove located outside to use in summertime and a coal stove from Soviet times inside for cooking and heating in wintertime (see Picture 2.37). Each family owns at least some light bulbs and an electric coil cooker. Additionally radio, tape player, TV and an electric water kettle are available in some households (see Table 2.18).

The different energy resources are not perennially or permanently available. For this reason, several resources meet the demand of the specific domestic activities throughout the year (see Table 2.17). As a consequence of the schedule for electricity generation in summer the villagers of Savnob rely on *teresken* shrubs to cover their needs for cooking, heating water and baking bread during daytime. Only in the evenings can the coil cooker and electric kettle be used for these purposes.

Owing to the hydro scheme's low capacity the electric cooking appliances are not adequate devices to perform these activities: To bake one loaf of bread on the coil cooker takes approximately seven hours and to heat a pot of water almost two hours. Electricity is mainly used for lighting, watching TV and listening to music. The metal stove is permanently kept burning, heating the accommodation in wintertime. Thus preparing meals, baking bread and heating water for tea are preferably performed on the hot stove, even though electricity is available in the mornings and evenings. Dung used primarily as fertilizer, is a scarce energy resource: The available quantity is only sufficient for room heating in combination with *teresken* during the coldest two or three months of the year. The use of diesel oil for domestic activities is an exception. One household receives five liters of diesel oil

***Table 2.17:*** *Energy Resources Used for Different Purposes in 2003.*

| Domestic demands | *Teresken* | Dung | Electricity | Diesel oil* |
|---|---|---|---|---|
| Cooking | ○ high, ❄ high | ❄ low | ○ low, ❄ medium | ❄ low |
| Heating water | ○ high, ❄ high | ❄ low | ○ low, ❄ medium | ❄ low |
| Baking | ○ high, ❄ high | ❄ low | ○ low, ❄ medium | |
| Room heating | ❄ high | ❄ high | | |
| Lighting | | | ○ high, ❄ high | ❄ low |
| TV, radio | | | ○ high, ❄ high | |
| Iron | | | ○ high, ❄ high | |

○ Degree of application in summer (low, medium, high)
❄ Degree of application in winter (low, medium, high)
* Exceptionally used in only few households

*Source: Field study 2003*

for free every second month from the husband's employer. Fossil fuel is saved for wintertime and used for lighting when there is no electricity supply and for cooking purposes.

To cover the different domestic needs the households use a combination of two to four energy resources. Richer households have the possibility to diversify their energy resource base while less privileged families totally have to rely on shrubs and electrical energy. The annual energy consumption of the six selected households varies between 109.4GJ and 139.2GJ. As shown in Figure 2.22 *teresken* shrubs are the most essential energy resource for all households, covering from 81-93% of the overall energy consumption. Accordingly biomass fuels (*teresken* and dung) meet up to 94% of a single household's energy demand. Since there is no data available on individual electricity consumption, the quantity shown in Figure 2.22 is the figure for an average household. It is obvious that this has a slightly negative effect on the calculations. It must therefore be considered that according to the

***Table 2.18:*** *Selected Households in Savnob.*

| Household (hh) | hh 1 | hh 2 | hh 3 | hh 4 | hh 5 | hh 6 |
|---|---|---|---|---|---|---|
| Members | 9 | 3 | 6 | 11 | 5 | 9 |
| Category: 1=poor, 2=middle, 3= rich | 2 | 3 | 1 | 3 | 2 | 1 |
| Arable land: m² | 2400 | 600 | 1300 | 2250 | 1000 | 3000 |
| Artificial fertilizer | yes | yes | no | yes | no | yes |
| Dung used as fertilizer/fuel | 50%/50% | 50%/50% | 0%/0% | 50%/50% | 50%/50% | 100%/0% |
| Arable land per cow-dung-unit | 863 | 216 | 0 | 508 | 755 | 1290 |
| Sheep and goat | 12 | 12 | 0 | 22 | 5 | 5 |
| Cattle | 2 | 2 | 0 | 3 | 1 | 2 |
| Donkeys | no | no | yes | yes | no | yes |
| Monthly income: somoni (USD) | 20 (6.4) | 104 (33.0) | 0 (0.0) | 37.5 (11.9) | 7 (2.2) | 13 (4.1) |
| Size of heated room: m³ | 90 | 60 | 60 | 40 | 45 | 90 |
| Electrical and other appliances | Tape recorder (5W), TV (40W), iron, bulbs: 5x100W, electric kettle (2.5kW), coil cooker (1kW), traditional stove, metal stove | TV (40W), iron, bulbs: 3x100W, electric kettle (2.5 kW), coil cooker (1kW), traditional stove, metal stove | 2 TVs (40W), bulbs: 3x100W, electric kettle (2.5kW), coil cooker (1kW), traditional stove, metal stove | Tape recorder (5W), TV (40W), iron, bulbs: 1x25W, 1x60W, 3x100W, electric kettle (2.5kW), coil cooker, traditional stove, metal stove | Bulbs: 2x100W, coil cooker (1kW), traditional stove, metal stove | TV (40W), bulbs: 2x100W coil cooker (1kW), traditional stove, metal stove |
| Maximum required capacity for all appliances: W | 4045 | 3840 | 3840 | 3930 | 1200 | 1240 |
| Energy consumption | | | | | | |
| *Teresken:* kg/y (GJ/y) | 6365 (95.46) | 6412 (96.18) | 7644 (114.66) | 8199 (122.96) | 8199 (122.96) | 6727 (100.91) |
| Dung: kg/y (GJ/y) | 1196 (14.35) | 620 (7.44) | 0 (0.00) | 644 (7.73) | 460 (5.52) | 0 (0.00) |
| Electricity: kWh/y (GJ/y) | 2356 (8.48) | 2356 (8.48) | 2356 (8.48) | 2356 (8.48) | 2356 (8.48) | 2356 (8.48) |
| Diesel: liters/y (GJ/y) | 0 (0.00) | 30 (1.05) | 0 (0.00) | 0 (0.00) | 0 (0.00) | 0 (0.00) |
| Annual energy consumption: GJ | 118.3 | 113.2 | 123.1 | 139.2 | 137 | 109.4 |
| Per capita energy consumption: GJ | 13.15 | 37.73 | 20.52 | 12.65 | 27.4 | 12.15 |
| Summer consumption | 26% | 36% | 34% | 38% | 39% | 28% |
| Winter consumption | 74% | 64% | 66% | 62% | 61% | 72% |
| Expenses: electricity/y: *somoni* (USD) *teresken* | 27.20 (8.80) 4h/30 kg | 27.20 (8.80) 4h/30 kg | 27.20 (8.80) 6h/80kg | 27.20 (8.80) 6h/80kg | 27.20 (8.80) 4h/30 kg | 27.20 (8.80) 6h/80kg |

Conversion factors:
firewood, *teresken*: 1kg = 15MJ, dung: 1kg = 12MJ, electricity: 1kWh = 3.6MJ
diesel: 1 liter = 36MJ
Sources: www.worldbank.org, www.asystems.ch, www.bioheiztechnik.de, www.worldenergy.org, Rijal (1999: 226).

*Source: Field study 2003*

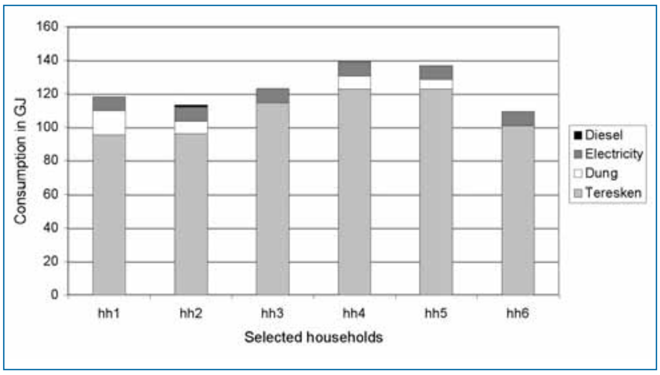



***Figure 2.22:*** *Annual Energy Consumption in GJ of Six Selected Households in Savnob. As mentioned in the MHPS section of this chapter, there is no data available concerning a household's individual electricity consumption, thus in this diagram all customers use the same amount of electricity. Source: Field study 2003*

available appliances the electricity consumption can considerably differ from one household to another. There are great seasonal differences in energy consumption, with 61-74% of the energy used in winter. Heating the accommodations consumes huge amounts of resources (see Picture 2.46), especially when fast-burning *teresken* shrubs are used for this purpose. The daily consumption of *teresken* per household ranges between 10-18kg in summer and between 22-27kg in winter.

## 11.6 Economy of Scale for Energy Consumption

The household sample has been selected by considering the number of members, the financial state of the family and the spatial distribution of the households over the village territory. Considering the collected quantitative data, there is no evidence that one of these three factors decisively influences the quantity of consumed energy at the household level. As can be seen in Figure 2.23, the per capita energy consumption decreases potentially from the household with only three members to the household with eleven members. This economy of scale[124] indicates that the number of household members itself is not the decisive factor in determining the amount of consumed energy. Thus the household, and not the individual inhabitants, should be taken as a unit for energy consumption.

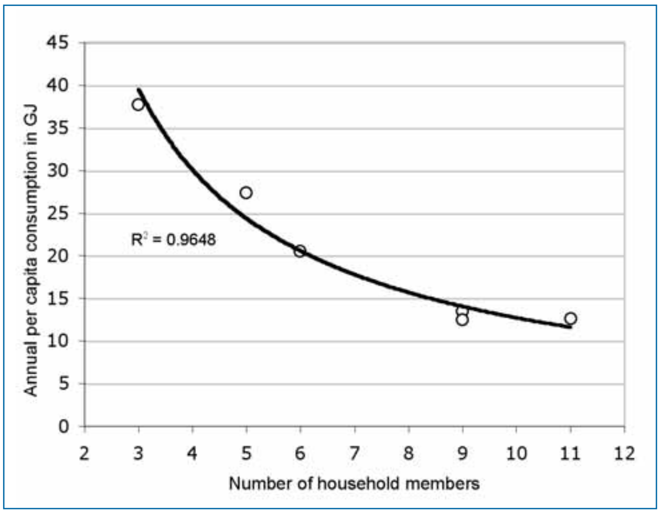
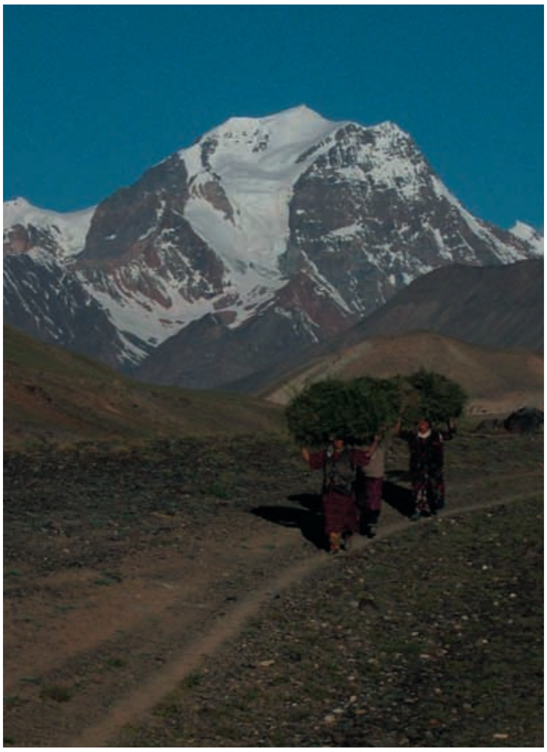



***Figure 2.23:*** *Economy of Scale for Energy Consumption at the Household Level. Source: Field study 2003*

## 11.7 The Drudgery of Collecting Fuel Wood

As seen in Figure 2.22 *teresken* shrubs make up the bulk of domestic energy consumption. The acquisition of *teresken* is an arduous and time-consuming task that is commonly performed by women and children. Almost daily from springtime to autumn one or two members of each household spend four to five hours collecting these shrubs, carrying head loads of 30kg back home. The use of a donkey eases the workload because about three



***Picture 2.47:*** *Especially women suffer from the daily drudgery of collecting teresken shrubs and carrying heavy head loads back to the village. (Photo: T. Hoeck, June 2003)*

124 The economy of scale for energy consumption at the household level is also mentioned in Clemens (2001: 106) regarding the Northern Areas of Pakistan. The economy of scale can also be observed in data concerning energy resource consumption at the household level in GBAO available in Kleinn (2002).

***Picture 2.48:*** *Gathering teresken shrubs is an arduous task. This couple in Savnob is lucky, because they have a hoe, gloves and a donkey, which ease the workload. (Photos: T. Hoeck, June 2003)*

head loads can be transported on the back of a pack animal at the same time. Due to the snow cover it is impossible to collect the shrubs in winter. Thus from April till October a sufficient stock of *teresken* has to be accumulated to survive the winter (see Picture 2.46). If there are only elderly or ill members in a household, the neighbors assist with the allocation of fuel.

The shrubs are mainly pulled manually out of the soil, without a hoe or gloves to protect the hands from injuries (see Picture 2.48). In springtime the soils are soft, making it easier to gather *teresken* than in the dry season when the surface hardens. Preferably the larger bushes are collected. Since the inhabitants of Savnob have started intensively collecting *teresken*, the distance to the areas where the shrubs grow increases steadily year by year, and with it the time spent on energy resource allocation. The surroundings of the village have been cleared of vegetation during the last years, so that people have to travel further and climb higher to obtain their main energy resource. *Tezkan* is seldom collected from areas at higher altitudes. This cushion plant features a better heating efficiency than the shrubby *teresken*, but requires great effort to be dug up and transported down to the village.

The acquisition of fuel wood and *teresken* shrubs is connected with hard physical work demanding strength and endurance. Women in particular suffer from various chronic complaints after performing this arduous task for years (see Picture 2.47). They complain of headache, backache, stomach-ache, injuries on feet and hands, and problems with lungs and kidneys. Some feel dizzy and ill after hours of walking and collecting, others mentioned slowly losing their hair because of the heavy head loads. Not only the energy resource allocation but also the use of *teresken* shrubs affects the women's health. When burned, these small bushes create very smoky fires, harming the eyes and respiratory tract. The women in Savnob say they have no choice, because men refuse to do this hard work. The male members of a household take care of the land and are responsible for irrigation. In addition, children, mainly girls, are helping with energy resource acquisition during vacation and after school. This hard work will certainly have severe consequences for the children's adolescence in terms of their health. It is a very urgent issue to relieve women and children of this daily drudgery.

Even though fuel wood procurement demands a lot of time and strength, the use of biomass fuels is the only

***Table 2.19:*** *Costs of Energy Resources and Appliances in Savnob in 2003.*

| | |
|---|---|
| Diesel oil | Sold in the village for 1 *somoni* per liter |
| Electricity from MHPS (PEC) | Summer: USD cents 0.25/kWh, over 50 kWh: USD cents 0.54/kWh<br>Winter: USD cents 0.25/kWh, over 200 kWh: USD cents 0.75/kWh |
| Firewood | 1 truckload from the *leskhoz* forest costs 195 *somoni* (USD 62) |
| *Teresken* | 4 hours for one bundle of 30kg<br>6 hours for one donkey load of 80kg<br>0.5 *somoni* (USD 0.16) for one bundle of 30kg (to hire a person) |
| Dung | 3 days per year for the preparation of dung cakes |
| Light bulbs | Khorog market: 60W for 80 *diram* (USD 0.25), 100W for 50-70 *diram* (USD 0.16-0.22) |
| Coil cooker | Dushanbe market: 15 *somoni* (USD 4.75)<br>Khorog market: summer 8 *somoni* (USD 2.50), winter 10 *somoni* (USD 3.20) |

*Source: Field study 2003*

energy option for the households since commercial fuels like diesel oil or firewood are hardly affordable. The temporal and monetary costs of different energy resources in Savnob are listed in Table 2.19.

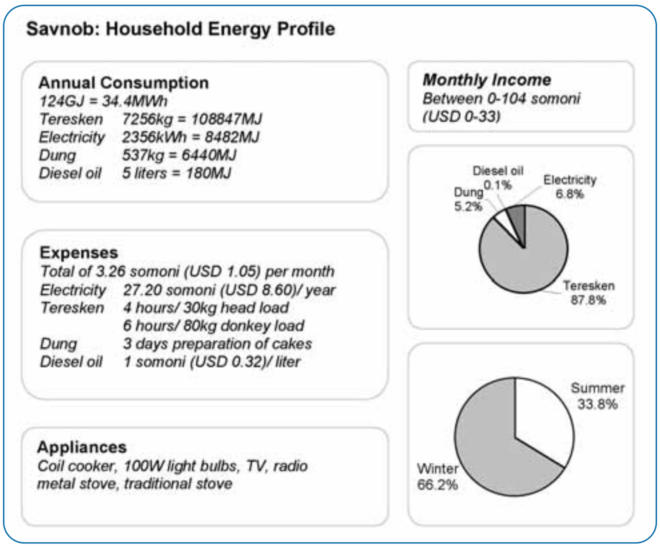



*Figure 2.24:* *Energy Profile of an Average Household in Savnob. Source: Field study 2003*

## 11.8 The Impact of Electricity

Although electricity account on average for not even seven percent of a household's energy consumption it has important impact on the people's livelihood. Electricity is perceived as the perfect energy resource, with no disadvantages and bringing light into people's lives. It offers a wide range of different applications. The possibility of cooking, baking and heating water on the electric cooker, having light inside and outside the home, watching TV and listening to the radio and to music increases the quality of life. Before the inhabitants enjoyed electricity supply they "lived in darkness" and went to bed after dinner. Electric power now allows further activities till midnight: The children can do their homework and study for school, women knit socks and sew different things or prepare wheat for grinding and above all people can watch TV. As a consequence they sleep less than before. Television is a window on the outside world; children can learn and improve their Russian and people have access to news from all over the world. The young generation is attracted by the pictures shown on TV, and are inspired to leave for Moscow or other places in Russia for a better life. Even dwellers from the neighboring villages (all without electricity supply) come to Savnob to watch TV in the evenings. At celebrations not only traditional live music is played but also recorded music from tapes. Electricity is also a precondition for the establishment of a community hospital allowing basic medical care for the inhabitants.

So far electricity has not been used to perform income-generating activities but only to cover a part of basic domestic needs. Nevertheless, it has an influence on the household budget: Electric power is cheaper than fossil fuels that would be used instead for lighting purposes: The dwellers of Savnob presently spend around 3.5 *somoni* (USD 1.10) a month for electricity to cover the energy demand for lighting and partially for heating water or cooking. Households in the neighboring village Nisur use between five to ten litres of diesel oil per month for lighting causing expenses of 5-10 *somoni* (USD 1.60-3.15). The MHPS in Savnob provides employment for two workers with monthly earnings of 55 *somoni* (USD 17.50), the highest salary in the village.

The availability and consumption of electricity in Savnob has only a slight impact on the ecological level. Electrical power is mainly used for such activities as lighting and watching TV that cannot be performed with fuel wood or dung. For this reason only a limited substitution of electricity for biomass fuels has been realized so far.

## 11.9 Household Energy Profile

Figure 2.24 shows the calculated energy profile of an average household in Savnob. The estimation is based on the quantitative data of the household sample (shown in Table 2.18), although qualitative data influencing the energy consumption was also considered to adjust figures. On the average, a household in Savnob uses energy resources equaling 124GJ[125] annually to cover its basic domestic needs. *Teresken* shrubs provide with a figure of 87.8% the bulk of a household's energy demand, followed by electricity, dung and fossil fuels. Two-thirds of the total energy is used in winter, mainly for heating. Financial expenses for energy resources are relatively low, varying around one dollar per month.

## 11.10 Energy Resource Use During Soviet Times

Before the village of Savnob enjoyed electricity supply for the first time in 1988 the inhabitants were totally dependent on imported fossil fuels (see Table 2.20). Even though the trucks from the *kolkhoz* occasionally drove to the forests for firewood acquisition, the bulk of the energy demand was met by coal and kerosene available at the local store. Fossil fuels were cheap[126] and affordable for everyone. One household consumed about 50 liters of

125 This figure equals the energy value of 2.95 tons of oil equivalent, of 3444 litres of diesel oil or of 34.4MWh of electricity (www.worldenergy.org).
126 One liter of diesel oil was available at 0.075 Soviet *rubles*, approximately USD 0.1. In 1989, one US dollar equaled 0.98 *rubles*. Source: Villager from Savnob.

***Table 2.20:** Energy Resources Used for Different Purposes During Soviet Rule (prior to the first electricity supply in 1988). The collected data does not allow differentiation among the seasons.*

| Domestic demands | Coal | Kerosene | Firewood | *Teresken** |
|---|---|---|---|---|
| Cooking | ○ (low) | ◯ (high) | ○ (medium) | ○ (low) |
| Heating water | ○ (low) | ◯ (high) | ○ (medium) | ○ (low) |
| Baking | ◯ (high) | ○ (low) | ○ (medium) | ○ (low) |
| Room heating | ◯ (high) | ○ (low) | ○ (medium) | ○ (low) |
| Lighting | | ◯ (high) | | |

○○◯ Degree of application (low, medium, high)

* Used to light the fire

*Source: Field study 2003*

kerosene per month for cooking and lighting purposes. If families additionally heated with kerosene stoves (burning up to 10 liters per day) the monthly consumption could rise to 200 liters. Coal was primarily used to heat accommodations, with approximately one ton sufficient for a season. *Teresken* shrubs were occasionally collected in the vicinity and burned together with coal to produce the fire.

## 11.11 Energy Resource Use Strategies

To satisfy the daily demand for energy, the villagers of Savnob have to deal with various constraints and **limiting factors.** The scarce energy resource base and the increasing pressure on resources require adaptive strategies with possibilities for resource substitution.

There are several factors limiting the availability and use of energy resources at the household level. The amount of livestock determines the ratio of manure as fertilizer or as fuel. Households with no or very few animals compared to the size of arable land (high arable land per cow-dung-unit factor)[127] do not use dung as a heating resource because manure is used to fertilize the cropland. If there are sufficient funds to buy artificial fertilizer dung can be saved for heating in winter. The MSDSP also offers a barter trade for artificial fertilizer: In spring the peasants receive fertilizer and in autumn they deliver a part of their harvest as payment. A higher regular income would enable people to buy fossil fuels, other electric appliances or even firewood.

Larger households need large pots and pans when preparing meals for a greater number of persons. The cooking devices will not heat up on a regular coil cooker so that cooking is performed on the fire. In a household with many members one larger room is preferably heated in wintertime. But the energy stock often does not allow heating of a sizeable room.

The scarcity of energy resources and increasing pressure on natural energy resources steadily increases the expenses for allocation. Every year people have to walk further and spend more time on collecting biomass fuels.

Competing demands limit the temporal and quantitative availability of energy resources: Water used for irrigation constrains electricity generation and dung has to be divided between its two applications (fertilizer and heating material).

Options and individual **preferences** are other decisive aspects influencing the use and consumption of energy. The villagers have a choice among various appliances and among different energy resources:

A household owns three different appliances for preparing meals, baking bread and heating water: a traditional stove located outside, a metal coal stove from Soviet times placed inside the house and an electric coil cooker (see Picture 2.37). These devices are used with specific preferences. The traditional stove is used prefer-

***Picture 2.49:** Tezkan (here on the roof of a Pamiri house in the village of Roshorv) is very seldom collected since its acquisition requires hard physical work. (Photo: T. Hoeck, July 2003)*

127 For the comparison of the arable land per cow-dung-unit factors for selected households in Savnob, the reader is referred to Table 2.18. A high factor indicates little dung available per arable land, so that the household commonly uses little or no dung as fuel.

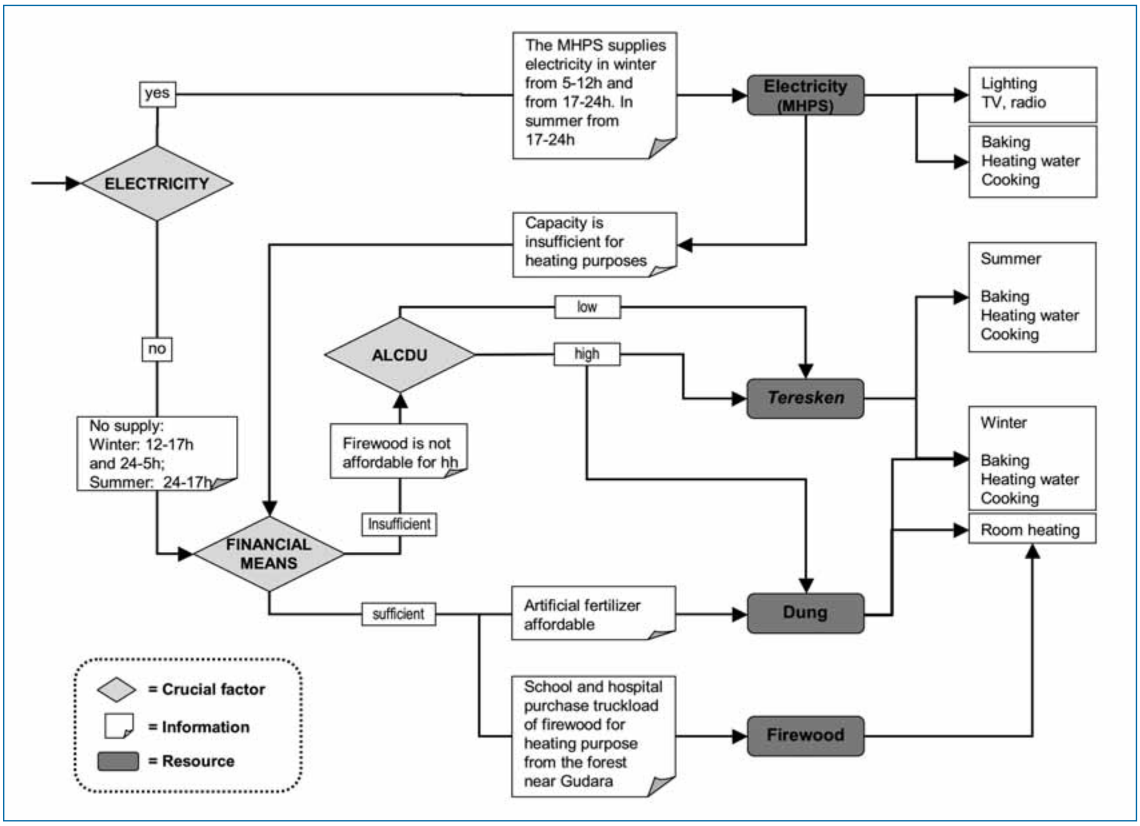



***Figure 2.25:*** *Present Energy Resource Use Pattern in Savnob. Concept: Droux & Hoeck*

ably during the summertime because it heats faster than the Soviet stove, although it consumes more *teresken* shrubs, and because it is uncomfortable to have a fire inside the house during the hot season. The metal stove inside is used for heating and for preparing meals in winter. In comparison with the electric coil cooker, the fire stoves provide better heat and operate faster. This is the reason why fire is preferred for baking bread, heating water and for preparing certain dishes.

Even though *teresken* shrubs cover the bulk of a household's energy demand, it is the least preferred resource for use, although easier to obtain compared to other resources. These small bushes burn very quickly like paper and give considerable heat but only for a short time. Especially in springtime the still green and moist *teresken* bushes create very smoky fires. A stock of the cushion plant *tezkan* lasts three times as long as *teresken*, although acquisition requires hard physical work, so that it is very seldom collected (see Picture 2.49). Electricity is the favorite energy resource, but due to low capacity it is not preferred for preparing meals, heating water or for baking. If the power supply were sufficient, electrical energy would be applied to all activities, even heating the accommodations in winter.

For the inhabitants of Savnob the different energy resources are not perennially or permanently available. This demands resource allocation strategies to accumulate a sufficient stock of energy resources and a substitution of resources for periods without supply. Due to the scarce energy resource base in Savnob, the villagers do not have many alternatives to choose from. They use electricity whenever possible according to the available capacity and accessible appliances. Demands that cannot be met with electric power have to be covered by *teresken*. Since these shrubs are not good heating material, whenever possible people substitute dung or firewood for *teresken* in winter. The villagers' **energy resource use strategy** can be characterized as follows:

On the one hand, electricity is used whenever possible to meet the energy demand, although due to its limited capacity and temporal availability people have to rely mainly on biomass fuels. On the other hand, an inter-biomass substitution is performed, selecting the resource with higher heating efficiency if affordable and available (see Figure 2.25).

A severe shortage of energy calls for **adaptive strategies:** Either increasing supply or decreasing demand through more efficient use or saving resources. Few measures have been taken so far to improve the energy situation, and no attempts at all have been made to increase supply. Restrictions were placed on cutting firewood at the local forests to achieve a rehabilitation of the vegetation, thus temporarily diminishing the available resource base. Coal provision during Soviet times allowed villagers to heat the main room (160$m^3$) in a household, but since people have to rely on *teresken* shrubs they are forced to move into a smaller room (40-90$m^3$) to survive the winter[128]. The smaller rooms were mostly constructed for this very purpose in recent years. The metal Soviet stove originally designed to run on coal requires a lot of shrubs and dung to produce an expedient heat. Hence some households started constructing a new stove with thinner metal elements to improve performance for cooking and heating (see Picture 2.37, Photo 8).

## 11.12 Village Energy Consumption Profile

Overall energy use in Savnob was estimated on the basis of an average household's consumption (see Figure 2.26). Public infrastructures such as the hospital, the school and the *hukumat* office were included in the calculation and counted as households. Considering the economy of scale at the household level it is legitimate to extrapolate the energy consumption to the village level based on data for an average household. Biomass fuels meet more than 93% of Savnob's energy demand, and electricity covers the remaining seven per cent. The 341 inhabitants annually allocate a total of 414 tons of *teresken* shrubs, which are collected near the village.

## 11.13 Resource Degradation[129]

The scarcity of natural resources determined by the biophysical characteristics of this region is steadily intensified by increased pressure on these resources. Rapid

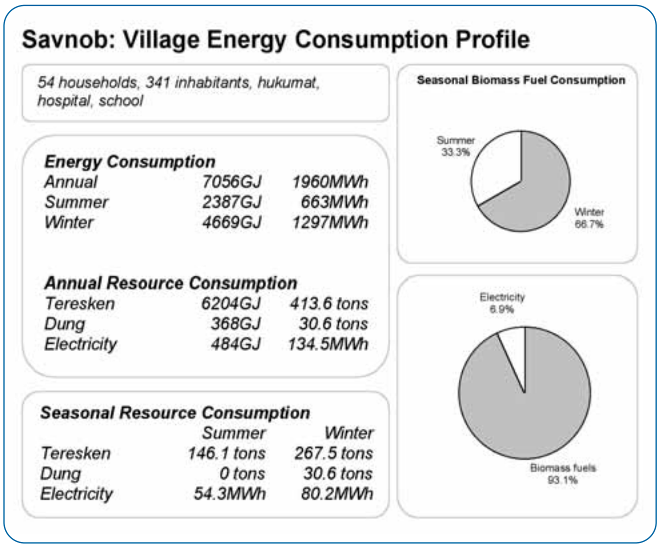



*Figure 2.26: Estimated Energy Consumption of the Village of Savnob. Source: Field study 2003*

***Picture 2.50:** Due to the intensive harvest of teresken, the surroundings of the village are already cleared of vegetation. (Photo: T. Hoeck, June 2003)*

population growth in the last 75 years (Breu & Hurni 2003: 10), the cessation of resource provisions after the collapse of the Soviet Union and the lack of alternatives created a total emergency situation for the local population. The almost total dependence on local natural resources offers little opportunities to relieve the pressure. The resources suffering the most from increased pressure and prone to degradation are woody vegetation and arable land. Some dwellers discovered salty soil or salt crusts on irrigated plots. High evaporation rates, the spring's considerable mineral content or inadequate irrigation methods are the likely causes. Lack of fertilizer, both dung and artificial, results in the slow decline in the soil's fertility, causing less productive harvests. Pesticides are not applied to the croplands because they are too expensive. Hence a great diversity of other plants is growing in the fields competing with crop plants for nutrients, thus further reducing yields. The forests in the riverbed were cut during the last years and are now partially protected for rehabilitation. The surroundings of the village are already cleared of vegetation – there are only scattered *teresken* shrubs left (see Picture 2.50). People must walk further and climb higher to collect these essential bushes, steadily clearing new and more remote areas. *Teresken* are pulled out together with their roots leaving behind bare and loose soil prone to water or wind erosion. The density of the *teresken* vegetation cover for the Murgab Region is mentioned in Domeisen (2002). On the average, the stock of this shrubby plant is 700kg/ha, although varying widely between 300-1350kg. Applying these figures to Savnob with an overall consumption of 413 tons per year, 590ha are cleared on the average to

128 Prior to the integration of GBAO into the Soviet Union the traditional Pamiri house consisted of one small room (20m$^3$) and a stable for the livestock. Only the richest households in the village had a house with a larger room (120m$^3$), which is similar to the size of present dwellings in Savnob (Schultze 1914: 31).

129 Other common forms of land and resource degradation at village level are discussed in Chapter 9.

***Table 2.21:** Loss of Vegetation Cover Due to Teresken Consumption in Savnob*

| Sparse, average and dense *teresken* stocks | Annual loss of vegetation cover | Daily loss of vegetation cover | Annual loss per average household |
|---|---|---|---|
| Density 300kg/ha | 1377ha | 3.8ha | 24.2ha |
| Density 700kg/ha | 590ha | 1.6ha | 10.4ha |
| Density 1350kg/ha | 306ha | 0.8ha | 5.4ha |

*Source: Field study 2003*

meet the demand of the village. The energy resource consumption thus results in daily vegetation loss amounting to 1.6ha (see Table 2.21).

## 11.14 Scenario Towards Sustainable Energy Resource Use in Savnob

Poor accessibility and the remote location of Savnob demand a decentralized energy supply based on local available energy resources. The challenge is to transform the present energy resource use patterns (see Figure 2.25), mainly based on *teresken* shrubs, into a sustainable energy resource use (see Figure 2.27) dependent on more efficient energy resources. Different measures concerning the increase of supply and decrease of demand have to be applied to achieve an amelioration of Savnob's energy situation (see Table 2.22).

A possible way towards a more sustainable energy use system for Savnob is discussed with the focus on hydropower's potential to substitute for biomass fuels and to relieve pressure on these resources. An MHPS running on half capacity only a few hours a day offers the possibility of better electricity supply.

Assuming that present annual energy consumption corresponds to the actual demand for energy, a total substitution of electricity for other fuels seems infeasible. Even if the MHPS is operating permanently at full capacity (80kW) only 19% of the village's energy consumption could be covered by electrical energy. The annual consumption of 7056GJ would require a 400kW-hydropower-plant, which is not realistic considering the availability of water in Savnob. In addition, people would not be able to pay for the huge amount of consumed power covering all their needs for energy. Based on present fees and the regular income of families, assuming they would spend all their income on electricity, only 11-65%[130] of the electricity required annually could be afforded. Therefore a total substitution of electrical energy for biomass fuels is insupportable for the households.

But considering seasonal differences and the assumption that due to the use of *teresken* shrubs the consumption is much higher than the actual demand for energy, the goal of a near total substitution of electricity for biomass fuels in summer appears to be feasible.

On the basis of the appliance capacities and their use in terms of time at the household level the monthly demand for power was estimated (see Appendix 3): As a re-

***Table 2.22:** Possible Measures to Increase Energy Supply and Decrease Demand for Energy Resources in Savnob.*

| **Decreasing the Demand for Energy Resources** | |
|---|---|
| Resource substitution: | Use electricity instead of *teresken* for preparing meals, use firewood instead of *teresken* for heating |
| More efficient appliances: | Adequate electrical devices for cooking, baking, heating water and lighting (LED lamps) demanding less watts, efficient firewood-ovens for heating and cooking |
| More efficient use: | Immediately extinguishing the fire after food preparation |
| Better insulation: | Lining heated rooms with felt mats or with other insulating materials |
| Individual billing for electricity consumption: | Since every household pays the same electricity bill regardlee of its actual consumption, there are no incentives to efficiently use electric power or to use it only when it is really needed. Billing according to electricity meters installed in each household could create such incentives. |
| **Increasing Supply with Local Natural Energy Resources** | |
| MHPS delivering full capacity: | Increase water supply and availability through construction of a new water channel (already planned for irrigating additional arable land), new electricity generation schedule, new irrigation schedule considering temporal demands for electricity, construction of bigger forebay tank to increase water pressure for turbine, water pump to refill the pool overnight |
| Better electric capacity (watts) per household: | Electricity distribution schedule supplying e.g. only one half of the village with electricity at the time, public bakery to ensure sufficient capacity for baking bread |
| Large-scale reforestation: | Reforestation and planting willow trees to use as a fuel wood resource |

*Source: Field study 2003*

130 Only the richest household could completely cover the electricity costs.

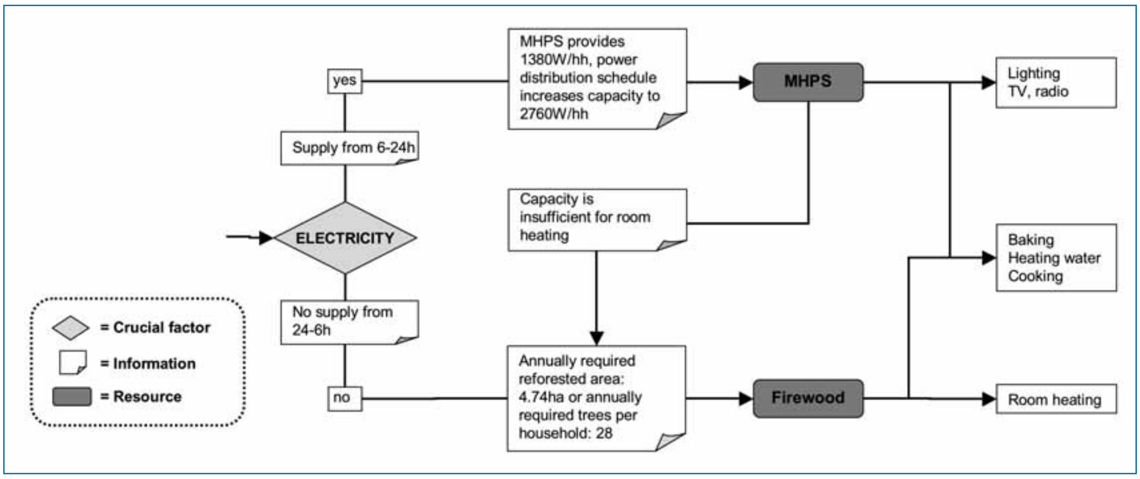



***Figure 2.27:*** *Possible Sustainable Energy Resource Use Pattern in Savnob. Concept: Droux & Hoeck*

sult 315kWh/month are sufficient for one household to prepare meals, bake bread, heat water and operate other electrical devices such as TV and radio. Almost every family in Savnob can afford the monthly costs of 4.8 *somoni*[131] (USD 1.50) for electric power. Assuming that the following preconditions for better electricity supply can be fulfilled, the MHPS is able to deliver the required current to households in Savnob:

- MHPS operating at full capacity (80kW) at least 18 hours a day. This requires additional workers at the MHPS.
- New water channel increasing water availability for the MHPS and irrigation and ensuring a sufficient perennial supply.
- Larger forebay tank increasing pressure for turbine.
- New irrigation schedule considering the MHPS' demand for water.
- New electricity generation schedule in summertime considering the demand for electricity.
- Electricity distribution schedule to increase available capacity per customer.
- Additional and more efficient electric appliances demanding less capacity.
- No other village is connected to the electricity grid.
- Possibility of water-pump refilling water pool overnight.
- Possibility of transformer stabilizing capacity.

Running on 80kW capacity, the MHPS supplies each household with 1380W. By establishing an electricity use schedule dividing Savnob into two halves for power supply, the capacity can even be doubled to 2760W. The available current is sufficient for standard use of a coil cooker (1000W), electric kettle (2500W) or electric oven (1300W). Simply substituting of electrical power for *teresken* shrubs results in a considerable reduction down to 16% of the former overall energy consumption in summer. This has a major potential of relieving pressure on *teresken* bushes and noticeably decreasing consumption. Covering all needs with electricity in summertime would make it possible to save 2.5 tons of shrubs per household, an amount equivalent to 35% of annual *teresken* consumption. At the village level, a quantity of 146.1 tons, representing an area of 208ha, could thus be conserved annually.

It is not feasible with the available infrastructure to meet all demands for energy with electricity in winter. *Teresken* is not an adequate resource for heating accommodations, so that it is necessary to replace these shrubs with other energy resources with superior heating ability. Firewood could serve as an adequate heating resource. This requires large-scale reforestation with willows, poplars and other species. Other domestic needs could be covered with electricity, as in summertime. Assuming an average firewood consumption of 2760kg[132] per household for room heating purposes in winter, the villagers of Savnob should reforest an area of 4.7ha yearly over a period of ten years to ensure sustainable use of firewood from then on (see Table 2.23). This area equals approximately 28 trees per household which need to be planted every year. A broad spatial assessment of possible reforestation sites on the surroundings of Savnob, performed with the help of GIS[133], allow us to assume that the required reforestation area of 47ha for the entire village is available. That means, there is a possibility of sustain-

131 Considering the steady increase of electricity fees as foreseen by the PEC from USD 0.0075/kWh to USD 0.03/kWh by 2010, while also considering subsidies with a lifeline tariff block, 315kWh will cost 12.45 *somoni* (USD 3.95) by the year 2010.

132 Figures concerning energy resource consumption in Vezdara in winter considering a complete substitution of firewood for dung results in an average required amount of 2760kg per household.

133 Based on observations the authors made in the field, possible reforestation plots in the floodplains of the river were drawn as polygons in ArcView-GIS, and their area was calculated. As a result, the potential overall area suitable for reforestation was calculated at 62.8ha. This figure should be viewed as a very rough estimate.

***Table 2.23:*** *Required Annual Reforestation (Trees or Hectares) During a Ten-Year Period. This allows sustainable use of firewood to cover energy needs in combination with electricity in Savnob.*

| Forest species | Biomass volume of tree in kg | Required trees per hh/year | Required trees per village/year | Annual biomass yield | Required area | |
|---|---|---|---|---|---|---|
| | 10-year old tree | 10-year old tree | 10-year old tree | tons/ha | ha/hh | ha/village |
| *Populus* | 182 | 15 | 880 | 61.9 | 0.045 | 2.59 |
| *Salix* | 49 | 56 | 3267 | 16.7 | 0.165 | 9.59 |
| *Robinia* | 105 | 26 | 1525 | 35.7 | 0.077 | 4.48 |
| *Elaeagnus* | 205 | 13 | 781 | 69.7 | 0.040 | 2.30 |
| Mean | 135.25 | 28 | 1613 | 46 | 0.082 | 4.74 |

*Source: Field study 2003. Estimations were performed according to Clemens (2001: 156)*[134].

***Table 2.24:*** *Present and Reduced Energy Consumption for an Average Household in Savnob*

| | Present resource consumption | Sustainable resource consumption |
|---|---|---|
| Summer | 41.9GJ | 6.8GJ* |
| Winter | 82.1GJ | 48.2GJ* |
| Total | 124GJ | 55GJ* |
| * Broad estimate based on an electricity consumption of 315kWh/month in summer and winter, and on a firewood consumption of 2760kg for room heating in winter | | |

*Source: Field study 2003*

able management of local biomass fuels, allowing sufficient yield to meet Savnob's heating resource demands.

This scenario shows that total non-reliance on *teresken* shrubs seems to be feasible and could significantly reduce overall energy consumption as shown in Table 2.24.

It is apparent that considerable financial means and time are required to achieve the needed measures for an amelioration of Savnob's energy situation. Larger projects like the construction of a new water channel and forebay tank or the development of more efficient appliances can only be accomplished with support and assistance from the AKF, MSDSP and international donors.

## 11.15 Conclusion and Recommendations

The collapse of the Soviet Union resulted in a sudden changeover from an energy resource use system almost completely based on imported fuels to a system totally dependent on local natural resources. Poor and irregular accessibility, and the scarcity of vegetation, arable land and water sources create difficult conditions for the agro-pastoralists in Savnob. There are no affordable alternatives for inhabitants other than to use the scarce biomass fuels and the available electricity from the MHPS to cover their daily domestic energy needs. Biomass fuels cover more than 93% of the village's energy consumption. The unsustainable use of the locally available energy resources (firewood and *teresken*) results in increased pressure on biomass fuels, reducing year-by-year Savnob's energy resource base and leading to large-scale degradation of the village surroundings. An estimated area of 590ha is cleared annually due to *teresken* gathering. Forests have disappeared during the last decade and are now nearly non-existent. Moreover, few measures have been taken so far to increase the supply of energy resources or improve the energy situation in Savnob. The time required for energy resource allocation increases each year and the acquisition of biomass fuels has a severe impact on the health of women.

Electricity from the MHPS allows only limited substitution for biomass fuels. Inadequate availability in terms of time and insufficient output capacity hinder the proper use of electric power to cover basic domestic needs. Thus hydropower only makes a slight contribution to relieving pressure on biomass fuels. Nevertheless, the availability of electricity ameliorates considerably the people's livelihood. Since the MHPS is managed by the private Pamir Energy Company and not by the community of Savnob, no measures have been taken to improve the hydro scheme's performance and adjust electricity generation to temporal demands.

The heritage of the Soviet Union determines present energy consumption. The provision of sufficient goods and resources fostered rapid population growth, the construction of larger houses and the use of appliances de-

134 The estimate implies the following premises: turnover: 10 years; distance from one tree to another: 1.5m; survival rate of the seedlings in the first year: 60%; conversion factor for the density of wood: 700kg/m3. (Clemens 2001: 156 et sqq.) Due to the low differences in heat values for the different trees, the factors are unified at 15MJ/kg.

signed to run on fossil fuels. It is impossible with the present available natural energy resources to meet satisfactorily Savnob's demand for energy that is still determined by a Soviet-sized infrastructure: Houses are too large[135] to be properly heated and appliances like the Soviet coal stove require too much local fuels to operate properly. Moreover, the use of *teresken* shrubs, offering a reasonable heating value but burning very quickly, considerably increases energy consumption. Although it sounds paradoxical, even though people can hardly meet their basic demands they still consume huge amounts of energy. An average household in Savnob annually consumes 124GJ, 50% more than the consumption of an average Swiss household with a figure of 78GJ in 2000 (SFOE 2002: 22; SFOS 2003: 5). It can be concluded that there is a great potential for decreasing overall energy consumption by use of more efficient resources and appliances. This is a precondition in ensuring a sustainable use of local energy resources and guaranteeing a sufficient supply for the inhabitant of Savnob. As depicted in the scenario, sustainable energy resource use in Savnob would seem to be feasible, provided that adequate electricity supply is guaranteed in summer and winter and that large-scale reforestation is carried out, thus creating the basis for sustainable use of firewood.

Below is a list of recommendations for the peasants and for the village organization, adapted to Savnob's specific energy situation. The short-term and long-term measures should mitigate the energy crisis and pave the way to sustainable energy resource use in Savnob. One should keep in mind that the recommendations listed below were compiled based on the authors' external view of the energy situation, but were not discussed with the dwellers of Savnob to assess their feasibility. Thus the measures should be viewed as a possible guideline to mitigate the energy problem.

***Short-term recommendations with immediate impact:***

To increase the temporal availability of electricity the villagers should …

…introduce a new **water distribution schedule** for irrigation and operation of the MHPS.

…introduce a new **electricity generation schedule** with longer operational periods for the hydro scheme.

To increase the electrical capacity per household the villagers should…

…introduce an **electricity user's schedule,** in which the first and the second half of the village is alternately supplied.

…introduce **restriction rules** on the use of electric appliances; to unplug devices not in use and to simultaneously use only a limited number of appliances.

…use **light-emitting-diode (LED) lamps or low-wattage light bulbs** instead of 100W-bulbs.

To increase water availability for the MHPS the villagers should …

…**control** the outflow of water from the forebay tank to the **water tap system** and close the taps when water is not needed.

To use electric power more efficiently the villagers should…

…improve their **electric coil cookers,** adapting them to the pan's size and form, or designing a new usable model made out of tufa stone available in the village.

To use biomass fuels more efficiently the villagers should…

…make better **use of waste heat** from their metal stoves or heat stones and water as heat storage media.

…immediately **extinguish the fire** when finished cooking, baking or heating water.

To relieve women from their daily drudgery of collecting teresken shrubs the villagers should …

…teach women how to make resistant **gloves** for *teresken* harvesting.

…manufacture **hoes** to ease *teresken* harvesting

…convince **men to do the dirty work** or at least participate in collecting *teresken*.

…breed **donkeys** to transport firewood and *teresken* bundles.

To increase the supply of dung to use as fertilizer and fuel the villagers should …

…collect **manure from the livestock compound on the high pasture** and transport it in autumn on the back of the cattle down to the village. The dung could be used as fuel for public institutions (hospital or school).

To realize the use of electricity for baking bread the villagers should …

…establish a **public bakery** run on electricity where villagers can bake their own bread (in a system similar to the public mills).

***Long-term recommendations with delayed impact:***

To increase the output capacity of the MHPS the villagers should …

…construct a **new water channel** for thus increasing water discharge for the hydro scheme.

…construct a **larger forebay tank** for thus increasing pressure for the turbine.

…construct an **additional forebay tank** to use other available water resources in the village.

135 The present traditional Pamiri-houses in Savnob have three rooms, one large room: (120-160m$^3$) and two smaller ones (40-90m$^3$). The Pamiri-houses as they existed prior to the integration of GBAO into the Soviet Union, consisted of one room with a volume of around 20m$^3$. Only the richest household had a room with a size (120m$^3$) similar to the present rooms (Schultze 1914: 31).

To reduce energy resource consumption the villagers should …

…better **insulate their homes and buildings** using wool, straw or felt mats. Lining only a single room, where to pass winter, with insulating material.

To increase the supply of biomass fuels the villagers should …

…**reforest large areas** with willows, poplars and Russian olive trees to use as a firewood resource. The villagers should annually reforest 4.7ha or every household should annually plant 28 trees over a period of ten years.

…cultivate and **manage existing forest areas in a sustainable way** and use them as a firewood source.

…introduce **agro-forestry regarding firewood cultivation** around their homes (as is done in Vezdara).

To make available a more efficient heating fuel the villagers should …

…establish **production of fuel briquettes**[136] made of manure, shrubs, agricultural residues and small branches.

***References***

Breu T. and Hurni, H. (2003) The Tajik Pamirs: Challenges of Sustainable Development in an Isolated Mountain Region. Berne: Centre for Development and Environment (CDE), University of Berne.

Clemens, Jürgen (2001) Ländliche Energieversorgung in Astor: Aspekte des nachhaltigen Ressourcenmanagements im nordpakistanischen Hochgebirge. Bonner Geographische Abhandlungen. Heft 106. Sankt Augustin: Asgard-Verlag.

Domeisen, Michael (2002) Marginalized by the Impacts of Transformation. A Study of Post-Soviet Livestock Breeding in the High Mountains of the Eastern Pamirs. Diplomarbeit. Bern: CDE.

Harvey, Adam (1993) Micro-Hydro Design Manual. A Guide to Small-Scale Water Power Shemes. London: Intermediate Technology Publications.

OSIENALA [Friends of Lake Victoria] and GFN [Global Nature Fund] (eds.) (2004) Renewable Energy for Fisherfolks of Lake Victoria. A joint East African Training Programme for Technicians for the Conservation of Lake Victoria Resources and the Environment. A Project of OSIENALA (Friends of Lake Victoria) in Collaboration with Global Nature Fund (GNF). Final Proposal Version 2.0.

Schultz von, Arved (1914) Die Pamirtadschik. Veröffentlichung des Oberhessischen Museums und der Gail'schen Sammlung zu Giessen (Abteilung für Völkerkunde). 1. Heft. Giessen: Verlag von Alfred Töpelmann (vormals J. Rickmers)

SFOE [Swiss Federal Office of Energy] (2002) General Energy Statistic 2002. Bern. http://www.energie-schweiz.ch/imperia/md/content/statistikperspektiven/gesamtenergie/9.pdf

SFOS [Swiss Federal Office of Statistic] (2003) Press release: population. According to the census of 2000.

Shrestha, Ganesh Ram (2001) Energy Technologies for Mountain Communities. World Mountain Summit 2001.

[136] Hand-operated fuel briquette machines are already used by the fisherfolk of Lake Victoria in East Africa to compact sawdust, wood chips and other biomass wastes into convenient shapes for use as fuel. The organization OSIENALA (www.osienala.org) has developed and tested the fuel briquette machines (OSIENALA and GNF 2004). In the Hindu-Kush Himalayan region beehive briquette-making has been successfully introduced in mountain communities. Composed of biomass and agricultural waste, briquettes are sold in the local market and burn about 1.5 hours. Thus, they are also an effective fuel for heating of rooms (Shrestha 2001).

# 12. Nisur: A Village Without Electricity

Nisur[137], one of Savnob's neighboring villages, is situated 2.2km downstream on the river Bartang. The 36 households are widely dispersed over the village's settlement area consisting of 75ha. The original center of Nisur was established around a fortress which used to be at a location where the school is now situated. Nothing is left of this building, which served as civil defense against Kyrgyz invaders. Only the graveyard and the oldest houses of the village recall those turbulent times. The village is divided into two parts: The upper part of the village is settled on a former river terrace steeply sloping over 60m in a 55° inclination down to the lower part of the village. The bridge over the Bartang connecting the main road and Nisur was completed in 1989. Before that, villagers had to cross the river by means of a small hand-operated cable car. Even with the bridge, the way to the district center where the next bazaars are located is far and the access especially during winter is very limited. Besides two radio call stations, one established by an international aid organization and the other belonging to the Ministry of Emergency Cases, there are no other means of communication in Nisur.[138] One is supplied by a photovoltaic panel the other by an accumulator battery.

| |
|---|
| Village: Nisur |
| Jamoat: Savnob |
| District: Rushan |
| Altitude: 2600m |
| Households 2003 (1993/1898): 36 (30/5) |
| Inhabitants 2003: 240 |
| Average members per hh: 7 |
| Female/male ratio: 70%/30% |
| Sheep and goats (per hh): 300 (8) |
| Cattle (per hh): 65 (2) |
| Arable land (per hh): 11ha (3000$m^2$) |
| Arable land per cow down unit: 1437 |
| Size of heated room: 30-87$m^3$ |
| Heating period: November to April |
| Mean annual precipitation: ~130mm |
| Minimum winter temperature: -35°C |
| Distance to Rushan, district center: 113 km |
| Distance to Khorog, oblast center: 168 km |
| Public infrastructure: secondary school, library, club, radio call, 4 mills, holy place with a cenotaph of a former Imam |

*Source: Cobbold (1898); Field study 2003*

***Picture 2.51:*** *The upper part of Nisur is situated on a former alluvial terrace. Only where it is irrigated crop can be cultivated. (Photo T. Hoeck, June 2003)*

Next to the school a small wind energy plant was established during Soviet times but broke down so that nowadays there is nothing left of this plant. The four water mills scattered over the village territory are only used during summer, not because of the division of labor but because of the limited water availability. The tributary stream which feeds the whole village with water for domestic purposes only flows from June to October. Due to this fact, people have restricted irrigation capabilities and are barely able to cultivate kitchen gardens. Only a few households grow carrots, cabbage or tobacco. The cultivation period is determined by the late melting snow, shortening the growing season. The scarcity of water is one of the mayor constraints on the villagers' livelihood. During winter all the households have to obtain water for domestic needs from the main river (Bargang), so that the families living at the top of the village must walk up to three km to fetch water. Because of the limited water availability even during summer, the three main irrigation channels supplying the households and the arable land with water are scheduled in a three-day rotation. Wheat, potatoes, milk products, and meat are the main staple foods produced by the villagers. In 2001, the MSDSP distributed a couple of chickens to the less wealthy households. Beside the humanitarian aid there is virtually no outside food consumed in Nisur.[139] Although a few old fruit trees were recently half cut or entirely chopped, a striking amount of tall apricot and apple trees are left in the vil-

137 According to some villagers the name "Nisur" evolved from the two terms "Nist Nur" which means "no light".
138 Due to the limited transmission area of the radio call stations the district center is only reachable over several stations.
139 In 2003 each household received four liters of edible oil only the poorest 40% of the households recieve three kg of flour three times per year.

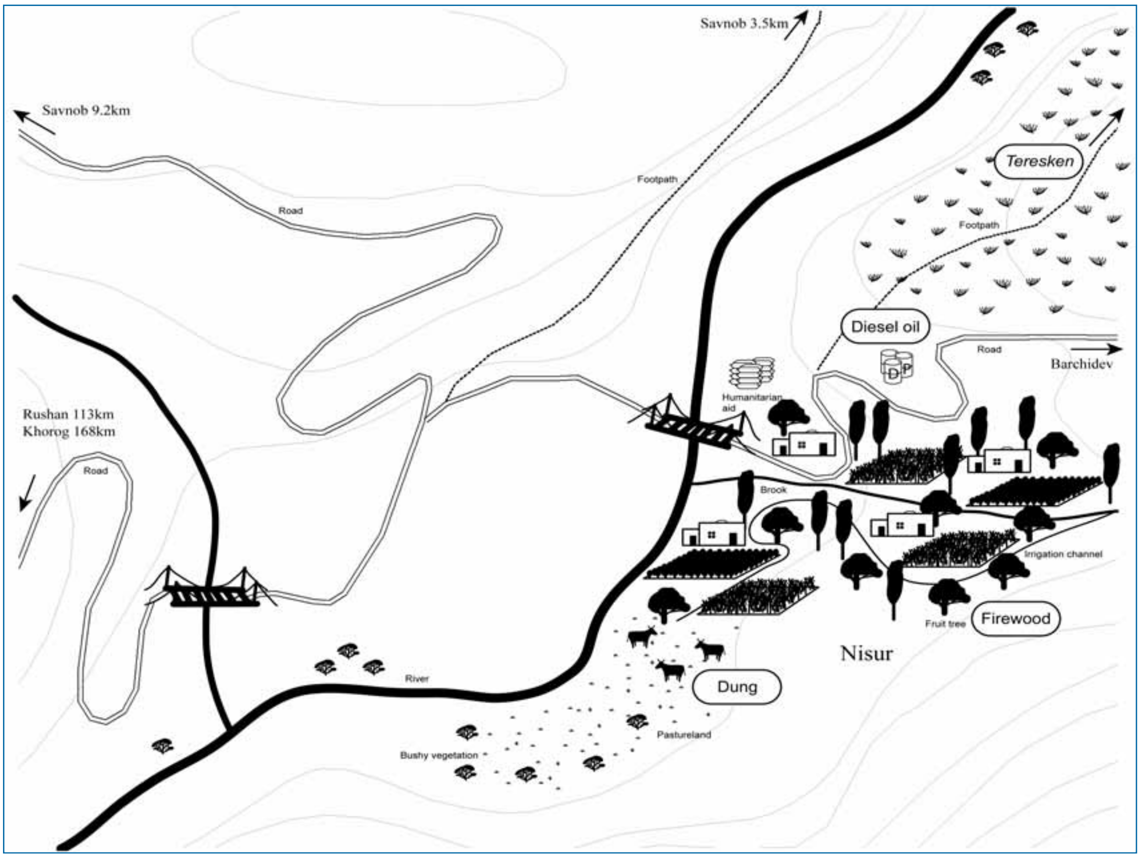



***Figure 2.28:*** *Schematic Sketch of the Village of Nisur Depicting the Major Assets and Energy Resources. Source: Sketch by T. Hoeck*

lage.[140] Very few households cultivate young fruit trees. Five years ago the inhabitants of Nisur founded their village organization (VO) with the education department, the women's committee and the health committee.[141] Nearly all the villagers are members of the VO and pay a non-recurring entrance fee of 1.5 *somoni* (USD 0.48). Few projects were initiated by the VO in recent years: One was a food-for-work project for rehabilitating the river-bank that was launched after a flood eroded the arable land. Another project was to construct an irrigation channel to extend the amount of arable land. Landslides have destroyed the channel several times and the villagers are no more motivated to successfully finish this project. At the time of investigation these 160ha of future arable land which ought to be divided between the two neighboring villages Nisur and Barchidev were not yet irrigated, because of lack of cement for the foundation of the channel.

## 12.1 Energy Resource Base

According to the elderly villagers, all the floodplains bordering the Bartang river were covered by riparian forest-land 40 years ago. The wood was already used as a fire-wood source during Soviet times. After the collapse of the USSR villagers from Nisur were confronted with a radical division of the provision sector. Kerosene and coal, which were imported in large quantities and used for cooking, room heating, baking, and lighting, ceased completely. Since this event, the villagers of Nisur were forced to intensify use of local available resources such as *teresken*,

### *Box 2.6: Background of the Energy Supply*

Before 1991: Coal and kerosene were imported by the government, used for cooking, room heating and lighting and were available and affordable for everyone. Small amounts of *teresken* were used to light the fire. The school and most of the households purchased firewood from the forests around the village. A small wind power plant was established for the school. Some households purchased a diesel generator or accumulator batteries. Only a few households used a small amount of dung in combination with coal.

Since 1991: Forests close to the village are already stubbed. Households started collecting *teresken* shrubs around the village. Only richer households can afford a truckload of firewood from the forest close to Gudara.

140 Nisur features a unique natural phenomenon: One of those old apple trees yields fruit twice a year although due to the short growing season the apples of the second harvest remain unripe and are inedible.

141 The chairman of the VO and the chairman of the women's committee were absent at the time of investigation.

*Table 2.25: Comparison of the Winter Energy Resource Use of the School in Soviet Times and Today.*

| Resource | Soviet time | Today |
|---|---|---|
| Firewood | 10 Truckloads: 22'500kg, paid by the government | Two truckloads: 4500kg, 500 *somoni* (USD 158.73) |
| Coal | 3 tons: paid by the government | No coal available |
| Teresken | Not used | 7560kg[142] provided from the pupil's family |
| Petrol | 150 liters: for the generator | No more used |
| Total | 430GJ/y | 180GJ/y |

*Source: Field study 2003, Rijal (1999: 226-227)*

wood from the forests and animal dung. The MSDSP started to supply the village with subsidized diesel oil in the mid-nineties. Even though it is sold for one *somoni* (USD 0.32) virtually all the villagers only use it for lighting. The price is too high for households to use it for cooking or baking bread on their kerosene stoves.

Already at the beginning of the nineties all the riparian forestland located on Nisur's village territory had vanished. Nowadays *teresken* bushes are the main energy resource and are consumed in great quantities. Thus the hills around the village are completely cleared. Only in the graveyard have some full-grown *teresken* bushes survived because of the collection restriction on this site (see Picture 2.55).

## 12.2 Local School

Nisur's school provides classes from the 1st to the 11th grade to 84 pupils and offers employment to 14 teachers. It is home to a library of 3000 rarely borrowed books. Each class has its own room equipped with desks, chairs, a blackboard and a small iron stove. Every winter the school purchases two truckload of firewood from the wood in Gudara financed by the pupils' parents and by the teachers.[143] The payment is not strictly defined; it depends on the families' ability to pay. This firewood is barely sufficient to heat the classrooms until February. For the remaining heating period pupils have to bring *teresken* shrubs from home. The classrooms are not lighted and still heated according to the Soviet schedule: November to March from 9-12 h and 13-14 h. The following statement of a pupil illustrates how the low temperatures substantially impede teaching and learning at school:

*"During wintertime it is very cold in the classrooms, we are not able to heat the classrooms properly, everyone has to wear thick clothes, and we can even see our breath while speaking."*

Because of the cold temperatures during wintertime and the limited fuel the teachers have to close the school during January. The school guard is responsible for the gathering firewood and he additionally cultivates a 1400m$^2$ plot belonging to the school. The yielded harvest is sold and the returns are spent on firewood.

The employees of the school cultivate some poplar trees around the building, generating some additional income by selling them for construction purposes for around 50 *somoni* (USD 15.87). The branches are also used as fire material for the school.

During Soviet times the school was provided with coal and 150m$^3$ of firewood. It owned a diesel generator for lighting the classrooms.

As indicated in Table 1, the amount of fuel available for the school was more than double during Soviet times than today. During this period the government entirely supplied the school with fuel, whereas nowadays in most instance the households are forced to provide the fuel wood, additionally increasing the strain on *teresken* procurement.

## 12.3 Household Consumption Patterns

The basic domestic needs in terms of energy resources used at the household level differ by season. During summer time energy resources are used for preparing hot meals, heating water for tea, baking bread, and lighting. During wintertime heating water for washing and bathing, and room heating are additional needs for energy resources.

Due to the lacking electricity supply and the remote location, the variety of common domestic appliances is limited in Nisur. Virtually all the households have two traditional clay stoves called *kitsor*: one outside of the house and another embedded in the raised living area in the

***Box 2.7: Daily Diet of the Villagers in Nisur***

Breakfast: *shir choi* (tea mixed with milk, salt and oil or butter) and bread
Lunch: tea, bread and sometimes yogurt
Dinner: tea, bread, potato soup. Occasionally some meat is added.

142 To heat the classrooms the teachers need one head load per classroom for the remaining 1.5 month of the heating period.
143 A teacher's monthly salary is between 15 and 35 *somoni* (USD 4.76-11.11).

***Picture 2.52:*** *Teresken is by far the most important energy resource in Nisur. Households consume up to eight tons of these shrubs every year. (Photo: T. Hoeck, June 2003)*

main room. The latter is used only for special events. During Soviet times all the households purchased a metal stove used mainly indoors to prepare meals, heat water, bake bread and heat the main room. Some households take it outdoors in summertime to maintain an agreeable temperature in the house. These cast iron stoves were actually designed for coal burning and are in fact inadequate for *teresken* which, due to its low density, rapidly deflagrates. Hence the thick cast iron of the stove can only be heated by intensive firing.

To light the rooms all the households own one to two diesel lamps, most of them holdovers from the Soviet era. During that time the lamps were used with kerosene which was available in the shop in Nisur. Another popular domestic relict is the willingly used kerosene stove eagerly used in former times but now lying idle, because of its immense consumption of fuel.[144] Nowadays, the subsidized diesel oil is delivered by truck from the MSDSP and sold in each village directly from the tanker.

*Teresken* is a substitute for coal and partly for kerosene. In fact, it is the bulk of all the present energy resources, used for cooking, baking, heating water, room heating and to some extent as fodder.

Some households use edible oil actually delivered as humanitarian aid to light homemade oil lamps in order to reduce consumption of diesel oil.

Table 2.27 features various attributes in the field of energy consumption patterns for the six households which were chosen for the research sample.

Due to the fact that Nisur was never supplied with electricity, a few wealthier households purchased a small generator or accumulator batteries, mainly used for radio receiver or radio call. The accumulators are either recharged on a small generator[145] in the village or from the current of the MHPS in Savnob.

Table 2.26 summarizes the linking between the resources and their intended use. The degree of application indicates a mere qualitative image to depict which resource is used for which purpose and to what extent compared to the others.

Villagers in Nisur use two to five different energy resources to meet the different domestic needs. In all households *teresken* is the mayor energy resource. The annual consumption varies from 4187 to 10,920kg, whereby a household consisting of twelve members uses the highest amount of *teresken*. Wealthier households have the possibility of diversifying the resource basis. They are able to pay for firewood from the *leskhoz*[146] forest in Gudara and for diesel oil, while very poor households have to use their edible oil donated as humanitarian aid for lighting in order to reduce expenses for diesel oil. As Figure 2.29 indicates, the annual overall energy consumption varies between 125.87 and 170.5GJ and is dominated by *teresken* shrubs. Between 48-97% of the

***Table 2.26:*** *Energy Resources Used for Different Purposes in 2003.*

| Domestic demands | *Teresken* | Coal | Firewood | Kerosene | Petrol* | Dung |
|---|---|---|---|---|---|---|
| Cooking | ○ summer: low, ❄ winter: low | ❄ winter: medium | ○ summer: low, ❄ winter: medium | ○ summer: high | | |
| Heating water | ○ summer: low, ❄ winter: low | ❄ winter: high | ❄ winter: medium | ○ summer: high | | |
| Baking | ○ summer: low, ❄ winter: low | ❄ winter: high | ○ summer: medium, ❄ winter: medium | ○ summer: medium | | |
| Room heating | | ❄ winter: high | ❄ winter: medium | ○ summer: low | | ❄ winter: low |
| Lighting | | | | ○ summer: high, ❄ winter: medium | ○ summer: low, ❄ winter: low | |
| Radio | | | | | ○ summer: low, ❄ winter: low | |

○ Degree of application in summer (low, medium, high)
❄ Degree of appliaction in winter (low, medium, high)

*Source: Field study 2003*

144 The stove used a half a liter of kerosene per hour at full capacity.
145 The costs for the petrol to recharge a battery entirely at a private generator total 45 *somoni* (USD 14.29).
146 The *leskhoz* is the governmental forestry office.

***Table 2.27:*** *Specification of the Household Sample in Nisur.*

| Household | Hh 1 | Hh 2 | Hh 3 | Hh 4 | Hh 5 | Hh 6 |
|---|---|---|---|---|---|---|
| Members | 8 | 5 | 2 | 6 | 12 | 6 |
| Category: 1=poor, 2=middle, 3= rich | 2 | 3 | 1 | 1 | 2 | 3 |
| Arable land: $m^2$ | 4300 | 2500 | 2000 | 2000 | 4700 | 1800 |
| Artificial fertilizer (kg/y) | no | yes (80) | yes (40) | yes | yes | yes |
| Dung used as fertilizer/ fire material | 95%/5% | 95%/5% | 50%/50% | 70%/30% | 90%/10% | 70%/30% |
| Arable land per cow dung unit | 1959 | 1645 | 1166 | 1587 | 1774 | 493 |
| Sheep and goats | 3 | 8 | 11 | 4 | 10 | 10 |
| Cattle | 2 | 1 | 1 | 1 | 2 | 3 |
| Donkey | no | no | no | no | no | no |
| Monthly income: *somoni* (USD) | 35 (11.10) | 25 (7.90) | 10 (3.15) | 8 (2.54) | 15 (4.75) | 60 (19.05) |
| Size of heated room: $m^3$ | 65 | 73 | 45 | 87 | 30 | 30 |
| Appliances | Traditional stove, metal stove, kerosene cooker (no longer used), 2 diesel lamps, 2 accumulators for radio and small light bulb (6V) | Traditional stove, metal stove, 2 diesel lamps, accumulator for radio call, radio, tape player | Traditional stove, metal stove, two diesel lamps, kerosene cooker (no longer used) | Traditional stove, metal stove, 1 diesel lamp, 1 kerosene cooker (no longer used) | Traditional stove, metal stove, 1 diesel lamp, kerosene cooker (no longer used) | Traditional stove, metal stove, generator with two bulbs (only used for special events), 2 diesel lamps, 1 kerosene cooker (no longer used) |
| **Energy consumption:** | | | | | | |
| *Teresken*: kg/y (GJ/y) | 8736 (131.04) | 8175 (122.63) | 9080 (136.20) | 7644 (114.66) | 10920 (163.80) | 4187 (62.81) |
| Dung: kg/y (GJ/y) | 90 (1.08) | 0 (0.00) | 340 (4.08) | 755 (7.73) | 405 (4.86) | 836 (10.03) |
| Diesel oil: liters/y (GJ/y) | 58 (2.09) | 58 (2.09) | 116 (4.18) | 120 (4.32) | 51 (1.83) | 311 (11.20) |
| Firewood kg/y (GJ/y) | 0 (0.00) | 0 (0.00) | 608 (9.12) | 0 (0.00) | 0 (0.00) | 3040 (45.6) |
| Petrol: liters/y (GJ/y) | 15 (0.50) | 35 (1.16) | 0 (0.00) | 0 (0.00) | 0 (0.00) | 30 (1.00) |
| Electricity: | Twice a year 2 batteries to recharge (at a generator) | Twice a year one battery to recharge (in Savnob) | | | | Generator only used few times a year |
| Annual energy consumption: GJ | 134.21 | 125.87 | 153.58 | 128.17 | 170.5 | 130.62 |
| Per capita energy consumption: GJ | 16.77 | 25.17 | 76.79 | 21.36 | 14.21 | 21.77 |
| Summer consumption | 34% | 24% | 19% | 32% | 33% | 20% |
| Winter consumption | 66% | 76% | 81% | 68% | 67% | 80% |
| **Expenses:** | | | | | | |
| Diesel oil: *somoni* (USD) per month | 5.83 (1.53) | 5.83 (1.53) | 9.67 (3.07) | 8.00 (2.54) | 4.25 (1.35) | 25.92 (8.23) |
| Petrol: *somoni* (USD) per month | 1.87 (0.60) | 4.38 (1.39) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 3.75 (1.19) |
| Firewood: *somoni* (USD) per month | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 20.80 (6.60) |
| Total: *somoni* (USD) per month | 6.87 (2.18) | 9.38 (2.98) | 9.65 (3.05) | 12.00 (3.80) | 4.25 (1.35) | 50.45 (16.00) |
| *Teresken* h (kg) per day: | 4 (30) | 4 (30) | 5 (50) | 2 (30) | 9h (80) | 4h (30) |

Conversion factors:
firewood, *teresken*: 1 kg = 15 MJ, dung: 1 kg = 12 MJ, electricity: 1 kWh = 3.6 MJ
diesel oil: 1 liter = 36 MJ

*Sources: www.worldbank.org, www.asystems.ch, www.bioheiztechnik.de, www.worldenergy.org, Rijal (1999: 226-227); Field study 2003*

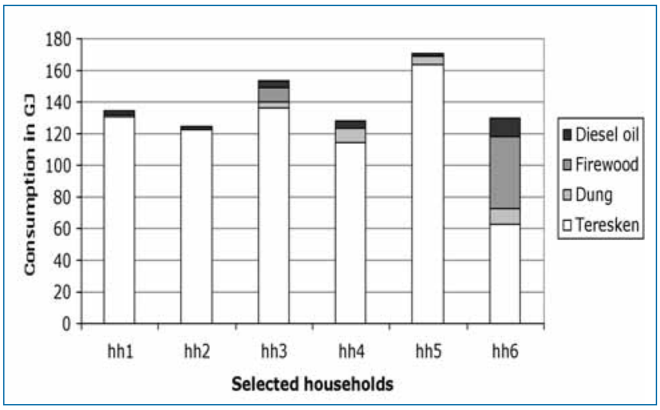



***Figure 2.29:*** *Annual Energy Consumption at the Household Level. Annual energy consumption in GJ of six selected households in Nisur. Source: Field study 2003*

overall consumed energy is provided by *teresken*. This large difference results from the fact that some richer households purchase firewood. They can thereby reduce the amount of *teresken* consumption. However, 97% of all the energy consumption is covered by biomass fuels such as *teresken*, firewood and dung. This fact emphasizes how the people of Nisur rely heavily on locally available energy resources.

Owing to the low temperatures during wintertime and the high energy demand for room heating especially by firing *teresken* shrubs[147], 66-81% of all energy is used in winter. Due to the fact that some households use firewood or animal dung during wintertime, the consumption of *teresken* can be reduced. Larger households consume more *teresken* than small ones because they have to bake a great deal of flatbreads and heat a big bowl for meals and are forced to reheat the stove repeatedly.

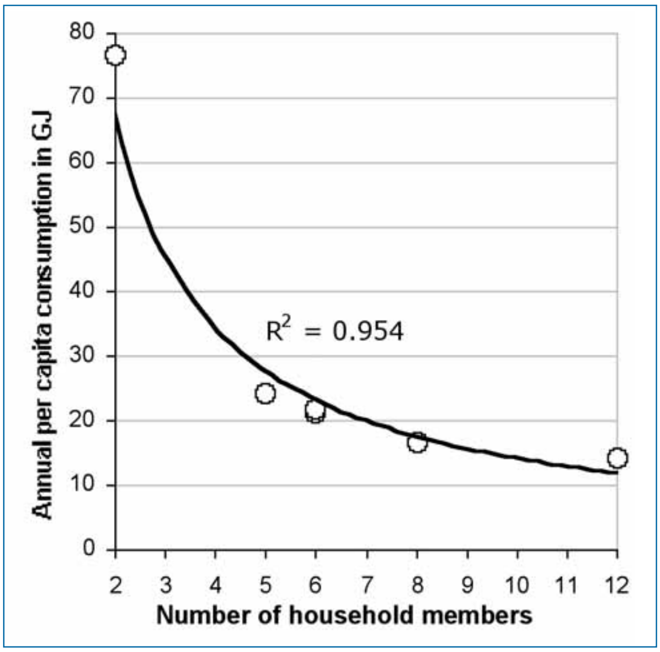



***Figure 2.30:*** *Economy of Scale: Comparison of annual per capita consumption and size of household. Source: Fieldwork 2003*

## 12.4 Economy of Scale for Energy Consumption

Figure 2.30 illustrates the fact that the annual per capita consumption decreases potentially with increasing members per household. This effect is known as economy of scale and influences the household consumption patterns remarkably. Thus declining population, induced by migration and birth control, affects the village energy consumption only to a small extent, because it is mainly male individuals who are migrating and only very rarely whole families.

## 12.5 The Drudgery of Collecting Fuel wood

*Teresken* is by far the most important energy resource in Nisur and used in great quantities by each household. As there are only eight donkeys in the village, most of the collection labor has to be done by women or girls[148], because men are engaged in crop cultivation and usually refuse to do this work. Women are doing this job mainly early in the morning starting at 4.30 am. Commonly the women form small groups so that they can assist each other in bundling and placing on their heads. They walk for one hour to an area where enough of larger *teresken* shrubs are left. Most of the women remove the entire shrubs with their bare hands, and only a few women wear gloves for this painful work. It is actually the appendage of the root that burns to any reasonably degree and not the brush-wood itself. To bundle the shrubs, they gather them into a large cluster, pile them up and align them to tie them in a bundle which is carried as head load back to the village. The whole process takes an average of three hours, which is repeated by some women several times a day. The head loads weigh between 20 and 30kg. It is conceivable that this backbreaking labor affects the women's health. Most women suffer from chronic headaches, back pains, lung ailments and sore hands.[149] Box 2.8 depicts the daily chore of women in Nisur.

Both genders consider this work to be men's work, but due to the traditional labor division women are still doing

147 Water boiling tests comparing efficiency of *teresken* and electricity resulted in 7-12 times higher energy use (Joules) to boil one liter of water with *teresken* than with electricity.

148 Girls have to start aiding collecting at the age of ten, and most of boys refuse to do this work.

149 The authors did this work themselves to ascertain the drudgery of this labor by participatory observation.

***Box 2.8: The Routine of a Summer Day in Amal's Live (28 years old, two children, married to the jamoat doctor)***

03.30: It is still dark. She gets up, takes a rope and walks without having breakfast accompanied by two other women of the village to the plots, where the bigger *teresken* bushes still grow. Although she walks quickly, it takes her about one hour to get there.

04.30: She starts collecting *teresken* bushes without gloves by pulling them with the roots out of the soil. She puts them all on one pile and sets them in the right position in order to make a large bundle. It takes her one hour to collect about 25kg. Then she ties up all the bushes into one large head load.

05.40: With this burden on her head she and her companions return to the village. Due to the heavy head load and the rocky trail she is forced to take several rests (see Picture 2.53).

07.00: She arrives back home and deposits the bundle on the flat roof of her house in order to store it and let it dry. Today the little irrigation channel does not have water. Due to the shortage of water in the village the inhabitants established an irrigation schedule, so she has to get two buckets of fresh water at the river for baking and cooking. She takes the opportunity there to wash her face.

07.30: She goes for milking the cows and goats to get milk for the *shir choi*, salted milk-tea, with dipped *gartha* (flatbread).

08.00: Her husband sets out for the neighbouring village going to work as the doctor of the hospital. In the morning she takes care of the children, washes clothes or cleans the house. Sometimes when she has spare time she can take a rest.

11.00: She starts to prepare the meal by peeling potatoes for a soup.

12.30: She and her two children have lunch. After washing the dishes she prepares dough for bread. Afterwards she gets some more buckets full of water from the small water channel beside the house.

14.00: The fire from the lunch does not last for long because *teresken* incinerates very quickly. She has to relight the fire in order to bake the bread. As soon as the stove is hot she starts baking bread. Every two days she has to irrigate the land. In order to yield a large crop she is forced to weed the potato field from time to time.

17.00: She prepares dinner.

18.00: The family has dinner. After washing the dishes she sometimes crochets socks but because of the dim light from the diesel lamp her eyes gets tired quickly.

20.00: She and here husband put the two children to bed and shortly thereafter go to bed themselves.

***Picture 2.53:*** *In Nisur it is virtually only the women who collect teresken. This backbreaking labor considerably affects their health. (Picture: T. Hoeck, June 2003)*

this job. The collection period starts as soon as the snow melts and ends when the soils starts to freeze. During this time more *teresken* is collected than consumed in order to retain it on the roofs of the houses for wintertime. Hence the amount of stored *teresken* is to a certain extent an indicator of wealth status: The more *teresken* stored on the roof of a house the lower the ability to pay for firewood.

At the time when Nisur was still supplied with coal and kerosene women collected *teresken* around their house only to light the fire once in a week at most. With the cessation of fossil fuel provision, women had to intensify then *teresken* allocation. The deployable radius and the labor time of the *teresken* collection had to be gradually expanded and became mainly a women's lifetime task. Nowadays this backbreaking drudgery is done exclusively by the women in Nisur and is considered by both genders as an irrevocable tradition (see Picture 2.53). Boys refuse to do this work, so that girls starting from ten years old are obliged to carry out this task. In fact, however, a majority of the women suffer from serious health problems caused by *teresken* collection and its connected work: Chronic headache, lung aliments, hypertension, backache and considerable lesions on their hands are the major symptoms. In some cases this is intensified by undernourishment, lack of medical knowledge and the insufficient medical treatment. This unreasonable division of work, where women do the heavy labor and men are in charge of irrigation and cropland cultivation, has developed in the past ten years. Owing to the gender imbalance and the linked social status of the women this situation will continue in the future. Only when men change their minds and take a fairer attitude toward the labor division can the poor living conditions of the women be improved.

Approximately eight households regularly purchase one truckload of firewood allocated in the woodlands near the village Gudara. The wood is either chopped with an axe or bucked with a saw. It takes the men one week to load the truck and come back to the village. The costs for a truckload of firewood are 250 *somoni* (USD 79.37) including the cutting permission (30 *somoni*; USD 9.52) from the *leskhoz*, the diesel oil and the driver's salary (see Table 2.28).

As can be seen in Table 2.27 the highest outlays are spent on diesel oil, the households spending between 4 and 26 *somoni* (USD 1.27- 8.26) on diesel oil exclusive-

***Table 2.28:*** *Expenses for Energy Resources in Nisur in 2003.*

| | |
|---|---|
| Diesel oil | Sold in the village by MSDSP for 1 *somoni* (USD 0.32) per liter |
| Firewood | 1 truckload from the forest costs 250 *somoni* (USD 79.37) |
| *Teresken* | 4 hours for one bundle of 30kg<br>6 hours for one donkey load of 80kg |
| Dung | 3 days for preparation of dung cakes annually |

*Source: Field study 2003*

ly for lighting. The energy costs constitute the bulk of the household budget: Between 20 and 100% of the income is spent on energy resources.

## 12.6 Household Energy Consumption Profile

Figure 2.31 summarizes the energy consumption profile of an average household in Nisur. This estimate is based on empirically collected data[150] which was quantified and averaged for a mean household in Nisur.[151] Individual management of resource use was taken into account so that, for example dung consumption not only differs among households in terms of daily consumption quantity but also in terms of the number of heating days.

Although the average household depicted in Figure 2.31 uses five different energy resources, only two to three households actually use petrol. The same is true for firewood. In fact, only a fifth of households can afford firewood.

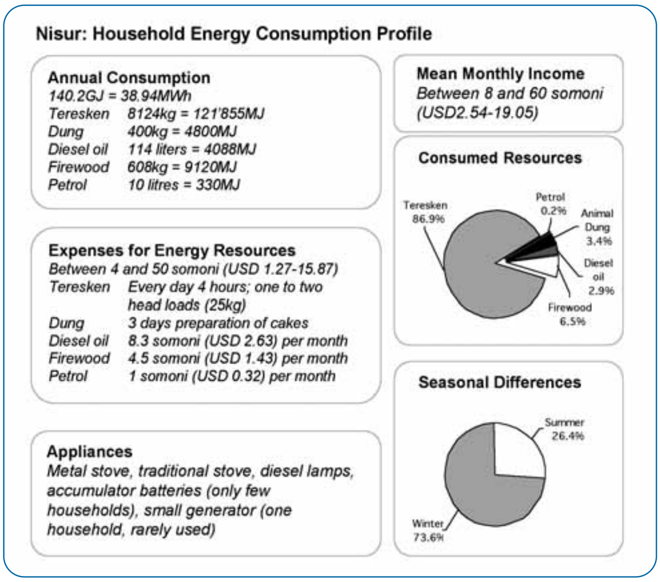



***Figure 2.31:*** *Profile of an Average Household in Nisur (7 members). Only few wealthier households purchase petrol and firewood. Source: Field study 2003*

## 12.7 Energy Resource Use During Soviet Times

The energy resource availability during Soviet times was more than enough to cover the essential needs of the villagers. Table 6 lists the energy consumption of an average household for this time, although the figures quoted are based on dwellers' statements and should thus be considered as rough estimates. Each household was provided annually with three tons of coal used mainly for room heating, cooking, and baking during wintertime (see Table 2.29). One truckload of firewood[152], which was free of charge for the public institutions and for the employees serving the state[153], was affordable for everyone and commonly used in combination with coal or dung. The latter was burned marginally in the stoves and distributed in small quantities on the fields because people owned only 800m$^2$ of arable land. Besides coal, kerosene was the second important resource delivered by the government to the shop in Nisur and readily used for lighting, cooking, baking and heating water, mainly in summer. Each household owned a kerosene stove and kerosene lamps which are nowadays used with diesel oil. *Teresken* was used exclusively to light the fire and thus consumed in small quantities. Consequently the allocation of firewood used to be men's work[154] in particular whereas women were engaged in other chores.

Due to the fact that the prices of the different fossil fuels were lower and the mean income higher during Soviet times, transport was more available and frequent. Thus, the households which privately owned a generator used much more petrol than today. Considering this issue, the consumption of fossil fuels would be slightly higher than the total listed in Table 2.29.

150 The annual average resource consumption is based on different original data which were projected and converted with the corresponding factors: kg per day (*teresken*), m$^3$ per year (firewood), liters per month (diesel oil) or per year (petrol).
151 For further information about data collection and evaluation the reader is referred to Chapter 5.3.
152 The cost of a truckload of firewood was 100 *somoni* (USD 31.75).
153 E.g. a teacher received 3-4m$^3$ of firewood per winter for free.
154 Firewood was collected annually by the male family members in the forest near Gudara. They stayed for some days there and loaded one truck to deliver the wood to the households.

***Table 2.29:*** *Estimation of the Energy Resource Consumption of an Average Household in Nisur During Soviet Times.*

| Energy resource | Quantity | Costs | Energy equivalent (GJ/y) |
|---|---|---|---|
| **Coal** | 3 tons per year | 15-17 rubles (USD 14.70-16.66) * | 87 |
| **Kerosene** | 40 liters per month | 0.15 rubles per liter (USD 0.15) * | 12.6 |
| **Firewood** | 4500kg (one truckload) | 30 ruble (USD 29.40) * | 67.5 |
| **Teresken** | 500kg | Free of charge | 7.5 |
| **Dung** | 100kg | Free of charge | 1.2 |
| **Total** | | 120 rubles (USD 117) per year[155] | **175.8** |

*Exchange rate in the late eighties: USD 1 = 0.98 rubles.

*Sources: Field study 2003. Rijal (1999: 226-227).*

Answers to the question, of which resources are used for which purposes and to what extent are gathered and qualitatively compared in Table 2.30. The image emerging form this table emphasizes that coal and kerosene were the key resource for the villagers of Nisur during Soviet times.

## 12.8 Energy Resource Use Strategies

Nisur is in fact an extremely remote village and becomes even more marginalized due to its undersupply of energy resources. After the collapse of the USSR the time of rearrangement was too short for the peasants to adapt their livelihood strategies to the new circumstances. Constraining Soviet heritages (such as deficit of knowledge regarding sustainable self-sufficiency economy, increased population and mismanagement of the local forests) force the peasants of Nisur to follow a certain kind of resource allocation strategy. One of the greatest limiting factors is the scarcity of locally available and affordable energy resources. The peasants are forced to collect more than 20kg of *teresken* shrubs a day, thereby actively depleting their own resource base. Diesel oil would have a potential to reduce this exploitation by using it for cooking and baking with the kerosene stove. But even the wealthier households are not able to purchase it in a reasonable quantity. This is an exemplary case illustrating how limiting narrow financial means determine resource allocation possibilities. The daily struggle for existence and the lingering hierarchical thinking lead to a 'hand to mouth'-strategy making anticipatory advancement almost impossible. The largest planning interval for the peasants is generally one year, so that activities with a longer time horizon are hard to manage. That is one reason why reforestation projects failed for example.

It may sound paradox that peasants in Nisur having such a scarce energy resource base hardly use their dung as fuel, but it seems that they give higher priority to a secure nutrition base than reduced *teresken* allocation labor. This issue may depend on the women's low self-determination and the linked labor division. The limiting factor regarding dung is the number of farm animals and the financial means which can be spent on artificial fertilizer. The MSDSP also provides artificial fertilizer as credit, which has to be repaid with wheat or potatoes. Consequently, the dung price can be seen as compensation for artificial fertilizer.

Thus the number of farm animals seems to be a secondary factor in terms of dung division between fertilizer and fire material, because dung is considered as a very

***Table 2.30:*** *Energy Resources Used for Different Purposes During Soviet Times.*

| Domestic demands | *Teresken* | Coal | Firewood | Kerosene | Petrol* | Dung |
|---|---|---|---|---|---|---|
| Cooking | ○ low, ❄ low | ❄ medium | ○ low, ❄ medium | ○ high | | |
| Heating water | ○ low, ❄ low | ❄ high | ❄ medium | ○ high | | |
| Baking | ○ low, ❄ low | ❄ high | ○ medium, ❄ medium | ○ medium | | |
| Room heating | | ❄ high | ❄ medium | ○ low | | ❄ low |
| Lighting | | | | ○ high, ❄ medium | ○ low, ❄ low | |
| Radio | | | | | ○ low, ❄ low | |

○ Degree of application in summer (low, medium, high)
❄ Degree of appliaction in winter (low, medium, high)

*Source: Field study 2003*

155 During Soviet times a teacher earned an average of 150 rubles (USD 147) per month.

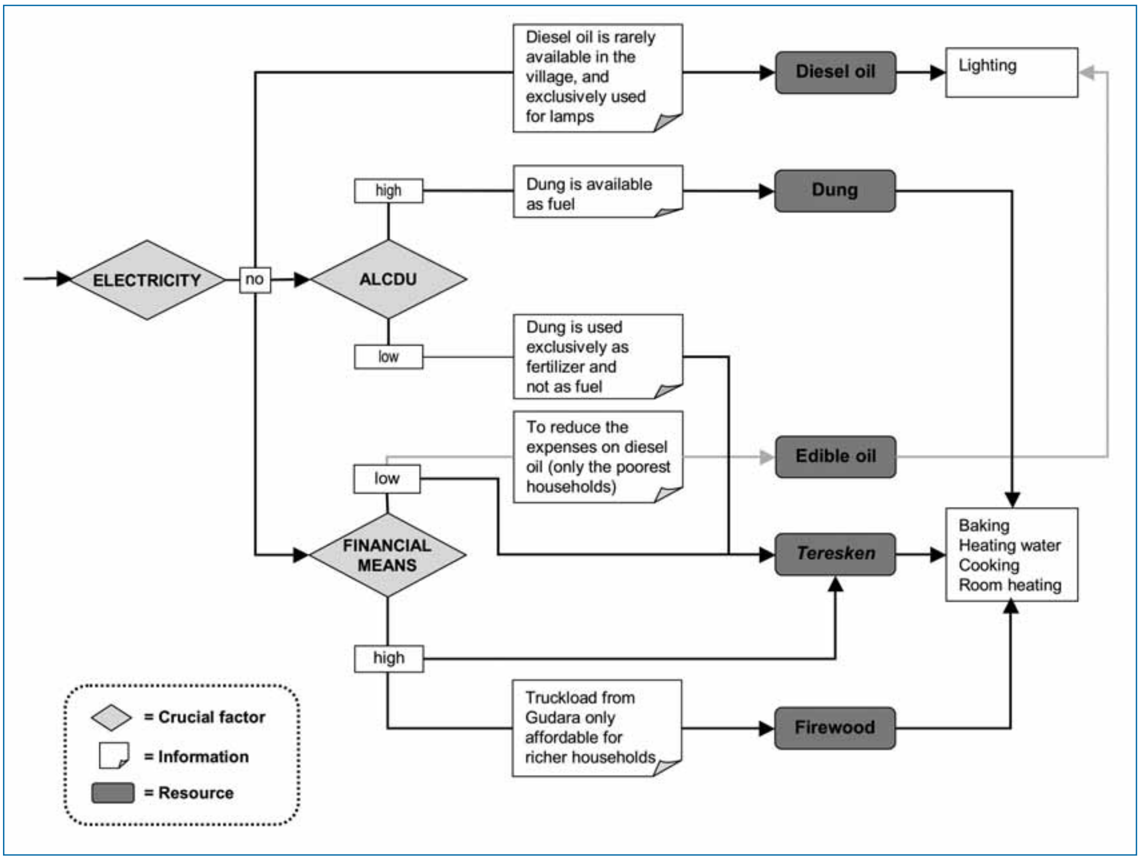



***Figure 2.32:*** *Present Energy Resource Use Pattern. Source: Field study 2003*

scarce and useful resource and used virtually as manure. The possible energy potential of the dung used as fire material is estimated in Chapter 12.11.

*Teresken* can only be collected on snow-free days, so that peasants have to acquire it between March and November to store it for winter time. During the winter months they consume three times more *teresken* than the summer months. A positive side-effect of storing the *teresken* shrubs on the roof is better insulation of the house, although keeping it away from the livestock might be the main reason.

Only wealthier households are able to purchase firewood from Gudara and thus reduce their *teresken* consumption. However, firewood collection has to be done, too. Men do this work during one week, mainly in autumn after the harvest. The wood is also dried and stored on the flat roof.

Diesel oil is used in each household only for lighting, although most of the households own a kerosene stove which could be used as well with diesel oil. But the peasants are unable to pay for the amount of diesel oil that would be needed for cooking and baking. More than 30 liters[156] was used during Soviet times, an amount that is far too expensive nowadays for the peasants in Nisur.

Due to the scarce resource base, the **options** and individual **preferences** are substantially restricted in Nisur. In terms of heating and cooking appliances the only real choice is between the *kitsor* and the iron stove. The indoor *kitsor* is only used once or twice a year and is thus not included among common appliances. Some households tend to use the *kitsor* outside and others move the iron stove outdoors during summertime. There is apparently no logical framework explaining why one household uses the iron stove and the other one uses the *kitsor*. According to the peasants, the energy consumption figures on the different stoves do not really differ from each other. It is safe to assume that this is a matter of individual preferences and cannot be concluded as a causal interrelation.

Although accumulator batteries or generators were purchased during Soviet times, nowadays they are too expensive for the villagers and generally difficult to obtain.

Most of the peasants would prefer to use the kerosene stove for cooking because the resource is easy to allocate but nowadays none can afford it anymore in an adequate quantity.

The energy resource most preferred by the peasants of Nisur is electricity. It is seen as a remedy for most of the livelihood problems there. If the village will be electrified someday and the capacity only serves for lighting, people would need their diesel oil for cooking, heating

156 In Nisur one liter of diesel oil is sold for one *somoni* (USD 0.31).

water and even for baking. Especially women expect many improvements from possible electrification. They would like to cook, bake and heat water with consumer electronic appliances in order to reduce the *teresken* allocation labor. They could then spend more time on crop cultivation, knitting and other handicrafts. Hence it appears that *teresken* is the least preferred resource to use and would be readily replaced if there would be an affordable alternative resource.

This severe energy crisis forces the peasants to adapt their resource management. To relieve pressure on the limited woody resources two possible strategies can achieve success: Either to increase the resource base by its regeneration and reforestation or decrease the demand by using it more efficiently or replacing it with an alternative resource. To recap, the energy resource strategy of the peasants conforms with the locally available and affordable resources additionally prioritized in terms of efficiency and handling.

Figure 2.32 depicts the interdependencies between the different resources and their applications. This present energy consumption framework is by no means sustainable. A challenging future task should be to induce specific trends to shift this consumption framework toward sustainable development. The measures which should be taken to achieve this aim are discussed in the Chapter 12.11.

## 12.9 Village Energy Consumption Profile

The overall energy use of Nisur was estimated on the basis of an average household's consumption. Public infrastructures such as the school and the library are included in the estimate and counted as households.

Figure 2.33 depicts the overall consumption of the different energy resources for the entire village. A striking factor is the extremely high percentage of biomass fuel consumption, endorsing heavy dependency on local biomass fuels of the peasants.

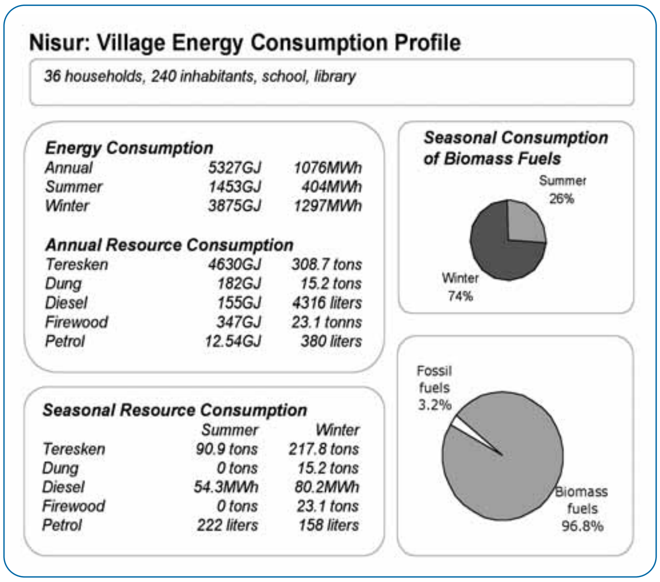



***Figure 2.33:*** *Estimated overall consumption of the entire village of Nisur. Source: Field study 2003*

## 12.10 Resource Degradation

Already during Soviet times the riparian forestlands were used intensively, to such a degree that in the late eighties all of them were entirely stubbed. This means that the villagers had to substitute the energy resource gap, triggered by the collapse of the USSR, mainly with *teresken* shrubs. This energy resource is actually considered by the villagers as the least preferred resource.

To appraise weather *teresken* is sustainably used, demand and supply has to be taken into consideration. Nowadays the entire village consumes 308.7 tons per year of *teresken* as fuel collected at a distance of more than three km from the village. At closer distance the shrubs are too small and their population density is too low for women to collect on these closer sites. That means the catchment area is extended year by year, a fact affirmed by the increased collecting time. Here is a palpable sign that the regeneration of the *teresken* shrubs is unable to meet the villagers' demand. According to Domeisen (2002) one ha of pasture terrain contains on average 700kg of *teresken* biomass. The average annual biomass growth of an *artemisia* terrain amounts to 70kg[157] per ha (Clemens 2001: 137). This fact strengthens the claim that *teresken* has a very low biomass accumulation rate. Consequently, *teresken* cannot

***Picture 2.54:*** *The riparian forests around Nisur have been entirely cleared within the last 20 years. Nowadays, few bushes are left. (Photo: T. Hoeck, June 2003)*

157 70kg of *teresken* is consumed by one household within two days.

be sustainably cultivated with today's demand. According to these figures an average household in Nisur would clear 11.6ha of pastureland annually. The extrapolated area cleared by the whole village in one year amounts to 406ha. Given how women only take the larger shrubs and leave the smaller ones, the population of *teresken* is greatly decimated but not eliminated. Grazing and trampling accelerate this degradation process and finally create a desert area. The woody resource base is thus unable to recover and due to continuous elimination the reproduction rate declines.

Due to the fact that the *teresken* shrub is a resource of woody biomass, growth is only possible when the plant is alive. As soon as the shrubs are eradicated the capability of reproduction and recovering recedes or is nonexistent. The forests of Gudara are the last larger woodlands in the upper Bartang Valley which are accessible for trucks, thus serving the richer households as a source of woody resources. However, with the recent demand for wood and present forest management, this woodland will disappear in the next years. If the energy resource base cannot be radically improved, all the woody resources will be exterminated in the next few years. The ultimate option is to use their own fruit trees as firewood, what is already happening, and the final stage is to emigrate, illustrating this statement of a villager:

*"Teresken will only be sufficient for the next four to five years. Afterwards we will have to move to another part of the republic."*

The depletion of the woody resource in the whole Jamoat is alarming, but meaningful and affordable alternatives are virtually non-existent. Due to continuing migration and the villager's rethinking in terms of birth control the demographic development in Nisur is slowly declining.[158] Younger families have noticeably less children than older ones. Nevertheless, the population decline will have no meaningful effect on energy resource consumption, because of the economy of scales (see Figure 2.30).

***Picture 2.55:*** *The hillsides around the village are all cleared. The only remaining larger teresken shrubs grow on the graveyard because peasants do not collect on this site because of religious reasons. (Photo: R. Droux, June 2003)*

Several reforestation efforts were made by the villagers in cooperation with different aid organizations. But most of the reforested trees died because of inadequate irrigation, and browsing damage or the villagers did not pay enough attention to the projects.

Due to the insufficient knowledge and the short period of water availability, the soil is covered with a salty crust in some areas. People try to manage this problem by putting ash on these plots. Beside salinization topsoil, erosion is a common problem and is reflected in the following statement:

*"Steeper plots are loosening soil. Every spring we have to clear the fields of new stones, and there are always more stones to clear."*

Degradations linked with deforestation are less visible but mentioned by the villagers, too. Wild animals such as foxes and deer are rarely observed around the village.

## 12.11 Scenario Towards Sustainable Energy Resource Use in Savnob

As it was concluded in the section on resource degradation that use of woody resources is not sustainable to any large degree. The serious questions arises: What appropriate and meaningful measures are needed to mitigate this hardly reversible process subverting the peasants' livelihood? Due to the present available and affordable resource base, expedient short-term alternatives are scarce. Given that, within the next few years, the village will remain unsupplied with electricity, mid-term reforestation strategies combined with 'first-aid' measures for bridging the energy gap have to be taken into consideration. Since the scenarios for the other case study villages (see Chapter 10.15 and 11.14) refer to the potential of electricity, the following estimation focuses on the potential of reforestation. Due to the fact that *teresken* is a very inappropriate and inefficient resource for heating purposes, the declared intention of sustainable energy resource management should completely dissociate from the *teresken* shrubs as a fuel resource. The following estimation gives an idea of the reforestation activities required to replace the *teresken* and firewood, collected in

158 The Soviet authorities actively promoted population growth by awarding mothers having more than ten children with a gold medal and financial subsidies. The ulterior motive was to strengthen Soviet influence and, especially in the Pamirs, to boost Soviet presence in a highly sensitive strategic border zone.

***Picture 2.56:*** *Even the potential reforestation area (green surface: 30.6ha) in the floodplains around Nisur is insufficient to cover the energy demand of the entire Village (Photo: T. Hoeck, June 2003)*

Gudara. Provided that the annually required firewood quantity of 6000kg should be entirely substituted by farm forestry, the first step is to convert the required biomass volume for the different trees into two different growing stages (Table 2.31). Using Clemens' (2001: 156 et sqq.) model calculation for the potential of farm forestry in northern Pakistan[159] an estimation was made of the annual firewood demand of an average household in Nisur.[160] Table 2.31 lists estimation for the amount of required trees per household and the floor space required for the reforestation. To meet the annual energy requirements, each household needs between 43 and 178 ten-year old trees, depending on the species used. Due to the relatively high biomass value and the advantageous potential concerning floor space, the Russian olive (*Elaeagnus augustifolia*) has the largest potential as a firewood resource (see Table 2.31). To meet the annual energy demand of the entire village, 4.5ha of ten-year old Russian olive trees (*Elaeagnus augustifolia*) would be required. Such a monoculture is certainly not recommendable, owing to the low biodiversity and the vulnerability to pests. Consequently, trees with a lower biomass production must be replanted, too. Thus, a diversified plot would cover a realistic area of 6.2ha. The estimation is based on a turnover period of ten years, so that the first trees could only be harvested after this period.[161] Therefore, the same amount of trees have to be replanted every year so that after ten years an area of 62ha should be reforested. This is an acreage extension which is impossible to establish and to cultivate in Nisur.

If the plots are situated in the floodplain of the main valley, only a few irrigation measures have to be constructed because the cuttings are supplied by the groundwater. Such riparian terraces, which used to be alluvial forest 40 years ago, are used nowadays as grassland. Therefore the water supply would be a secondary constraint. The main conflicts would occur with pasturing. As before, it is mainly the failed reforestation efforts that show that protection measures were insufficient. Most of the cuttings perished because of browsing damage by livestock. Though arable land is scarce in Nisur, potential plots for reforestation could be found in the surroundings of the village. The maximal potential area which could be used as reforestation plots is estimated at 30.6ha (see Picture 2.56).[162] In addition, water channel edges and brook sides should be replanted with willow trees (*salix terasperma*). The potential of reforestation and farm forestry to release the pressure on *teresken* shrubs is large, but as the above-mentioned figures illustrate, it is impossible to meet the entire energy demand with wood from reforestation. Such mid-term projects are urgent and absolutely necessary to provide a secure energy base for the future generations. In any case, however, they have to be well designed and managed, considering how the fruit can not be yielded immediately.

Some years ago the VO of Nisur submitted a request to the MSDSP to establish a new 30kW MHPS in the village, up to now without any positive response (see Chapter 8.2). A 30kW MHPS is on an appropriate scale to cover the basic needs of the 36 households. But the runoff of the tributary stream flowing through Nisur is only sufficient for the period between May and August. A rumor about establishing a transformer at the MHPS in Savnob to distribute electricity to Nisur gave rise to new hopes among the peasants, but so far nothing has been done. The villagers would be willing and able to contribute livestock, money and unpaid labor. Even the indigent villagers could pay an electricity fee of three *somoni* (USD 0.95) and are able to purchase the basic electric appliances such as coil cooker, rudimentary electric oven and kettle.

159 The biophysical conditions (precipitation, temperature, humidity, altitude) in the Rupal Gah Valley (Astor, Pakistan) are very similar to the ones in the upper Bartang valley.

160 This estimation implies the following premises: Turnover: 10 years; Distance from tree to another: 1.5m; Survival rate of the seedlings in the first year: 60%; Conversion factor for the density of wood: 700kg/$m^3$. (Clemens 2001: 156 et sqq.) Due to the low differences in heat values regarding the different trees the factors are unified at 15MJ/kg.

161 Alternative utilization like pollarding and pruning remain out of consideration.

162 These estimations made by means of the GIS and include the flat floodplain plats and plots, which can be irrigated without huge efforts.

***Table 2.31:*** *Annual Domestic Demand for Mature Trees, Potential Annual Biomass Harvest, and Floor Space Required for the Households and the Entire Village of Nisur.*

| Forest species | Biomass volume of tree in kg | | Required trees per hh/y | | Required trees per village/y | Annual yield | Required area | |
|---|---|---|---|---|---|---|---|---|
| | *10y* | *20y* | *10y* | *20y* | *10y* | *tons/ha* | *ha/hh* | *in ha/village* |
| Poplar (*Populus*) | 182 | 502 | 33 | 12 | 1154 | 61.9 | 0.097 | 3.39 |
| Willow (*Salix*) | 49 | 441 | 122 | 14 | 4286 | 16.7 | 0.359 | 12.57 |
| Black locust (*Robinia*) | 105 | 516 | 57 | 12 | 2000 | 35.7 | 0.168 | 5.88 |
| Russian olive (*Elaeagnus*) | 205 | 534 | 29 | 11 | 1024 | 69.7 | 0.086 | 3.01 |
| **Mean** | 135.25 | 498.25 | 60 | 12 | 2116 | 46 | 0.178 | 6.22 |

*Source: Cemens (2001), Field study 2003; Calculation: R. Droux and T. Hoeck*

The impact of future electricity is hard to asses in Nisur because the peasants' responses are based on hypothetical questions and they are liable to envisage a future with electricity too optimistically. At any rate, this indicates at least an enormous willingness among the peasants to change some of their present habits to a more sustainable energy resource management although the largest constraint is insufficient income.

The potential for mitigating the energy resource crisis in Nisur by means of a MHPS is large. In the first instance the further ruination of woody resources could be embanked, which is the basis for its regeneration. Additional measures are area-wide reforestation and orchard tree cultivation or subsidizing of diesel oil so that poorer peasants are able to purchase it for cooking and baking purposes. Not only resource degradation processes but also the terrible work load of the women could be reduced. Together with the extremely scanty equipment and the low salaries of the teachers, the education in Nisur suffers highly from the inexistence of electricity. The unsatisfying lighting and heating conditions at school and at home could be improved by an MHPS so that the education level could be raised.

According to the teachers' statement, they would use electricity for the tape recorder during language classes to improve auditory skills, in the chemistry and physics laboratory, and for the slide projector.

Generally speaking, electricity would trigger major changes in the community and the daily life of Nisur's peasants. Habits and traditions are apt to shift in positive as well as in negative effects, with local knowledge being lost as a result.[163]

## 12.12 Conclusions and Recommendations

The energy crisis is highly acute in Nisur and causes consequences which are impossible for the inhabitants to solve themselves. Due to the 'hand to mouth'-strategy villagers are unable to develop alternative opportunities. The drastic energy resource scarcity and the enormous dependency on biomass resources (96%) of the peasants, has already triggered noticeable impacts in the environmental and socio-economic spheres. The degree of the energy crises is characterized by the large quantity of *teresken* used as fuel. It is the least preferred resource and, due to the low regeneration rate and slow biomass growth, it is impossible to use it in a sustainable way. Owing to the fact that *teresken* is a highly inadequate fuel, the peasants in Nisur have an immense energy consumption of 140GJ per year.

A large potential for mitigating this crisis is attributed to farm forestry combined with electricity supply. Nevertheless, the potential areas for reforestation are insufficient to cover the entire actual firewood needs of the whole village. Even if the recommended 6.2ha could be reforested every year, the first trees could yield only after ten years. Hence, the actual energy demand cannot be met only by the local biomass resources. All these preconditions call for external 'first-aid' measures, which might be unsustainable for longer periods but would help to tide over the vegetation regeneration time. Electricity generated by an MHPS would be a more meaningful option, because electricity is highly desired and would be used without hesitation. In addition, the households generally would be able and willing to pay an adequate amount for the fees. Today's outlays for diesel oil could be spent on electricity, which would be at least five *somoni* (USD 1.59) per month. The crucial factor for the MHPS is adequate capacity which is, due to the low winter hydropower potential, impossible to generate within the village territory of Nisur. However, in order to meet a sustainable resource management (a diversified energy resource pattern is desired). Nevertheless, the present situation does not provide a realistic alternative energy resource.

The following recommendations are designed for people in Nisur to make a step towards a sustainable energy resource use that is not exhaustive. The measures

163 These estimations made by means of the GIS and include the flat floodplain plats and plots, which can be irrigated without huge efforts.

are specifically adapted to the present resource situation in Nisur and should serve as guidelines for the peasants and the village organization. They shall be deemed as possible proposals generated from outside and should act as a topic for discussion with locals. Due to different implementation approaches the recommended measures are split into short-term and long-term initiatives:

***Short-term recommendations with immediate impact***

To use biomass fuels more efficiently the villagers should…

…make better **use of waste heat** from their metal stoves or heat stones and water as heat storage media.

To relieve women from their daily drudgery of collecting *teresken* shrubs the villagers should…

…teach women how to make resistant **gloves** for *teresken* harvesting.

…manufacture **hoes** to simplify *teresken* harvest.

…convince **men to do the drudgery** or at least participate in collecting *teresken*.

…breed **donkeys** to transport firewood and *teresken* bundles.

To increase the supply with dung to use as fertilizer and fuel the villagers should…

…collect **manure from the livestock compound on the high pasture** and transport it in autumn on the back of the livestock down to the village. The dung could be used as fuel for public institutions (hospital or school).

To reduce the consumption of *teresken* the villagers should…

…establish a **public bakery** run on firewood where villagers can bake their own bread (according to the public mills).

To reduce the expenses for recharging the accumulator batteries should…

…construct a handmade, household based **midget hydro power plant.**

***Long-term recommendations with delayed impact***

To reduce energy resource consumption the villagers should…

…better **insulate their homes and buildings** using wool, straw or felt mats. Lining only a single room, with insulating material to spend the winters.

To increase the supply of biomass fuels the villagers should…

…**reforest large areas** with willow and Russian olive to use as a firewood resource. The villagers should annually reforest 6.2ha or every household should annually plant 60 trees over a period of ten years.

…cultivate and **manage existing forest areas in a sustainable way** and use them as a firewood source.

…introduce **agroforestry regarding firewood cultivation** around their homes (as is done in Vezdara).

To make available a more efficient heating fuel the villagers should…

…establish **production of briquettes** made of manure, shrubs, agricultural residues and small branches.

…strew *teresken* in the stable so that the shrubs aggregate with the dung.

To electrify the village the dwellers should…

…elaborate a **joint venture power generating plant** together with a neighboring village, such as Barchidev, Roshorv or Yapshorv, because the hydropower potential is insufficient in Nisur.

***References:***

Clemens, Jürgen (2001) Ländliche Energieversorgung in Astor: Aspekte des nachhaltigen Ressourcenmanagements im nordpakistanischen Hochgebirge. Bonner Geographische Abhandlungen. Heft 106. Sankt Augustin: Asgard-Verlag.

Cobbold, Ralph (1898) Report on his Journeys on the Pamirs and in Chinese Turkestan. To the Foreign Office. Srinagar. Kashmir.

# 13. Comparison of the Three Village Studies

In this chapter the three case-study villages are compared and discussed regarding their energy situation. Since two of the case-study villages are electrified, an analysis is made concerning the impacts of electrical power supply on ecology, society and economy.

## 13.1 The Bolshevik Heritage

Sovietization not only brought electrification and a high level of education[164] but also relinquished a large population to the Tajik Pamirs. Traditional knowledge concerning resource management, which would be of great use nowadays, disappeared. Another constraining heritage of the Soviet period for all three case-study villages is the enormous population growth.[165] Under Soviet rule many forests were cut and transformed into arable land.[166] The larger floodplains of the Pandzh Valley were most affected by this crop land expansion. Additionally, wood was used as construction material and as fuel to heat public buildings. The Soviet heritage still greatly influences the today's energy resource consumption. Owing to the good energy supply and to the larger families, houses were considerably bigger than before the Soviet period.[167] Moreover, most of the appliances still in use designed for one particular resource, were purchased during Soviet time, so that they do not meet today's demands. All the villages were highly dependent on imported fossil fuels. For all peasants the period of civil war was a time of starvation and pure struggle for survival aggravated by refugees from the lowlands, momentarily straining the fuel and the foodstuff shortage. Moreover, the system changed from an import oriented economy to a self-sufficiency economy.

## 13.2 Present Energy Resource Base

Vezdara, with 28 households, is the smallest of the three villages (see Table 4). It has considerable advantages compared to the two other villages. Due to the relatively good road and the rather short distance to larger markets, Vezdara has much better accessibility. Not only are roads

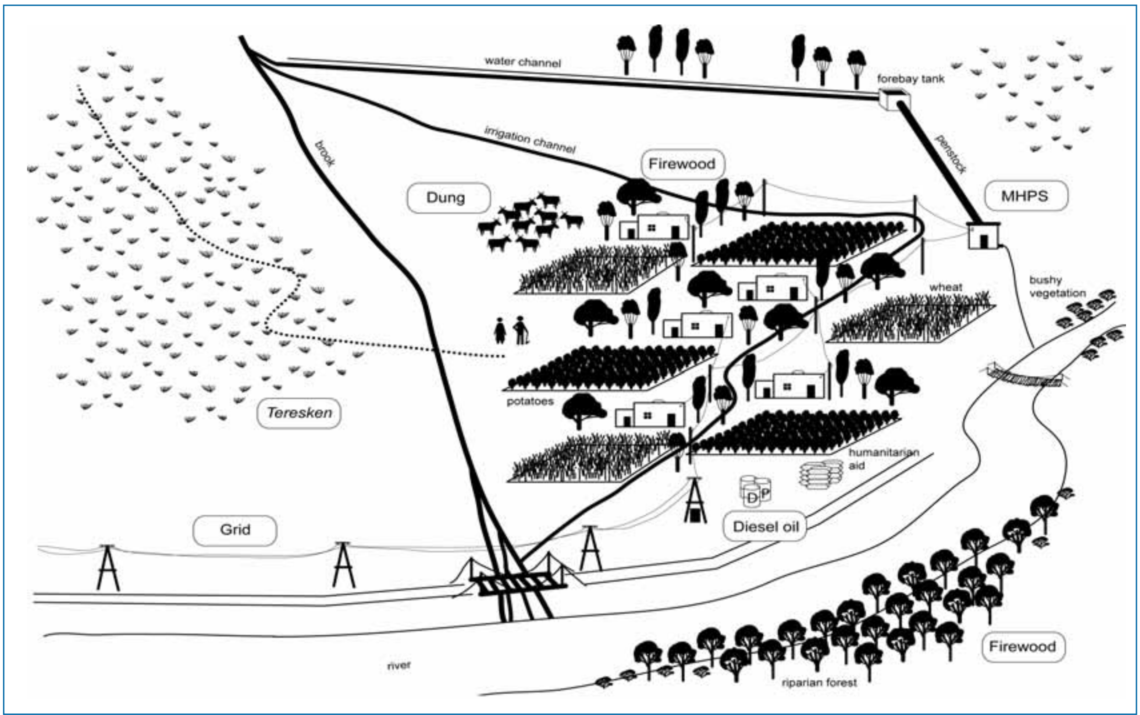



***Figure 2.34:*** *Typical Village in the Pamirs Equipped with the Major Energy Sources. Sketch: T. Hoeck*

164 In the eighties, the literacy rate was estimated at 99% in GBAO (Hafizullah 1998:12).

165 Nisur was home to about five households in 1898 (Cobbold 1900: 167) and in 2003 there were 36 households counted. Savnob counted about 20 households in 1898, and nowadays it is home to 54 households (Cobbold 1900: 158).

166 Schultz (1914: 22) stated that malaria was the main case of disease (497/ 32%) treated in Russian infirmaries in 1911. The swamps and thickets around Kala-i Wamar (former name of Rushan), as a natural habitat for the anopheles mosquito, are assumed to be the major source of the high rate of malaria cases.

167 The average size of the main room of the house was about 20m$^3$ in 1913. Today it is between 100 and 160m$^3$.

better in the Roshtkala districts than in the Bartang Valley, but also other infrastructures such as electrification, irrigation channel systems and primary health-care infrastructures. Moreover, the households in Vezdara have an average of two to three times more livestock than in the upper Bartang Valley, being one of the main assets of the self-sufficiency economy (see Table 2.33). The number of farm animals affects, besides the wealth status of a family, the amount of dung, the stock for barter and the potential source of capital. The only larger trees embellishing the natural scenery in Nisur and Savnob are left within the settlement area, which is surrounded by barren land, sparsely populated by puny *teresken* shrubs. Some insular woodlands still exist near the village Vezdara.

Figure 2.34 illustrates an abstracted typical village in the Pamirs featured with all possible energy sources and the main assets of the peasants, which are discussed and compared below. Obviously, only few villages are home to all the depicted plants and equipment. However, it is very close to the general setting in Vezdara.

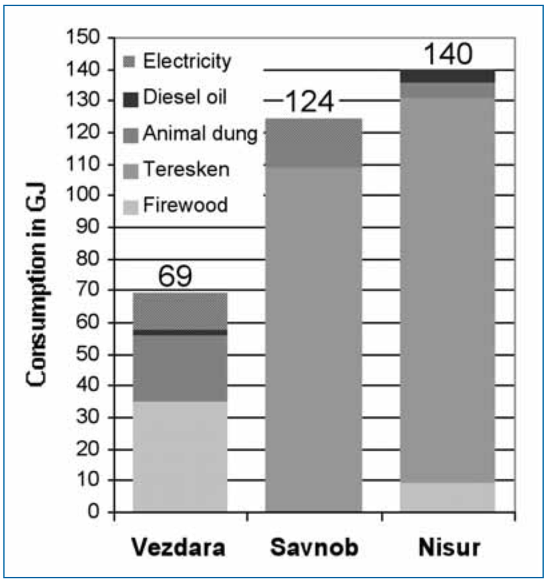



***Figure 2.35:*** *Overall Annual Energy Consumption in GJ per Household. Comparison of the three case study villages regarding annual mean household energy consumption. Source: Field study 2003*

## 13.3 High Overall Energy Resource Consumption

Generally speaking all average households in all three case-study villages have a considerably high energy consumption[168], although there are still some striking differences. As indicated in Figure 2.35 the annual consumption of an average household in Vezdara is half as much as a similar household in Nisur.

The largest consumer in Nisur uses even three times as much as a small consumer uses in Vezdara. At first, this fact may sound paradox because the self-evident estimation would conclude that the better the living standard, the higher the energy consumption, but it is just the opposite. Basically, the varieties appear owing to the different energy resources used for cooking and heating purposes and their burning characteristics. In Vezdara people use as much electricity as possible for cooking and baking bread, which is more efficient compared to woody fuels. The villagers of Nisur and Savnob predominantly use shrubby *teresken* for these purposes. Due to the fact that this fuel deflagrates like paper emitting intensive heat energy only during a short time, peasants use large quantities of it, especially for room heating. The caloric equivalent of the different energy resources is a crucial issue for their comparison. The large percentage of biomass fuel emerges from their high conversion factors.[169] Results of water boiling tests accomplished on a *kitsor*[170] emphasize this issue.[171]

## 13.4 Two-Stage Fuel Wood Use: Firewood – Teresken

*Teresken* is a highly inadequate fuel and its use is considered by the authors as highly inappropriate. However, it is the ultimate resource option. By using electricity instead of burning biomass resources, overall consumption can be considerably reduced, as the case of Vezdara confirms. An average household in Vezdara uses nearly four times less than a comparable household in Nisur (see Figure 2.36). There are mainly two explanations for these differences.[172] First, due to *teresken's* low heating efficiency, Nisur's dwellers need countless of kilograms of shrubs. Second, Vezdara covers 60% of the energy resource demand with electricity in summer, whereas

168 The annual mean consumption of a Swiss household is 78GJ (2000), not including industry, transport, service sector, and agriculture (SFOE 2002: 22 and SFOS 2003: 5). The overall final consumption of an average Swiss household, including industry service sector and transport, is 160GJ per year (SFOE 2002: 3).

169 The authors calculated with the following values: wood and *teresken*: 15MJ/kg; dung: 12MJ/kg; electricity: 3.6MJ/kg; diesel oil: 36 MJ/kg.

170 *Kitsor* is the traditional Pamiri stove.

171 To heat one liter of water to the boiling point takes between eight to ten minutes and consumes one to 1.5kg of wood. This results in an energy equivalent of 15 to 22MJ, depending on the firewood. To proceed it likewise on a trivial electrical coil cooker it takes on average 29 minutes which corresponds to an energy equivalent of 1.8MJ. Recapitulating, to heat water to the boiling point with electricity it uses only at a fraction of what is used with woody energy.

172 All three villages are approximately situated on an altitude of 2700m. A glacier located at the end of the Ved-dara (valley above Vezdara) negatively influencing the local climate conditions for the vegetation.

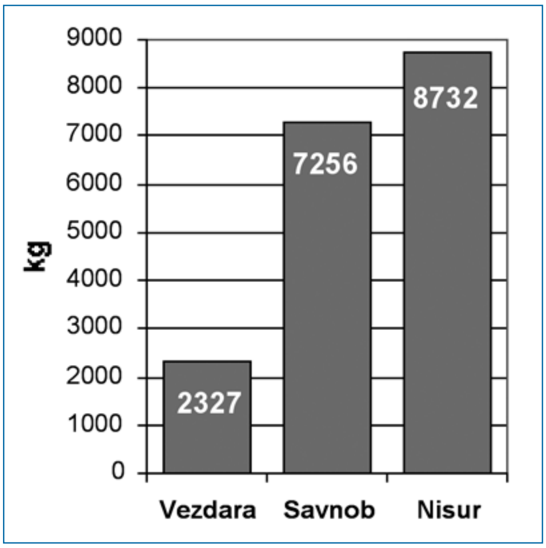



***Figure 2.36:*** *Annual Fuel Wood Consumption. Depicted are the average households from the three case-study villages. Vezdara uses manly willow trees, Savnob and Nisur teresken. Source: Field study 2003*

Savnob covers less than 10% of the summer consumption with electricity.[173]

Generally, firewood is enthusiastically used in each village if it is available and affordable. But only the villagers of Vezdara use it as their main heating fuel. It is foreseeable that if Vezdara's inhabitants cut all the remaining forests that are reasonably accessible, they will start collecting *teresken* shrubs like the peasants of Nisur and Savnob nowadays. In those two villages, forests are no more accessible by foot and only a few richer households can afford firewood from the distant located *leskhoz*[174] forest, which has to be brought by truck. Since the financial means are the crucial factor this commercialization of the firewood has created a two-class consumption pattern. It can be concluded that the less firewood (not *teresken*) and electricity that is available in a village, the higher the household's overall energy consumption is, because the peasants have to rely on the last remaining resource (*teresken* shrubs), which have a very low heating efficiency. Consequently, they use large amounts of this inadequate energy resource to satisfy their entire demand. The fact that peasants use *teresken* as a major fuel is in fact an indicator of a severe energy resource situation. It can be concluded that, in villages where *teresken* is used as a major fuel, the energy resource management is unsustainable and the consequences of the energy resource scarcity reaches a severe level.

In Vezdara, the collection labor is mainly performed by women, girls, boys and only few men. In Savnob, however, and especially in Nisur, virtually no men were observed collecting *teresken* shrubs. This issue appears to be dependent on the gender role allocation and on the partitioning of the decision-making authority. Firewood collection was traditionally men's work, but at the time when *teresken* was only collected around the house and used to light the fire, it became part of the women's daily housework. Today it is, especially women who suffer severely from the daily drudgery of fuel wood procurement.

## 13.5 Dung: Dilemma Between Fertilizing and Burning

Dung is used as a fuel in all three case-study villages only in winter. This fact may indicate that it has better room heating characteristics than other applied fuels. Figure 2.37 shows the quantity of dung used as fuel.[175] However, by burning the dung the peasants also reduce at the same time their available amount of fertilizer. The decision on when dung is used as fuel or as fertilizer depends on the proportion between the number of farm animals and the acreage. The amount of arable land varies among the three villages between 0.02ha and 0.1ha per capita.[176] Consequently this ratio, which is referred to here as 'arable land per cow-dung-unit' (ALCDU)[177] is an indirect indicator of the availability of dung as fuel (see Table 2.33). The higher the ratio between livestock and arable land, the more dung is applied as fuel. Households having a low ALCDU tend to use all the manure as fuel because there is not so much arable land which has to be fertilized compared to the available dung. If a household applies artificial fertilizer, larger quantities of dung can be used as fuel. Nisur displays, with an average ALCDU of 1437, the highest figure of the three case-study villages. In that village, the households having an ALCDU above 1600 (see Table 2.27 in the Chapter 12.) tend to use manure exclusively as fertilizer. Thus, the reason why peasants in Nisur hardly use dung as fuel is because their livestock is too limited to generate sufficient manure for fertilizing and burning. Consequently,

173 According to Zibung (2002: 125) an average household in Vezdara uses 3m$^3$. He calculated the caloric equivalent of 30.6GJ with a wood density of $\rho$=0.68, resulting in 2040kg/year. The survey of AKF (2003) calculates that an average household in Vezdara uses 17m$^3$. It does not give any particulars in terms of density or caloric equivalent. Kleinn (2003) estimated a mean firewood consumption of 16m$^3$.

174 The *leskhoz* is the governmental forestry office.

175 The GTZ study estimated an annual average dung consumption of 3600kg for an average household.

176 According to different statements of the peasants, 0.06-0.07ha per capita would be sufficient for total self supply.

177 A cow generates abut 10kg of wet dung per day and a sheep or a goat 0.65kg (Kadian und Kaushik 2003: 64). This is the potential amount of dung, not the effectively used dung. The cow-dung-unit is calculated considering the productivity of a cow (1 unit) and a sheep/goat (0.065 unit).

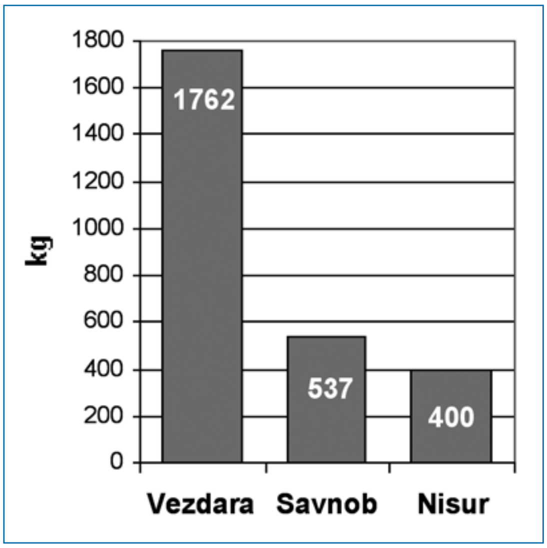



***Figure 2.37:*** *Average Annual Dung Consumption per Household. Source: Field study 2003*

the less dung available for the fields, the more teresken that has to collected. Although the peasants in Nisur have the lowest average income, their expenses for energy resources are much higher than the other two villages. This is due to the high expenses for diesel oil used for lighting. Therefore, electricity not only reduces overall energy consumption but also the household's average expenses for energy.

## 13.6 Electricity: High Potential for Resource Substitution

Since Savnob and Vezdara have another source of electricity supply in summer, it is possible to differentiate between grid-electricity and MHPS-electricity (see Chapter 10. and 11.). In Vezdara, more than 60% of total energy consumption is covered by grid-electricity in summer. Firewood is rarely used for cooking, baking and heating water during this period. The relatively good wattage from the grid enables the peasants to use electricity for basic domestic energy demands. Meanwhile, the MHPS in Vezdara which runs during winter is unable to meet the entire demand. The same applies for Savnob's MHPS. Its power output covers only the energy demand for lighting, TV, radio and a few electric cookers. Hence, due to the low capacity, electricity supply from the MHPS has virtually no impact on the biomass resource base and is thus unable to relieve pressure on woody energy resources. Consequently, the hard labor, which causes severe health problems and contributes to increased degradation of the woody resources, cannot be mitigated with the present output of the MHPS either in Savnob or in Vezdara. So far, it can be stated that electricity from the grid has a positive impact as a substitute to the overused biomass fuels. Whereas MHPS make a low contribution to reducing pressure on biomass fuels, due to their insufficient outputs (compared to the needs). A wattage of 1500W[178] would allow cooking, baking and heating water. Neither the MHPS in Vezdara nor the one in Savnob exceed this value.[179] So far, electricity bills are relatively low, so that the financial situation of an average household does not constrain use of electricity. Moreover, there is commonly no individual billing, so that the monthly fee is not dependent on the actual individual electricity consumption. However, electricity increases considerably the living standard. On the one hand, the peasant's feeling of having light and being relieved from the 'darkness' enables the peasants to read books in the evenings, watch TV and listen to radio, improving the general quality of life. On the other hand, electricity may improve the service quality of institutions such as schools and medical-points. Focusing on socio-economic issues, the differences between a grid supplied village and a village having only an MHPS is noticeable.

The small hydropower schemes in Vezdara and in Savnob generate an acceptable salary for two people.[180] The successful MHPS-project in Vezdara triggered other community based projects such as a chicken farm and a guest house that was under construction at the time of investigation.

Due to the fact that the majority of the population already enjoyed electricity during Soviet times there are no cultural barriers to using electrical appliances instead of traditional lamps or stoves. It can thus be concluded that electricity has a generally high potential to replace overused woody energy resources. Provided that the capacity per household reaches 1500W and the estimated monthly consumption of 315kWh[181] covers basic domestic needs. However, it is obvious that the high demand for room heating cannot be covered with electricity. Thus, an additional option is needed.

## 13.7 Towards a Sustainable Energy Resource Use

In order to create concrete outlines for sustainable energy resource use in the Pamirs, it is important not only to have a deeper insight into the household's energy consumption patterns, which are analyzed and compared in

178 This value is based on consumption patterns of electrified households. 1500W enables the peasants to use electricity for lighting, television, radio, cooking, water heating and baking whereas the coil cooker, the electric kettle and the electric oven can only used be separately.

179 For further information the reader is referred to the Chapter 8.2.

180 A machinist in Vezdara earns between 13 and 15 *somoni* (USD 4.13 and 4.76) in Savnob 55 somoni (USD 17.50).

181 This amount of consumed energy meets the basic needs except for room heating.

***Table 2.32:*** *Determining Factors for Energy Resource Use.*

| Factors | Determining… |
|---|---|
| Biophysical setup of the village's environment | Potential of (re)production and reserves of fuel wood |
| Forests' status, accessibility and degree of protection | Quantity and price of available wood |
| Amount of households in the village | Overall demand for energy |
| Peasants' financial situation | Capability of purchasing commercial fuels or firewood Dependency of non-commercial fuels |
| Number of farm animals compared to arable land (ALCDU) | Disposability of dung as fuel |
| Availability of electricity | Amount of diesel oil used for lamps and biomass fuels consumed for cooking, baking, water heating |

*Source: Field study 2003*

the previous sections, but also to know about the reasons why peasants follow a certain kind of energy consumption strategy. It is considerably constrained by the general mountainous conditions and by the factors listed in Table 2.32. They influence not only the diversity but also the quantity of the applied resource.

Personal preferences are other factors influencing the peasants' energy resource strategy. Obviously, in remote regions where peasants tend to have the lowest incomes, their opportunities are extremely limited. These peasants also have certain resource preferences influencing their present energy resource strategy, even though most of the resource preferences are based on visionary perceptions such as statements concerning electricity in non-electrified villages. The peasants' opinion about the different energy resources are listed in the form of advantages and disadvantages in Table 2.33. At the same time, the resources are ranked from the most preferred (1) to the least preferred resource (6). Due to the fact that the commercial fuels are easily available the peasants consider them as highly useful and beneficial. Owing to diesel oil's high cost, its consumption is very limited and not even the wealthier households can afford it in a sufficient quantity for use in cooking and baking.

Based on the peasants' consumption patterns, their preferences and the above-mentioned determining factors, four different household types can be subdivided. Figure 2.38 depicts these different types of households, which are dependent on a certain level of energy resource consumption. The poorer a household, the lower the ability to pay for energy resources and the more inadequate the resources are applied. Thus, the household's energy consumption increases with increasing poverty. The collapse of the Soviet Union and the ensuing civil war considerably debased the wealth status of each family in GBAO, so that their energy consumption level (see Figure 2.39) was also downgraded. Virtually all households were Level 1-households during Soviet era,

***Table 2.33:*** *Ranking and Comparison of Energy Resources: Advantages and disadvantages of the different energy resources are based on peasant's opinion.*

| Ranking | Resource | Advantages | Disadvantages |
|---|---|---|---|
| 1 | **Electricity from the Grid** | Polyvalent resource. No procurement outlays. Still relatively cheap. Peasants do not have to worry about maintenance and operation. | Price for the kWh will increase in future. No supply in winter. Inadequate capacity in remote areas. |
| 2 | **Electricity from the MHPS** | No procurement outlays, compared to diesel oil rather cheap. Polyvalent resource. Local, renewable energy resource. Community based management, generating additional salaries. | Appliances needed. High investment. Dependent on external support and assistance for construction. |
| 3 | **Diesel oil** | Very low procurement outlays. Sometimes available in the village. | Due to relatively high costs, it is only used for lighting. It discharges gas and sooty particles. In order to reduce the consumption people run it on a small flame emitting a dim light. Relatively large price fluctuations. More expensive than electricity. |
| 4 | **Firewood** | Higher heating efficiency than *teresken* shrubs. Dry branches are available free. | It is tedious to cut and collect it or it has to be brought by a truck. Scarce resource. Commercialized in several regions. |
| 5 | **Dung** | Free of charge. Relatively low time exposure for the procurement. Relatively good heating characteristics. Locally available. Renewable resource. | Reduced availability when the arable land is large compared to the livestock. Since the application as fertilizer is given higher priority, the availability as fuel is reduced. |
| 6 | ***Teresken*** | Free. Locally available. | High time exposure (3-6 hours per day for collection), heavy labor causing severe health problems. Bad heating characteristics. Enormous quantities required. |

*Source: Field study 2003*

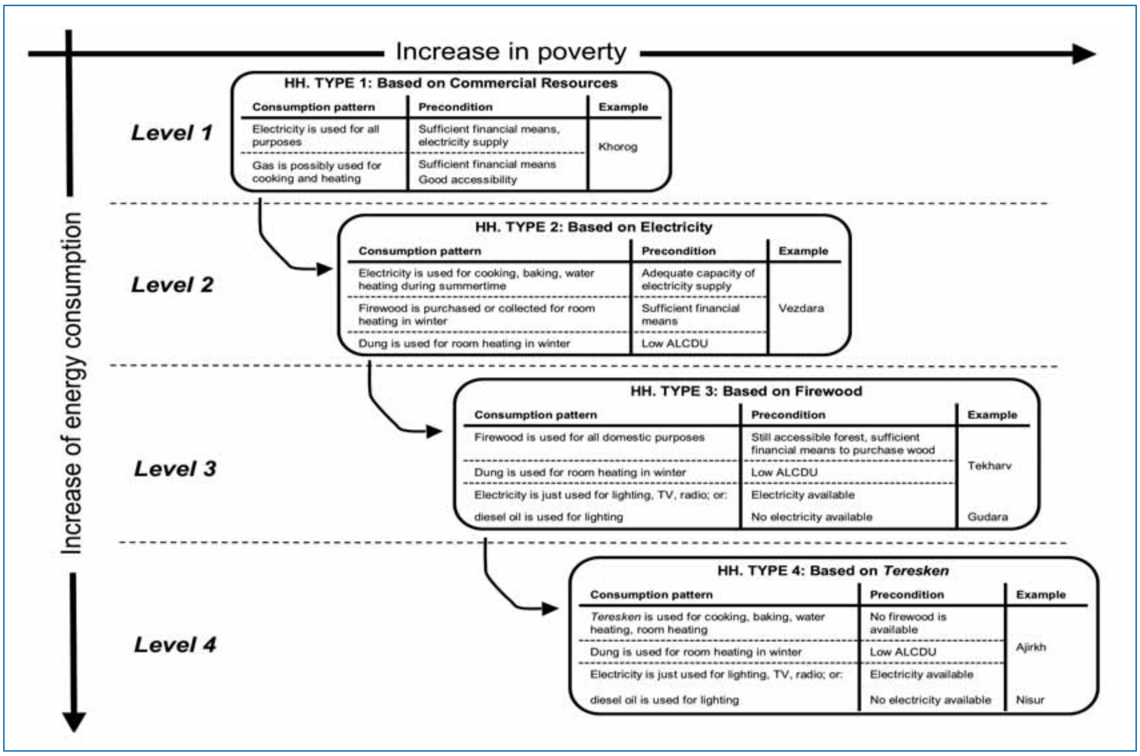



***Figure 2.38:*** *Household Types Rated by their Consumption Patterns. Concept: Droux & Hoeck*

whereas nowadays the bulk of the households can be subdivided in Level 2 and downwards. Only a few families, mainly living in Khorog, can be ranked in Level 1. Due to the fact that the resources in Level 3 and 4 are not used sustainably, the aim of a sustainable energy resource management should focus on Level 2.

Thus the authors' general advise is to follow the scenario towards a sustainable energy resource management in rural areas based on two main pillars:

1. To establish an adequate electricity supply in order to cover the basic domestic demands such as cooking, baking bread and heating water with electricity in summer. The goal is to get away from biomass fuel at least in summer and to reduce its consumption in winter. To also use electricity for room heating is unrealistic. The two reasons are the enormous investment for such infrastructures and the unaffordable electricity bills. Thus, another resource is needed for room heating.
2. To build up well-managed firewood sources such as household-based firewood tree cultivation and community based farm forestry plots. The aim is to completely substitute *teresken* shrubs and to reduce the consumption of dung as fuel, so that it can be used as fertilizer.

For this purpose, firewood cultivation should be started and intensified, as is done by some households in Vezdara. Thereto the estimation focusing on the firewood tree requirement is described in the section scenario (Chapters 10., 11., 12.). Figure 2.39 illustrates the annual required number of trees covering the firewood demand of the mean households and the corresponding annual reforestation area. According to this scenario,[182] which includes the substitution of dung and teresken

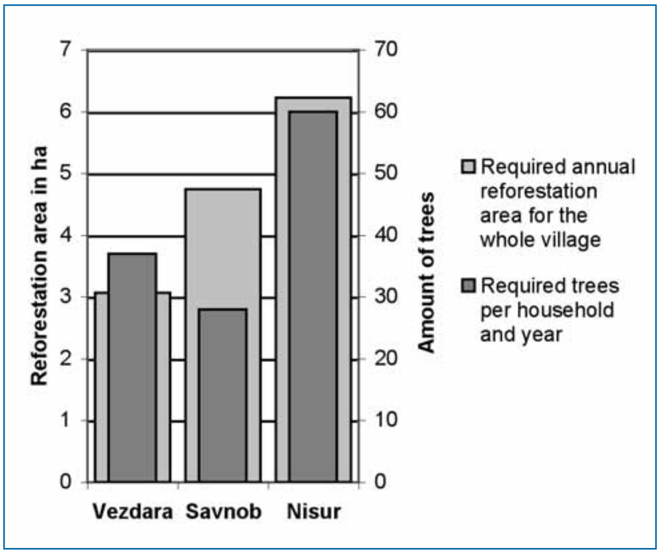



***Figure 2.39:*** *Annual Firewood Requirements in Trees (right scale) and in the Corresponding Reforestation Area (left scale) of the Average Households (Vezdara: 28 hh; Savnob: 54 hh; Nisur: 36 hh). Source: Field study 2003*

182 In Vezdara the required firewood amount is based on the following scenario: firewood only used in winter mainly for room heating and dung are substituted entirely by firewood. In Savnob the required firewood quantity covers winter consumption, according to the scenario the MHPS replaces *teresken* consumption in summer. In Nisur the entire *teresken* consumption should be covered with the required firewood.

***Table 2.34:*** *Compilation of the Relevant Energy Figures.*

| | Vezdara | Savnob | Nisur |
|---|---|---|---|
| Households (1898) | 28 | 54 (20) | 36 (5) |
| Average members per household | 7 | 6 | 7 |
| Altitude: m above sea level | 2800 | 2700 | 2600 |
| Mean annual precipitation: mm | ~300 | ~130 | ~130 |
| Arable land per household: $m^2$ | 2500 | 1660 | 3000 |
| Livestock: large / small | 5/18 | 2/12 | 2/8 |
| Arable land per cow-dung-unit | 484 | 597 | 1437 |
| Heated room: $m^3$ | 40-160 | 40-90 | 30-87 |
| Mean annual firewood consumption: kg | 2327 | 0 | 608 |
| Mean annual *teresken* consumption: kg | 0 | 7256 | 8124 |
| Mean annual electricity consumption: kWh | 3054 | 2356 | 0 |
| Mean annual dung consumption: kg | 1762 | 537 | 400 |
| Mean annual diesel oil consumption: liter | 47 | 5 | 114 |
| Mean annual petrol consumption: liter | 0 | 0 | 10 |
| Overall annual consumption: GJ | 69 | 124 | 140 |
| Monthly expenses for diesel oil: *somoni* | 6 | 1 | 8.2 |
| Monthly expenses for electricity: *somoni* | 2.5 | 2.27 | 0 |
| Monthly expenses for firewood: *somoni* | 0 | 0 | 4.5 |
| Total monthly expenses for energy resources: *somoni* | 3.5-70 | 3.26 | 4-50 |
| Mean monthly income: *somoni* | 7-200 | 0-104 | 8-60 |
| Ratio between monthly income and the monthly expenses for energy resources: | 2-62% | 3-100% | 20-100% |
| Collecting time and quantity | 4 hours every second day, 1 back load (15kg) | 4-6 hours a day, one head load (30kg) or one donkey load (80kg) | 4 hours a day, 1-2 head loads (25kg) |
| Fuel wood collector | Boys, girls, women, men | Women, girls (men) | Women, girls |
| Seasonal energy consumption. summer/winter | 13% / 87% | 34% / 67% | 26% / 74% |
| Resource application | Firewood 51%<br>Animal dung 31%<br>Electricity 16%<br>Diesel oil 2% | Teresken 87.8%<br>Electricity 6.8%<br>Dung 5.2%<br>Diesel oil 0.1% | Teresken 86.9%<br>Firewood 6.5%<br>Animal dung 3.4%<br>Diesel oil 2.9%<br>Petrol 0.2% |
| Percentage of biomass fuel | 82% | 93.1% | 96.8% |
| Annually required trees per household | 37 | 28 | 60 |
| Required annual (total) reforestation area for the whole village: ha | 3.07 (30.7) | 4.74 (47.4) | 6.22 (62.2) |
| Potential available reforestation area: ha | 73.3 | 62.8 | 30.6 |

*Source: Field study 2003, Clemens (2001), Cobbold (1898)*

shrubs, a mean household annually needs 28 ten-year old trees in Savnob[183], 37 in Vezdara and 60 in Nisur. Due to the high dung consumption (1762kg per year) Vezdara's households need more trees than the mean household in Savnob. Since, in Nisur, the bulk of the consumed energy resources is teresken (8124kg) and no electricity is available, the village would need the largest reforestation areas. However, the total required forest area of 62.2ha is not available in Nisur's vicinity. By means of the GIS data, 30.6ha have been determined as potential reforestation plots in Nisur. Consequently, the energy resource demand reached a level which cannot be met with the locally and potentially available biomass resources. Savnob and Vezdara have sufficient potential reforestation area (see Table 2.34, last row) to cover the above mentioned firewood demand in combination with electricity.

Generally, it can be concluded that a sustainable energy resource use is not possible based only on locally available biomass fuels, so that additional energy

183 Provided that in Savnob the MHPS runs on full capacity and electricity distribution is scheduled, providing alternate halves of the village with power.

resources are needed to cover today's demand. One of the most adequate and auspicious energy options for remote villages is electricity generated by small hydropower plants. Such schemes, properly managed and suitably designed, and firewood resources which are well managed, allow a sustainable energy resource use at the village level, which guarantee a long-term energy supply.

These problems cannot be solved solely by the peasants; mitigating measures have to be introduced with external support. Without a fundamental improvement of the energy resource base and its management, the depletion process will result in a sever crisis.

***References:***

Clemens, Jürgen (2001) Ländliche Energieversorgung in Astor: Aspekte des nachhaltigen Ressourcenmanagements im nordpakistanischen Hochgebirge. Bonner Geographische Abhandlungen. Heft 106. Sankt Augustin: Asgard-Verlag.

Cobbold, Ralph (1898) Report on his journeys on the Pamirs and in Chinese Turkestan. To the Foreign Office. Srinagar. Kashmir.

Cobbold, Ralph (1900) Innermost Asia. William Heinemann: London.

Hafizullah Emadi (1998) Politics of Transformation and Ismailis in Gorno-Badakhshan, Tajikistan. In Internationales Asienforum International Quarterly for Asian Studies.. Volume 29, 1-2/98.

Kadian, Promila and Kaushik, Sushma (2003) Rural Energy for Sustainable Development. Participatory Assessment of Energy Resources. New Dehli: Deep & Deep Publications ltd.

# 14. Assessment of the Energy Situation at District Level

The following chapter provides a spatial appraisal of the energy situation in Gorno Badakhshan with regard to electrification, dependence on biomass fuels and pressure on forestland (see Map 2.4) and shrubby vegetation (see Map 2.5). These issues are discussed for all eight districts[184] of GBAO, and spatial hotspots of the energy crisis are identified (see Map 2.6). This qualitative appraisal is based on the authors' impressions and data gained during the field survey in the Western Pamirs, as well as on related data available in other reports[185]. The following factors were considered for the appraisal of the dependence on biomass fuels, of pressure on fuel wood sources and of the general energy situation:

- The spatial distribution of vegetation and precipitation determining the availability of firewood sources and their reproduction.
- The average village altitude above sea level determining the availability of firewood, the use of *teresken* shrubs and the demand for heating resources.
- The population size determining the overall demand for energy.
- The availability of electricity from the grid determining the dependence on biomass fuels.
- The availability of electricity from MHPS determining the dependence on biomass fuels.
- The average annual fuel wood consumption of a household determining pressure on forestlands and *teresken* pastures.

## 14.1 Murgab District

***Murgab District (Eastern Pamirs)***

| | |
|---|---|
| Villages | 23 |
| Households | 3614 |
| Inhabitants | 17,035 |
| Number of HPP | 1 (Murgab center) |
| Grid supply | From Kyrgyzstan (only Sari-Mangol) |
| Electricity supply to: | 57% of the population |
| Perennial electricity supply | From grid: no data<br>From HPP: yes |
| Persons without electricity | 7344 |
| Main energy resource | *Teresken* and dung |
| Dependence on biomass fuels | Extremely high |
| Pressure on teresken | Extremely high |
| Energy situation | Alarming |

Murgab is the largest district, located on the arid high plains of the Eastern Pamirs and covering more than half of Gorno Badakhshan's territory (almost 40,000km$^2$, Breu & Hurni 2003: 22). A total of 22 villages are scattered on the high plateaus, home to 14,114 inhabitants or around 7% of GBAO's population[186]. Electricity supply in Murgab district can be viewed as a luxury. There is only one hydropower plant (HPP) in the whole district, supplying Murgab center (6770 inhabitants, 1483 households) with electricity. Another village, Sari-Mangol (2921 inhabitants, 518 households), appearing in the demographic statistics of Murgab district, but not located within the official boundaries of GBAO, enjoys grid supply from Kyrgyzstan as it is situated on the Kyzyl-Suu River within the Chong Alay district of Kyrgyzstan[187]. Thus 57% of the inhabitants in Murgab district are provided with electric power. Since power supply is insufficient, the dwellers of Murgab center, like the ones living in the remaining 21 villages without electricity supply, are totaly dependent on locally available *teresken* shrubs and manure. Since firewood is not available and fossil fuels are hardly affordable, shrubs and dung are the main energy resources in this region. Even though the district is only sparsely populated, the demand for cooking and heating resources exerts exorbitant pressure on *teresken* pastures, since due to the specific burning characteristics of these shrubs and the average high altitudes of the Eastern Pamirs, huge quantities are needed (see Map 2.5). It is reported in Kleinn (2003) that in the district center alone five to six trucks[188] per day left for *teresken* harvest in winter 2002/2003, driving several tenths of kilometers to areas,

184 The authors visited the entire districts of Roshtkala, Rushan and Vanj, as well as the city of Khorog and the settlements of Shugnan district on the Pandzh River. The appraisal of the energy situation in all other districts is not so detailed, because it is based on secondary statistics and reports.

185 These are AKF (2003), Degen (2001), Domeisen (2002), Hangarten (2002), IFC & GoT (2001), Kleinn (2002), Kleinn (2003), MSDSP (2003) and Zibung (2002).

186 The demographic statistics for the year 2003 are provided by the MSDSP (2003).

187 In the sixties this piece of land, and with it the village Sari-Mangol, was rented to Tajikistan by the Republic of Kyrgyzstan. Even though the rent has long been overdue, the village seems to belong still to Murgab district as it is listed in the demographic statistics provided by the MSDSP in 2003.

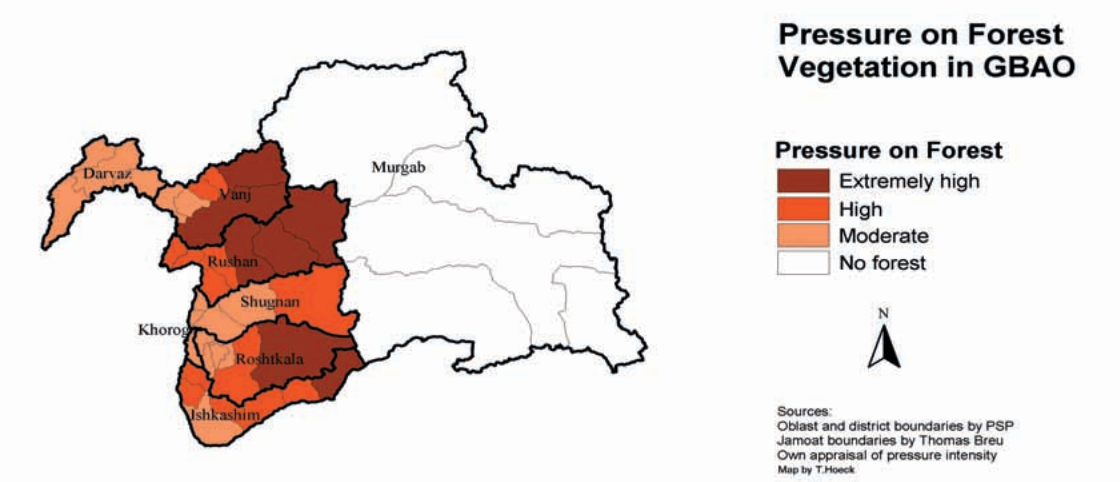
188 Each truck transports four to six families (Kleinn 2003).

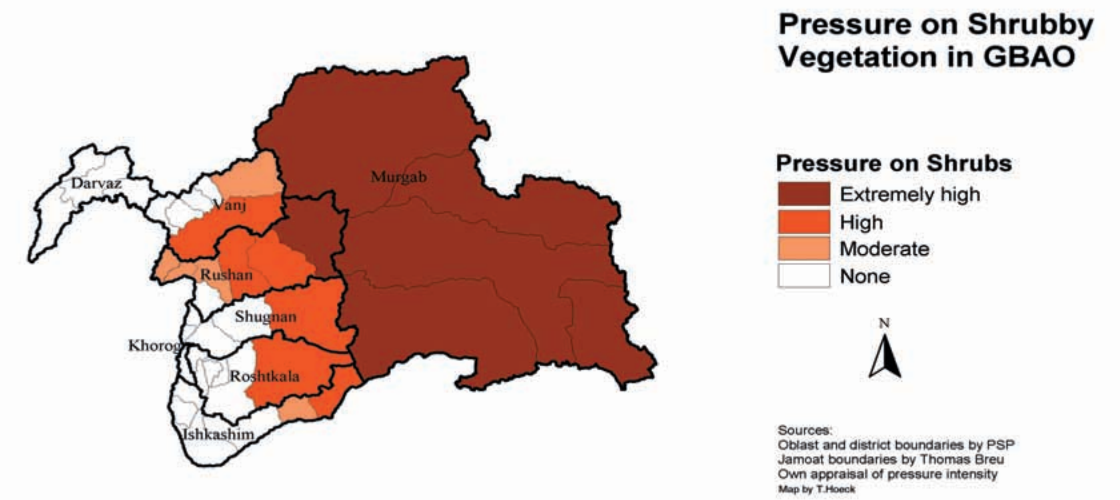
***Table 2.35:** Estimated Loss of Vegetation Cover Due to Teresken Consumption in Murgab District.*

| Sparse, average and dense *teresken* stocks[189] | Annual loss of vegetation cover | Daily loss of vegetation cover | Annual loss per average household[190] |
|---|---|---|---|
| Density 300kg/ha | 815.3km$^2$ | 223.4ha | 26.3ha |
| Density 700kg/ha | 349.4km$^2$ | 95.7ha | 11.3ha |
| Density 1350kg/ha | 181.2km$^2$ | 49.6ha | 5.9ha |

*Source: Calculations based on figures from Domeisen (2002), Kleinn (2002) and Zibung (2002).*

which had not yet been cleared. To satisfy basic domestic energy needs, an average household in Murgab district annually consumes about 7.9 tons[191] of *teresken*. Extrapolated to the district level, an overall estimated quantity of 24,458 tons of these shrubs is harvested annually on the high plains of the Eastern Pamirs. Considering an average vegetation stock of 700kg/ha (Domeisen 2002: 75), the annual *teresken* consumption of the whole district represents an average estimated area of 349km$^2$, which is cleared every year (see Table 2.35). As *teresken*




***Map 2.4 (top):** Pressure on Forestland Due to Firewood Consumption Spatially Differentiated for Districts and Jamoats. Since there is virtually no forest vegetation in the Eastern Pamirs, pressure on forests does not exist. Source: The authors' qualitative appraisal.*
***Map 2.5 (bottom):** Pressure Exerted on Shrubby Vegetation as a Result of Intensive Fuel Wood Harvest Spatially Differentiated for Districts and Jamoats. Source: The authors' qualitative appraisal.*

189 The density of the *teresken* vegetation cover for the Murgab Region is mentioned in Domeisen (2002).
190 In Hangartner (2002: 9) the area annually cleared per household is even estimated at 36ha.
191 This is the mean figure from annual *teresken* consumptions provided in Zibung (2002), Domeisen (2002) and Kleinn (2002).

shrubs have a very low annual biomass production[192], due to the harsh climatic and biophysical conditions in this region, the regeneration of the vegetation cover cannot keep pace with *teresken* harvesting. As a result, the clearance of extensive pastureland is steadily progressing, provoking the hazard of desertification. It must be concluded that Murgab district is suffering from a real energy crisis with disastrous consequences for the pastureland and the people's livelihood (see Map 2.6).

## 14.2 Ishkashim District

In Ishkashim, the southern-most district of Gorno Badakhshan, 45 villages are located on the northern bank of the Pandzh River, representing the border to Afghanistan. Except for one small village (Ratm with 17 households and 138 inhabitants) at the east end of the district, all settlements are connected to electricity infrastructure. Thus 99.5% of the inhabitants are at least temporarily supplied with electricity. In addition to one mini hydro scheme (Namadgut) there are two micro hydro schemes (Yamchun and Langar), as well as grid supply, providing insufficient electric power on an irregular basis to the dwellers of the Ishkashim district. Due to the unsatisfactory power supply, people rely to a great extent on firewood and dung to meet their basic demands for energy. As reported by AKF (2003) an average household in Ishkashim district uses around 6 tons of firewood per year.

Since several villages are connected to the main grid from Khorog, which will provide perennial and more reliable power supply after the completion of the Pamir Private Power Project[193] (PPPP), and since the hydro scheme in Namadgut will be rehabilitated within the PPPP as well, there is hope for improved electricity supply in Ishkashim district in forthcoming years. This has the potential of substituting electric power for biomass fuels and thus relieving pressure on forest vegetation.

***Ishkashim District (South-Western Pamirs)***

| | |
|---|---|
| Villages | 45 |
| Households | 3554 |
| Inhabitants | 28,059 |
| Number of HPP | 3 |
| Grid supply | Main grid |
| Electricity supply to: | 99.5% of the population |
| Perennial electricity supply | No, only from the micro hydro schemes |
| Persons without electricity | 138 |
| Main energy resource | Firewood and electricity |
| Dependence on biomass fuels | High |
| Pressure on firewood | High |
| Energy situation | Moderate-severe |

## 14.3 Roshtkala District

In the Roshtkala district 100% of the population is connected to the main grid and supplied with electricity from spring until autumn. To fill the winter power supply gap,


***Picture 2.57:*** *Vegetation change in the Shakhdara Valley. The entrance and the middle parts of the valley are characterized by rather dense forest vegetation (see Photos 1, 2 and 3). Riparian forests change to single tree lines (see Photo 4) and bushy vegetation alongside the river (see Photo 5). At the far end of the valley, trees are virtually non-existent and pasturelands prevail (Photos: T. Hoeck, June 2003).*

192 The average annual biomass growth of *teresken* amounts to 70kg (Clemens 2001: 137).
193 For more information concerning the Pamir Private Power Project, the reader is referred to Chapter 8.1.3.

***Roshtkala District (Western Pamirs)***

| | |
|---|---|
| Villages | 106 |
| Households | 2991 |
| Inhabitants | 21,041 |
| Number of HPP | 8 |
| Grid supply | Main grid |
| Electricity supply to: | 100% of the population |
| Perennial electricity supply | From grid: no<br>With HPP: yes |
| Persons without electricity | 0 |
| Main energy resource | Firewood and electricity |
| Dependence on biomass fuels | High |
| Pressure on firewood | High |
| Energy situation | Moderate |

seven villages[194] own a micro hydro scheme, which provides insufficient electric power to cover needs for cooking and space heating, but at least allow the use of light bulbs and perhaps of some other electrical devices. The majority of the population has no power supply during the winter months, when the demand for energy is highest. Thus, despite the complete electrification of the Shakhdara Valley, people are still highly dependent on firewood, shrubs and manure to cover their basic domestic needs, especially in wintertime. An average household in Roshtkala district consumes around 5.8 tons[195] of firewood per year in addition to manure and electricity. At the far end of the Shakhdara Valley, where forests are inexistent, besides dung an average household uses around 4.1 tons of *teresken* shrubs (Kleinn 2002). The entrance and the middle sections of the valley are characterized by remains of dense forests located in the floodplains of the Shakhdara River. With increasing altitude, the valley vegetation changes to smaller trees and thorn bushes, and finally consists of pastureland and areas sparsely populated with *teresken* shrubs (see Picture 2.57). With the changing vegetation cover the energy resource base changes as well, so that people in the upper part of the Shakhdara Valley rely on electricity, dung and *teresken*, whereas villages in the lower part use electricity, firewood (willow) and dung to cover their needs for energy.

The successful completion of the PPPP will probably lead to a major improvement of the energy situation in the Roshtkala district. Since all villages are connected to the main grid, a perennial and better power supply will allow people covering a substantial part of their energy demand with electricity. Considering that the majority of the dwellers can afford electric power at increased prices, there is a great potential to relieve pressure on forests and pasturelands.

## 14.4 City of Khorog

Khorog, as the *oblast* capital and the economic centre of the Tajik Pamirs, enjoys privileges in energy supply. In contrast to dwellers in the villages supplied from the main grid, the 27,914 inhabitants of Khorog are regularly provided with sufficient electricity. Due to the rigorous measures taken by Pamir Energy Company (PEC) to accelerate the payment of outstanding electricity bills, some parts of the city have to rely again temporarily on firewood. Entire quarters are being cut off from the grid in case one or more households have not paid their bills on time[196]. All in all, electricity constitutes the main energy resource and its appropriate supply allows the use of various appliances for domestic and commercial activities. The completion of the PPPP will contribute to good and reliable electricity supply in Khorog.

***Khorog District (Capital of GBAO)***

| | |
|---|---|
| City | 1 |
| Households | 4637 |
| Inhabitants | 27,914 |
| Number of HPP | 1 (Khorog) |
| Grid supply | Main grid |
| Electricity supply to: | 100% of the population |
| Perennial electricity supply | Yes |
| Persons without electricity | 0 |
| Main energy resource | Electricity |
| Dependence on biomass fuels | Low |
| Pressure on firewood | Low |
| Energy situation | Satisfactory |

## 14.5 Shugnan District

Shugnan district is also fully electrified, but not regularly supplied with electric power. As in the Roshtkala district,

194 In Roshtkala district the villages of Vezdara, Barmev, Sumjev, Andarv, Bodom, Rijist own one micro hydro scheme and Khidorjev owns two.

195 This is the mean calculated from figures provided in Kleinn (2003), AKF (2003), Zibung (2002) and field study 2003.

196 In early 2004 the PEC was fined 40,000 *somoni* (USD 12,700) by the managerial office of the State agency on Antimonopoly Policy and Entrepreneurship Support under the government of the Republic of Tajikistan for contravention of legislative instruments dealing with consumers' rights advocacy and the law on natural monopolies. The Agency demanded that apart from the fine the PEC should provide a record of the energy consumed registered by electrometers; in case the latter are non-available - by electrical appliances belonging to consumers. Besides the PEC has been required to limit mass disconnection of electricity and not to infringe on the rights of conscientious consumers (http://varorud.org/english/herald/pulse101003.html).

***Shugnan District (Western Pamirs)***

| | |
|---|---|
| Villages | 63 |
| Households | 5514 |
| Inhabitants | 35,587 |
| Number of HPP | 3 |
| Grid | Main grid |
| Electricity supply to: | 100% of the population |
| Perennial electricity supply | From grid: no<br>With HPP: yes |
| Persons without electricity | 0 |
| Main energy resource | Firewood and electricity |
| Dependence on biomass fuels | High |
| Pressure on firewood | Moderate-high |
| Energy situation | Moderate |

the 63 villages enjoy electricity supply from the mains from spring until autumn, but lack power during the winter months. Thus people are dependent on locally available biomass fuels, such as firewood, shrubs and manure to prepare meals and heat their houses in wintertime. Shugnan district is home to three hydro schemes: The Pamir 1, the largest power plant in GBAO located on the Gunt River supplying the main grid together with the HPP in Khorog, and two MHPS located in villages on the Pandzh River bridging their hibernal power supply gap. An improved electricity supply can be expected for Shugnan district after the completion of the rehabilitation work at the Pamir 1 HPP and after the construction of the water flow regulation structure at Lake Yashilkul, enabling the Pamir 1 to perennially operate at full capacity.

## 14.6 Rushan District

A great number of the MHPS in Gorno Badakhshan are situated within the boundaries of Rushan district. This is mainly due to the limited extent of the main grid. The settlements lining the Pandzh River are connected to the mains and supplied accordingly. In addition, the majority of these 13 villages own a MHPS to tide over the supply gap in winter. However, as is already known from other districts, the dependence on biomass fuels is enormous. A household with regular electricity supply annually consumes around 1.7 to 4.9 tons of firewood and around one ton of *teresken* shrubs (Kleinn 2002; AKF 2003).

The entire Bartang Valley, the last two villages downstream on the Pandzh River and even Rushan centre have to rely on decentralized electricity supply from micro or mini hydropower stations. A total of 12 villages[197] in Rushan district, accommodating 3232 inhabitants (13.3%), have no power supply at all due to no electricity infrastructure or broken power plants. All of them are situated in the deeply incised and arid Bartang Valley, constituting one of the regions of Gorno Badakhshan with the worst energy supply. Vegetation is scarce and limited to the narrow floodplains of the Bartang River and its tributaries (see Picture 2.58). Forest areas have already been cut to a large extent during the past decade. Thus fire-

***Rushan District (Western Pamirs)***

| | |
|---|---|
| Villages | 42 |
| Households | 4420 |
| Inhabitants | 24,374 |
| Number of HPP | 29 |
| Grid | Main grid |
| Electricity supply to: | 86.7% of the population |
| Perennial electricity supply | From grid: no<br>From HPP: yes |
| Persons without electricity | 3232 |
| Main energy resource | Firewood and *teresken* |
| Dependence on biomass fuels | On the Pandzh: High<br>Bartang Valley: Extremely high |
| Pressure on firewood | On the Pandzh: High<br>Bartang Valley: Extremely high |
| Energy situation | On the Pandzh: Severe<br>Bartang Valley: Alarming |


***Picture 2.58:*** *Forest vegetation in the Bartang Valley is scarce. Photo one represents the entrance of the valley, still characterized by veritable trees, whereas the middle and upper parts are only home to bushy vegetation (Photo 2) and completely cleared riparian forest areas (Photo 3). (Photos: T. Hoeck, June 2003)*

197 The reader is referred to Chapter 8.1 for further information about electricity supply and non-supplied villages.

wood is a very scarce resource, which can be declared as a luxury good in the Bartang valley. Since most hydropower plants do not operate at full capacity and provide insufficient power, the main energy resources are *teresken*, firewood and dung. In the lower part of the valley an average household annually uses between 3.2 and 6.75 tons of firewood (AKF 2003; Degen 2001). Meanwhile, in the upper part, where firewood sources are virtually inexistent, a household consumes around eight tons[198] of *teresken* per year in addition to dung. The high dependence on this fast-burning shrub results in the clearance of existing pastureland in the surroundings of the villages. The following two examples from the case study villages give an impression of the extension of degradation: To satisfy the demand of the village of Savnob with 341 inhabitants, 414 tons of *teresken* shrubs are being collected a year, representing an estimated area of 590ha. The neighboring village of Nisur, home to 240 dwellers, annually consumes 309 tons of these shrubs, resulting in an estimated loss of vegetation cover of 406ha. The energy situation in the Bartang Valley, especially in the upper part, is alarming, since the inadequate *teresken* shrubs constitute the main energy resource and at the same time the last locally available energy option. The expected improvements in electricity supply after the completion of the PPPP will only affect 47.3% of the population in Rushan district. Since Pamir Energy Company has no plans so far for grid extension, the villages with decentralized or no electricity supply will suffer from an insufficient power supply and from a heavy dependence on the scarce biomass fuels also in the near future.

## 14.7 Vanj District

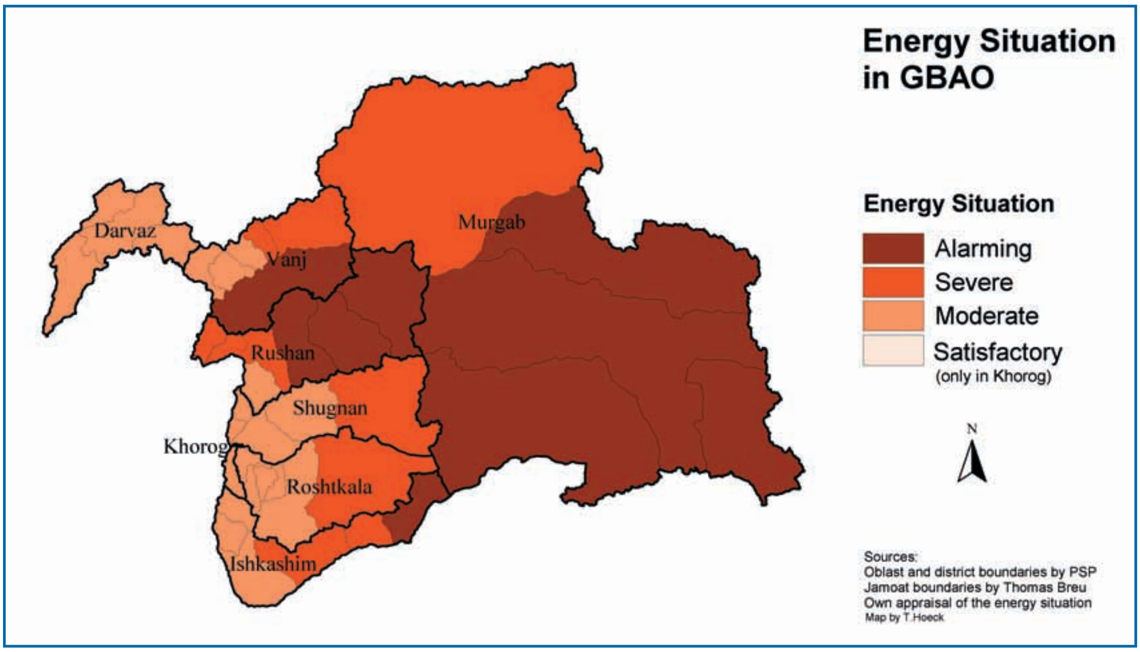
The Vanj district can be divided spatially into three regions: The valley defined by the Pandzh River (the border with Afghanistan), and the two valleys formed by the tributaries Vanj and Yazgulom. The district is not connected to the main grid supplied by the Khorog and Pamir 1 power plants. However, the settlements situated on the Pandzh River and at the entrance to the Vanj Valley enjoy supply of electricity from the Southern Tajik power system, which is fed by the Nurek HPP, Tajikistan's largest storage scheme located in the Khatlon *oblast*. The district centre and neighboring villages in the Vanj

***Vanj District (North-Western Pamirs)***

| | |
|---|---|
| Villages | 57 |
| Households | 4204 |
| Inhabitants | 32,632 |
| Number of HPP | 4 |
| Grid supply | From Nurek |
| Electricity supply to: | 97.5% of the population |
| Perennial electricity supply | From grid: no data<br>From HPP: yes |
| Persons without electricity | 830 |
| Main energy resource | Firewood and electricity |
| Dependence on biomass fuels | High |
| Pressure on firewood | High |
| Energy situation | Severe |

***Picture 2.59:*** *The Vanj Valley enjoys higher precipitation and is characterized by wide floodplains, relatively dense forest vegetation and green pastures (Photos: T. Hoeck, July 2003).*

198 The reader is referred to the Chapters 11 and 12 on the two case studies conducted in the villages Savnob and Nisur in the upper Bartang Valley.




***Map 2.6:*** *Appraisal of the Energy Situation in Gorno Badakhshan Differentiated Spatially by Districts and Jamoats. Source: The authors' qualitative appraisal.*

Valley have decentralized power supply from the Vanj HPP. The villages further up the valley are connected to the hydro scheme in Tekharv. Only the last four villages with a total number of 830 inhabitants have no power supply for 18 years already due to damages on transmission lines. Thus 97.5% of the population is connected to the electricity infrastructure. In summer 2003 the construction of an MHPS located in Poimazor was almost completed, giving rise to the hope, that the four villages just mentioned, soon enjoy power supply. Since the hydropower plants and the transmission systems are old and under a latent threat of being damaged or washed away by floods or debris flows, a satisfactory electricity supply cannot be guaranteed. Thus, firewood and dung are still the most important energy resources in rural areas. This is illustrated by consumption figures provided in AKF (2003) and Kleinn (2002): A household annually uses around 8.3 tons of firewood. Compared to other districts, the Vanj Valley has relatively dense forest and pasture vegetation (see Picture 2.59). Higher precipitation and the wide topography of the valley offer larger areas for forests or land cultivation. But the woody vegetation also suffers severely from the high demand for firewood.

The Yazgulom Valley is home to seven villages, all connected to the HPP in Andarbak and forming a small and independent electricity grid. As the capacity of the hydro scheme is insufficient to supply all villages at a time, they are provided with power alternately. People thus rely to a great extent on biomass fuels, such as firewood and dung, to cover their daily energy needs. A household in Yazgulom consumes around 7.8 tons of firewood per year (Kleinn 2002).

Only the district centre will benefit from the Pamir Private Power Project with the rehabilitation of the hydropower plant in Vanj centre. For the remaining 79% of the population there is no hope for an amelioration of their energy situation.

## 14.8 Darvaz Distric

Darvaz district, located in the northwest of Gorno Badakhshan, enjoys more favorable climatic conditions than the regions to the south and east. Higher annual precipitation allows growth of denser vegetation, serving as a source of firewood. Even though the district is fully electrified, a household annually consumes around 5.9 tons of firewood (AKF 2003). Electricity is provided to

***Darvaz District (North-Western Pamirs)***

| | |
|---|---|
| Villages | 61 |
| Households | 3578 |
| Inhabitants | 26,202 |
| Number of HPP | 4 |
| Grid supply | From Nurek |
| Electricity supply to: | 100% of the population |
| Perennial electricity supply | From grid: no data<br>From HPP: yes |
| Persons without electricity | 0 |
| Main energy resources | Firewood and electricity |
| Dependence on biomass fuels | High |
| Pressure on firewood | Moderate |
| Energy situation | Moderate |

all settlements by the Southern Tajik power system, and four mini hydro schemes complement power supply in the district centre (Kalai-Khumb) and in three other villages (Khost, Shikev and Oluni). Due to the insufficient storage capacity of the Nurek hydro scheme to meet the winter demands of the Southern Tajik power system, it can be assumed, that villages in Darvaz district do not enjoy winter power supply. The completion of the PPPP will have no impact on the energy situation in the Darvaz district, since no village is connected to the main grid, and rehabilitation of the hydro scheme in Kalai-Khumb is not foreseen.

## 14.9 Conclusion

Even though 94.6% of the population enjoys electricity supply, dependence on local biomass fuels in GBAO is generally high. In rural areas power supply is unsatisfactory, both in terms of supply times and amount supplied. Only the city of Khorog enjoys reliable and sufficient power provision. Thus for the majority of GBAO's inhabitants, biomass fuels are still the main resources to cover the basic domestic demands for energy. Since wood and pastureland is naturally scarce and steadily declining due to the high consumption of fuel wood, Gorno Badakhshan faces the threat of large-scale land degradation and desertification. The use of *teresken* shrubs as the main energy resource can be taken as an indicator for an alarming energy situation (see Map 2.5 and 2.6) and the virtual non-existence of forest areas, since these shrubs are the last energy option. Furthermore, in regions where pressure on firewood is extremely high and forests have already been cleared to a great extent, it can be expected that in the near future people will start collecting shrubs as their last option to meet the energy demand for cooking and heating. Hence there is an urgent need for immediate measures to improve energy supply, especially in these regions of Gorno Badakhshan.

The authors consider the following areas of GBAO as hotspots of the energy crisis and call for immediate action in these regions:

- Larger settlements in the Murgab district
- Middle and upper parts of the Bartang Valley (Rushan district)
- The upper parts of the Vanj Valley (Vanj district)
- The Yazgulom Valley (Vanj district)
- The Eastern extent of the Ishkashim district

***Gorno Badakhshan Autonomous Oblast***

| | |
|---|---|
| City | 1 |
| Villages | 398 |
| Households | 32,512 |
| Inhabitants | 212,844 |
| Number of HPP | 53 |
| Grid supply | From main grid, from Nurek |
| Electricity supply to: | 94.6% of the population |
| Persons without electricity | 11,544 |
| Main energy resources | Firewood, *teresken*, dung and electricity |
| Dependence on biomass fuels | High |
| Pressure on fuel wood | High |
| Energy situation | Severe |

***References***

AKF [Aga Khan Foundation] (ed.) (2003) Lighting up Communities. A Case Study of the Mountain Societies Development Support Programme's Mini-Hydel Projects in Gorno Badakhshan Autonomous Oblast. Evaluation Learning and Communication Unit Tajikistan: Dushanbe.

Breu, Thomas and Hurni, Hans (2003) The Tajik Pamirs: Challenges of Sustainable Development in an Isolated Mountain Region. Bern: Centre for Development and Environment, University of Berne.

Clemens, Jürgen (2001) Ländliche Energieversorgung in Astor: Aspekte des nachhaltigen Ressourcenmanagements im nordpakistanischen Hochgebirge. Bonner Geographische Abhandlungen. Heft 106. Sankt Augustin: Asgard-Verlag.

Degen, Muriel (2001) Local Development Profile of Basid, Tajikistan. Internal Report Pamir Strategy Project. Bern: Centre for Development and Environment, University of Berne.

Domeisen, Michael (2002) Marginalized by the Impacts of Transformation. A Study of Post-Soviet Livestock Breeding in the High Mountains of the Eastern Pamirs. Diplomarbeit. Bern: Centre for Development and Environment, University of Berne.

Hangartner, Judith (2002) Dependent on Snow and Flour. Organization of Herding Life and Socio-Economic Strategies of Kyrgyz Mobile Pastoralists in Murghab, Eastern Pamir, Tajikistan. Lizentiatsarbeit. Institut für Ethnologie. Universität Bern.

IFC [International Finance Corporation] and GoT [Government of Tajikistan] (2001) Evaluation of the GBAO Electric Networks and Assistance in Project Preparation. Volume 3 Environmental and Socio-Economic Measures. Elektrowatt Engineering Ltd.

Kleinn, Eva (2002) Report on the Survey on the Use of Fuel Resources on the Territory of GBAO Districts. GTZ.

Kleinn, Eva (2003) Unpublished Report on Teresken Acquisition in Murgab Center (Eastern Pamirs). GTZ.

MSDSP [Mountain Society Development and Support Programme] (ed.) (2003) Demographic Statistics of Gorno Badakhshan Autonomous Oblast 2003. Mountain Society Development and Support Programme. Dushanbe.

Zibung, Daniel (2002) Eine integrale Analyse der Infrastrukturausstattung und Energieversorgung in der Grossregion Gorno-Badakhshan, Tajikistan. Diplomarbeit. Bern: CDE.

http://varorud.org/english/herald/pulse101003.html

# Part III
# Synthesis and Conclusion

*In the final part of the thesis the three main topics (land degradation, micro and mini hydropower provision, and energy consumption patterns at village level) are linked and their interrelations are discussed. Chapter 15 concentrates on the origin of the present energy crisis, and discusses the driving forces for unsustainable energy resource use in the Tajik Pamirs. Moreover, the impact of unsustainable use of local biomass fuels on ecological and socio-economic levels, as well as factors exerting pressure on the local energy resource base are presented. A discussion of energy options for Gorno Badakhshan, focusing on firewood sources and hydropower, as well as an assessment of their potential to relieve pressure on local biomass fuels and mitigate land degradation are found in Chapter 16. The last chapter presents stakeholder-specific recommendations, practical indicators for rural energy appraisal, and recommendations for further research.*

# 15. Synthesis

## 15.1 The Origin of the Energy Crisis

Gorno Badakhshan experienced two great socio-economic transitions within a century which also considerably affected the energy situation. Figure 3.1 shows schematically the evolution of the energy situation from 1920-2010, comparing supply and consumption. The pre-Soviet peasants covered their entire energy requirement with local renewable resources, mostly with firewood and animal dung. *Teresken* was very rarely used as fuel. Thus, their energy resource use appears to have been managed in a sustainable way at that time. The above-mentioned resources were plentiful, so that no shortage occurred even without a proper management. Since the number of inhabitants is a crucial factor in terms of the quantity of energy resource consumption, the graph of overall demand is congruent to population development. A first stimulus came particularly with the invasion of the Soviets in the thirties. Modern techniques, fossil fuels, and diesel generators were brought to the Pamirs. Due to the extension of arable land and the increased firewood requirements, the forestlands were gradually decimated during Soviet times. In the forties, the population started to grow exponentially[1] and with it the requirement for energy resources. This demand was covered particularly by fossil fuels and electricity (hydropower and diesel plants). At the end of the eighties the Pamiris were highly dependent on external energy supply. More than 95% of energy consumption within GBAO was covered by imported energy resources (Kleandrov 1974; Zibung 2002). With the collapse of the Soviet Union virtually all these deliveries ceased. Suddenly, the scarce local biomass fuel base had to cover the entire energy demand of 170,000 people compared to a demand of 19,000 in 1908. Moreover, with improved living standards individual demand for energy also increased (see Figure 3.1). The Badakhshani had no other option than to fill this gap with the heavily decimated local energy resources since alternative resources were not available and affordable. This exerted an enormous pressure on the local energy resources. A massive energy deficit thus emerged.

The civil war additionally aggravated this precarious situation. On the one hand, a considerable number of

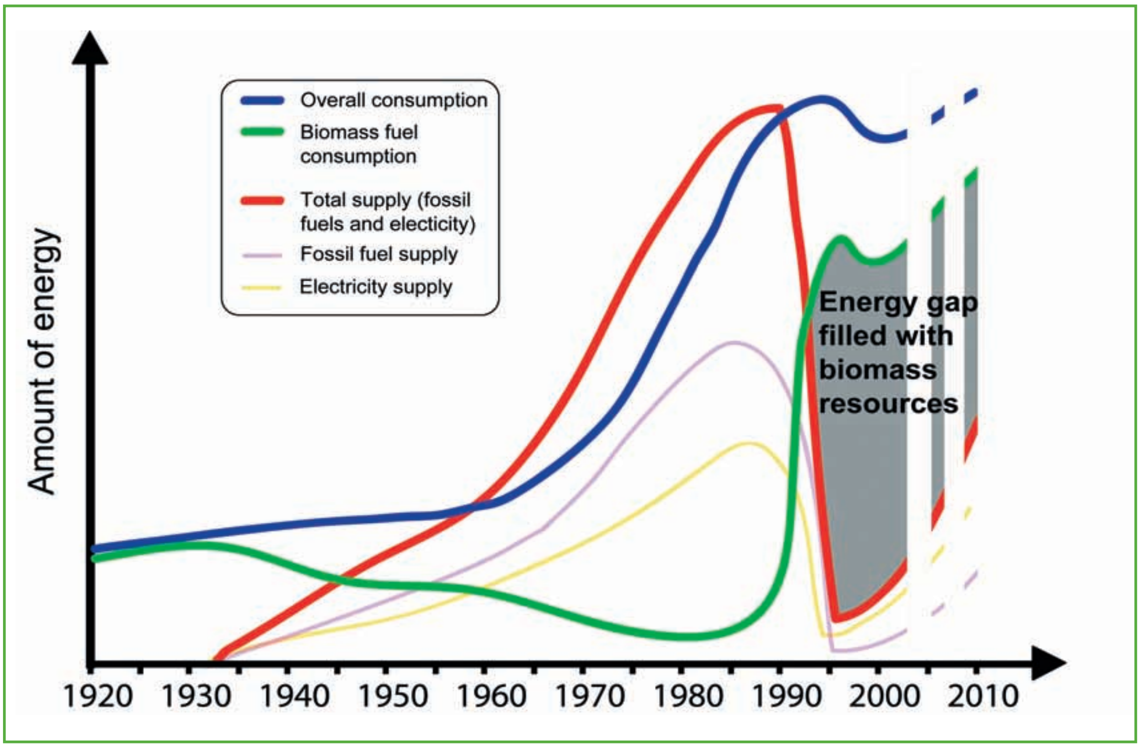



***Figure 3.1:*** *Qualitative Comparison of Energy Supply and Demand over the Last Century. Before 1930 the overall consumption was met by biomass fuels. The total supply mainly consisted of electricity plus the fossil fuels. Source: Luknitsky (1954); Kleandrov (1974); Renner (1977); Zibung (2002); Field study 2003*

1 Population growth in GBAO:1908: 19,000 inhabitants (Snessareff 1908: 180); 1961: 80,000 inhabitants (Krader 1963: 235); 2003: 212,844 (MSDSP 2003).

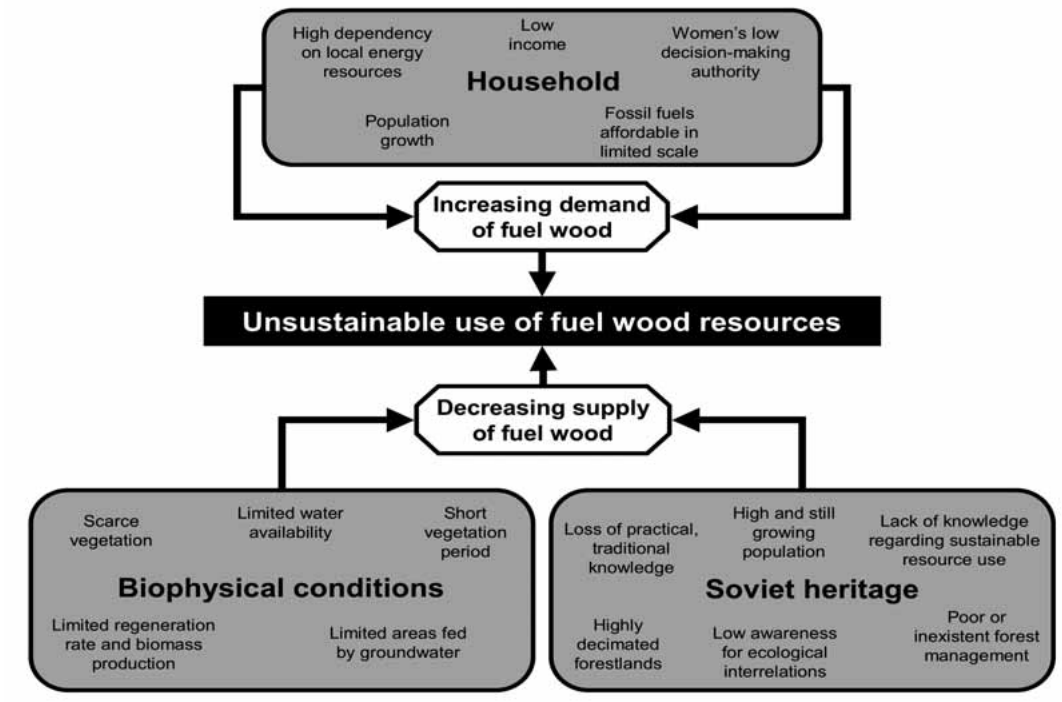



***Figure 3.2:*** *Interaction of the Driving Forces Leading to Unsustainable Energy Resource Use in the Pamirs. Concept: Droux & Hoeck*

refugees[2] fled from the lowlands into the Pamirs, additionally increasing the demand for local energy resources. On the other hand, transport links and many energy infrastructures were out of order or even destroyed during civil war. Even today, broken transmission lines hinder power supply to several villages (see Chapter 8.1.1.).[3]

Though the Tajik Republic cannot be blamed for the collapse of the Soviet Union, it can be stated that the period of transition led to a bloody civil war in which the state and the political system failed completely. The state was and is still not able to fulfill its general duties and responsibilities regarding power supply in GBAO. Since independence there is a lack of effective management and controlling bodies taking care of the local energy sources (forests, pastures). Such institutions and regulations are highly needed, especially when a resource is scarce and its management is difficult.

## 15.2 Driving Forces for the Unsustainable Use of Energy Resources

The energy crisis in the Pamirs and the unsustainable use of local energy resources – in this case mostly woody resources – are obviously inked in a way that they enforce each other. Unsustainable use of energy resources can be seen as a depletion of a resource to the extend that its natural reproduction cannot keep pace with present demand. This results in a considerable deterioration of its primal function or in its total disappearance. The origin of an unsustainable resource use is a setting that involves various complexly interacting factors with multidimensional cause-and-effect chains containing self-energizing mechanisms.

### 15.2.1 The Motor of Unsustainable Use of Local Energy Resources

The biophysical conditions of an arid mountain ecosystem such as the Tajik Paimrs only allow a sustainable local energy supply for small a population. Moreover, since the Soviets practiced a deteriorating management of the local biomass resources, the peasants took over a miserable firewood base at a miserable time. These two preconditions affect highly today's resource base which, due to its large demand, requires careful management. Figure 3.2 depicts the different driving forces contributing to unsustainable use of energy resources in the Tajik Pamirs.

Nowadays, reproduction of locally available renewable energy resources (biomass fuels, hydropower) is insufficient to cover in a sustainable way the present domestic demand for energy. Furthermore, due to high transaction costs, fossil fuels (coal, diesel oil, gas, kerosene, petrol) which would have a great potential for biomass resource substitution, are unaffordable for the majority of the population. The peasant's choice of ener-

2 This immigration induced a temporary population growth of up to 40% in GBAO.

3 In the Rushan district, they say that *mujahedins* used the poles as firewood during civil war.

gy options determines the amount of consumption and thus demand for the specific energy resource. As a result of too few alternative energy options and years of mismanagement, the majority of the GBAO's population is forced to overtax the remaining energy resources if they do not want to starve or freeze to death. Another dead-end option is emigration, in the hope of finding better living conditions in a city. Since it is mainly young men who migrate or hold a job outside the village, women are left with the additional burdens of the rural household. They already bear the main responsibility for allocation and use of fuel wood. But their obligations and particularly their authority to decide is rather reduced, if not they would migrate, too. The domestic decision-makers are mainly the men, and they also hold for the area of energy resource issues. Although women are perhaps more aware of emerging scarcities and would be more receptive to planting efforts, men still decide for example weather a tree planted near the house is meant for firewood or for timber, or to what extend dung is used as fuel. Thus, not surprisingly, in some regions men seem unconcerned about unsustainable use and the degree of fuel wood scarcity because they are not directly affected by the physical agony caused by the backbreaking task of procuring energy resource.

### 15.2.2 Obstacles to Overcome

Since the energy situation in GBAO has turned into an energy crisis the question has been raised, what keeps the Pamiris from applying sustainable energy resource management strategies? The peasants might be aware of overusing local energy resources, but they do not feel able to change or adapt their energy resource management. The following list contains factors hindering a sustainable energy resource use ranked in order of importance:

1. One of the major constraints is the tremendous poverty of the Pamiris. Due to the **lack of financial means** the peasants are unable to purchase energy resources, particularly kerosene, diesel oil and coal as during Soviet times when most of the peasants purchased the appropriate appliance.
2. Since in principal the local energy resource base has deteriorated so much by **large-scale degradation** (disappearance of forests, depletion of teresken pastures), people are forced to use the remaining resources in an unsustainable way, if they are to avoid extremely cold and starvation because alternative affordable resources are not available.
3. Another important reason why peasants do not take measures to ensure the sustainable use of energy resources is the **daily struggle for survival** and living from hand to mouth. The extremely difficult living conditions prevent the peasants from implementing anticipatory energy resource management. Due to this fact, long-term projects meant for the next generation are liable to fail.
4. Today, there is a **lack of practical knowledge** concerning  sustainable use of local resources. During the Soviet era, when it was mainly abstract academic knowledge that was fostered, traditional resource management disappeared which nowadays would be much in demand.
5. Additionally, due to the still lingering **'Soviet-mindset'** that believes in hierarchical structures, some people nowadays still wait for help and are rather passive in taking the initiative to ameliorate the energy situation.

Measures addressing the constraints on the top of the list bear the biggest potential for change of the present resource management towards a sustainable energy resource use.

## 15.3 Impact of Unsustainable Energy Resource Use on the Ecological and Socio-Economic Dimensions

This chapter aims to depict the consequences for the environment and for the people's livelihood resulting from continuous depletion of local energy sources, and also to provide an overview of the crucial factors exerting or relieving pressure on biomass fuels in the Tajik Pamirs. An understanding of the consequences and resultant problems is important when appraising the potential of different energy options to relieve pressure on local biomass fuels and mitigate the energy crisis.

### 15.3.1 Impact on the Environment

The unsustainable use of local firewood sources triggers degradation phenomena not only on forestlands, but also indirectly on *teresken* pastures, arable land and orchards (see Figure 3.3). The scarce riparian forests are quickly depleted due to the high demand for energy resources and the absence of appropriate forest management. The cleared forest areas are commonly turned into grazing lands, since pastures for livestock are limited. This change in use hinders the natural rehabilitation of forest vegetation and triggers soil degradation and erosion. Since the protective tree cover is missing, the riparian pastures are ruthlessly exposed to intensive solar radiation and high evaporation rates resulting in salinization of the soil. Moreover, these areas become very prone to erosion by floods. Once the succession of degradation on former forestlands has reached this irreversible extent, a natural rehabilitation of the vegetation is severely constrained. With the transformation of riparian forests into pastureland an important habitat for various plants and animals disappears in the Tajik Pamirs.

As a consequence of the depletion of forests the most

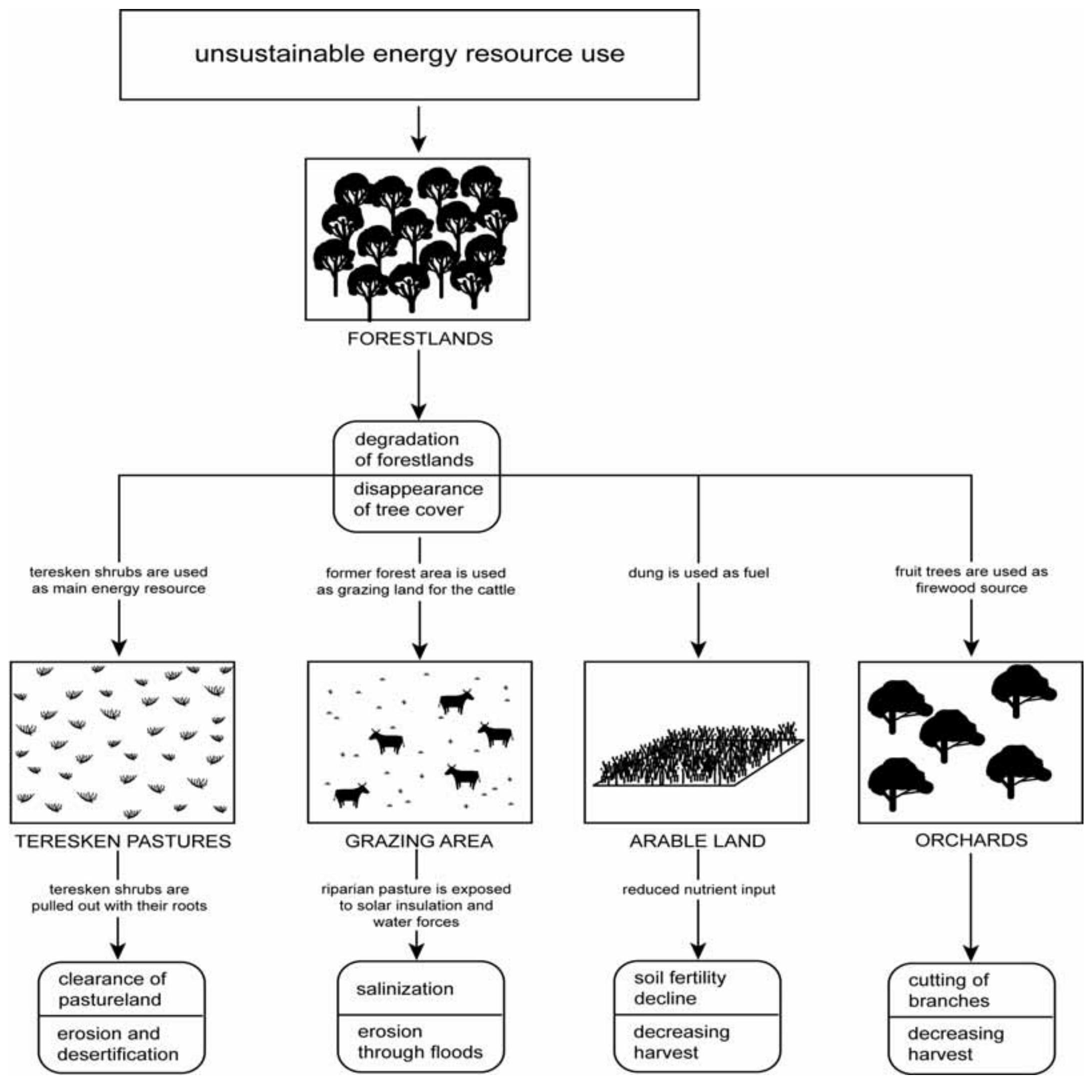



***Figure 3.3:*** *Impact of Unsustainable Energy Resource Use on the Environment. Not only forestland suffers due to increased pressure on firewood sources, but also teresken pastures as a result of their depletion, while grazing and arable land, and orchards are degraded. Concept: Droux & Hoeck*

important local energy resource vanishes. Since commercial fuels are hardly affordable, people switch to other locally available and free biomass fuels, such as dung, wood from fruit trees and shrubs. This results in the degradation of cultivated vegetation and soil, as well as in desertification of vast areas. The burning of dung constrains its application as fertilizer with the consequence of reduced nutrient input into the soil. Artificial fertilizer is often not affordable, so that in the long run the fertility of arable land decreases and with it the agricultural yield. Harvests from orchards provide an important vitamin-rich supplement to the people's daily diet predominated by bread and soup. By cutting branches from fruit trees as firewood to survive exceptionally hard and prolonged winters, the yield is considerably reduced or even completely lost. Large-scale harvesting of *teresken* shrubs leaves extensive areas without vegetation cover. Since biomass production is limited in this high mountain desert and the shrubs are pulled out of the soil with the roots, the natural potential for regeneration is drastically reduced. Vast areas thus become liable to wind erosion. This leads to a veritable hazard of desertification.

It can be concluded that the degradation of forestlands (or their non-existence) is a crucial factor in the sequence of degradation phenomena related to unsustainable energy resource use (see Figure 3.3). Due to the land user's specific resource use strategy, it indirectly triggers the degradation of arable land, orchards and *teresken* pastures, which in turn shows consequences on a socio-economic level.

### 15.3.2 Impact on Socio-Economy: The Vicious Circle of Unsustainable Energy Resource Use

The unsustainable use of local energy resources triggers not only severe consequences at the ecological but also

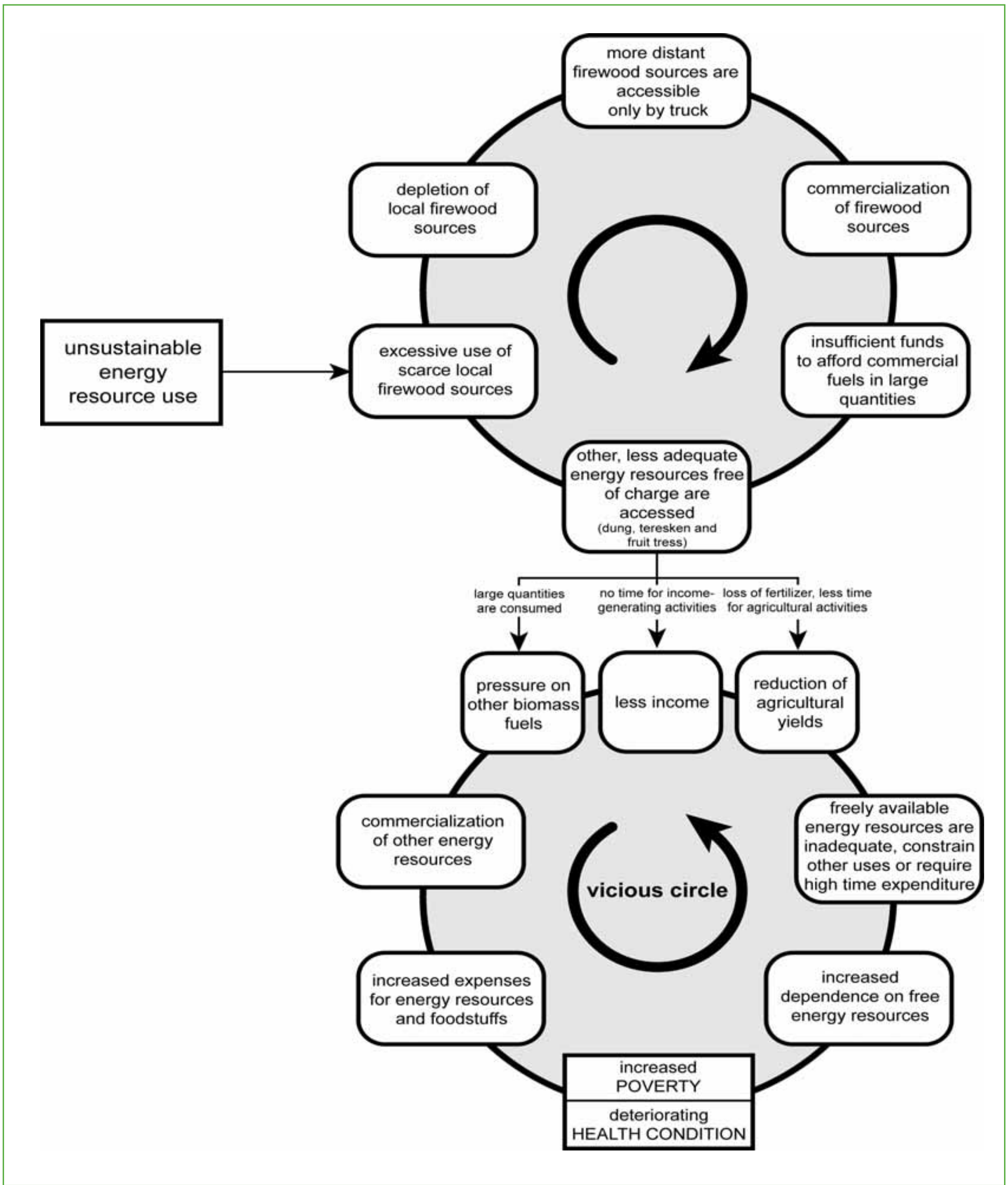



***Figure 3.4:*** *The Vicious Circle of Unsustainable Energy Resource Use. The consequences are increased poverty and deteriorating health condition of the population. Concept: Droux & Hoeck*

at the socio-economic level. The degradation of the environment caused by the overuse of local biomass fuels has disastrous effects on the people's livelihood. A sequence of energy source depletion, commercialization of biomass fuels and tapping of new energy sources, determined to fulfill other functions in the livelihood system, forces the people into a vicious circle of increased poverty and deteriorating health (see Figure 3.4). As shown in Chapter 13, firewood is the biomass fuel of choice. Considering present forest management, there are almost no hindering factors that limit continuous depletion of local firewood sources. Thus, before fruit trees are cut down or *teresken* shrubs are harvested, local forests will be cleared. Since firewood is then only available in more distant locations, which can only be accessed by trucks, it becomes a commercial fuel. Income or the availability of financial means are crucial factors when determining the choice of energy option. As the majority of the rural population is forced to a great extent to use non-commercial fuels due to their financial situation, other, less adequate biomass fuel sources, such as dung, *teresken* shrubs and fruit trees are accessed. Thus, a new demand suddenly exerts additional pressure on the scarce resources, which already have the function of providing fertilizer (dung), fodder for livestock (*teresken*) and foodstuff (fruits). In addition, the procurement of shrubs is ex-

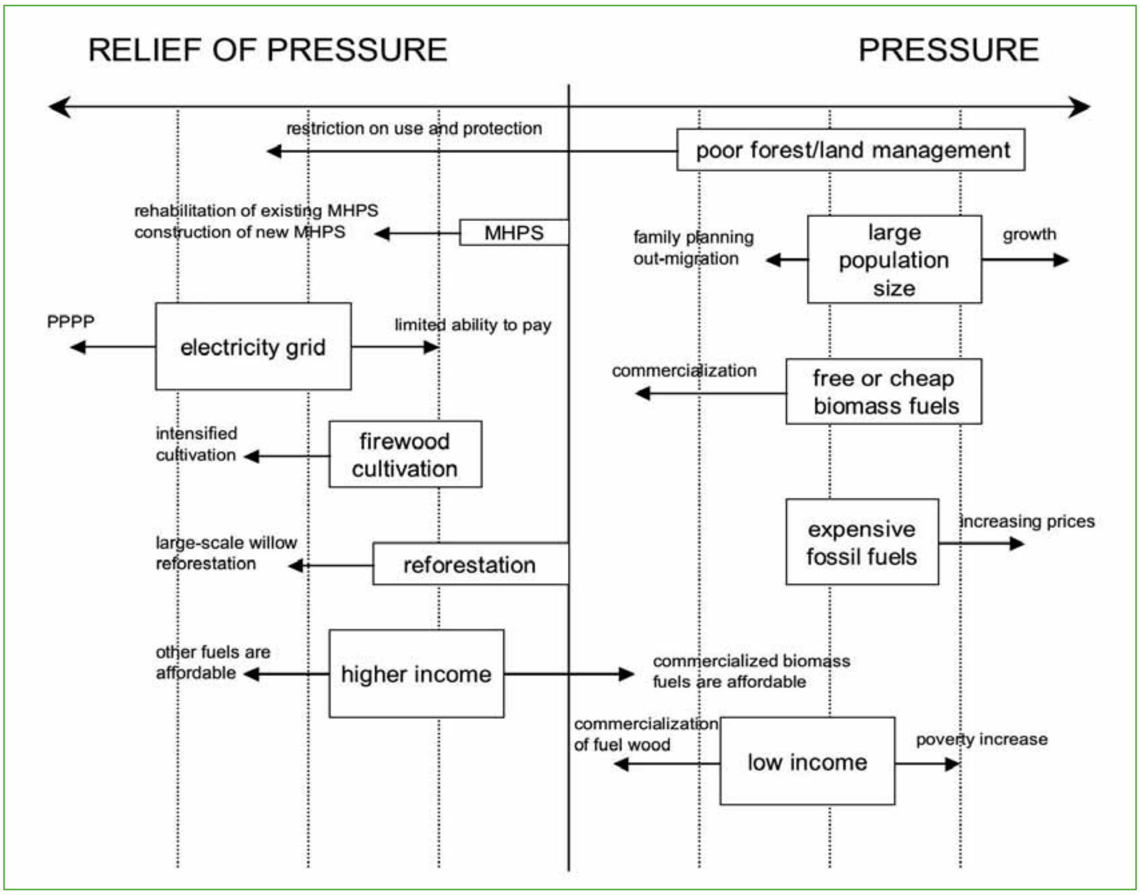



***Figure 3.5:*** *Socio-Economic Factors Exerting Pressure or Relief of Pressure on Biomass Fuels. The boxes represent the present situation for these aspects in GBAO on the pressure-relief-scale. The arrows indicate the dynamics of these factors influenced by possible changes at the socio-economic level. Concept: Droux & Hoeck*

tremely arduous and demands high, continuously increasing time expenditures. It also causes severe health problems, especially for women, and diminishes the time available for income-generating and agricultural activities. The vicious circle is thus perpetuated. The possibility of generating additional income and improving the people's financial situation to enable them purchase of commercial fuels is constrained by high labor input for energy resource acquisition. Additional financial expenses arise to ensure sufficient food supply, since agricultural yields can only be kept at the same level by introducing artificial fertilizer. Expenditures in terms of time and money for energy resources and foodstuffs exert additional pressure on the household budget. As a result, dependence on non-commercial biomass fuels increases and concurrently more and more time has to be spent on collecting the diminishing available energy resources. Once the fuel wood source is no longer accessible on foot within a reasonable amount of time, less adequate biomass fuels will also become a commercial fuel (as has already happened with *teresken* shrubs in the Eastern Pamirs). In the end, people will have no other choice than to spend steadily increasing financial means to satisfy their demand for energy.

Unsustainable energy resource use thus has a self-enforcing mechanism, leading on the one hand to commercialization of local biomass fuels and transfer of pressure to other energy resources that are still freely available. On the other hand, it causes a continuous increase in time and money invested in energy procurement and therefore contributes to increased poverty and to deterioration of the people's health.

### 15.3.3 Pressure and Relief on Local Biomass Fuels

The extent of the above-mentioned impacts on ecological and socio-economic levels is determined by various factors exerting pressure on local biomass fuels. It must be considered that the specific combination of a whole set of biophysical and socio-economic factors leads to pressure or relief of pressure on the local energy resource base. The biophysical features[4] of the region determine the framework for the use of local resources and thus also define extent of the vulnerability to degradation and the

[4] The following biophysical features determine the region's natural ability to cope with pressure on local biomass fuels: Climate (arid or humid), altitude (high mountains or lowlands), soil (barren or fertile), and water availability (poor or good).

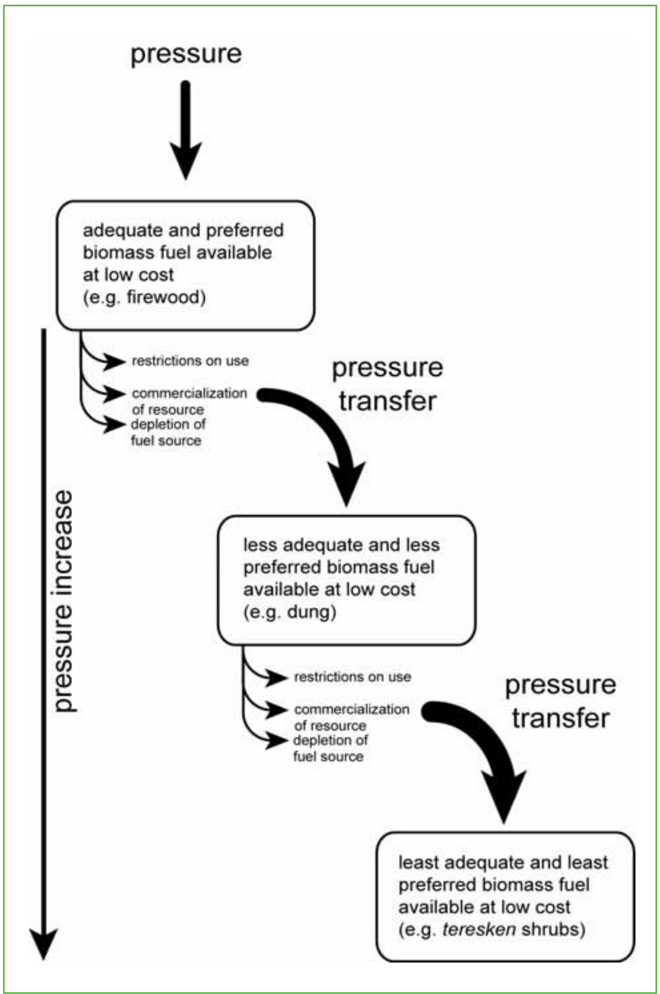



***Figure 3.6:*** *The Mechanism of Pressure Transfer from the Preferred to the Least Preferred Energy Resource. Since less adequate fuels demand larger quantities to satisfy the energy demand, pressure is not only transferred, but also intensified. Concept: Droux & Hoeck*

natural resilience of the resource base. It can be stated that in general the high mountains of the Tajik Pamirs present unfavorable biophysical conditions to cope with pressure on biomass energy resources. Therefore the pressure exerted on forestlands and *teresken* pastures to satisfy the energy demand in Gorno Badakhshan shows an intense impact.

In addition to these naturally given and rather static factors, there is the dynamic of the socio-economic setting, which exerts or relieves pressure on the local resource base. Figure 3.5 shows the most important socio-economic factors, their present position on the pressure-relief-scale as well as their possible dynamics in the Tajik Pamirs. Inappropriate forest management and lack of control mechanisms, the fact that most biomass fuels can be obtained at low cost, and the relatively large size of Gorno Badakhshan's population compared to the scarce resource base create high pressure on local firewood sources. Moreover, low income and expensive fossil fuels greatly reduce the possibility of using commercial energy resources. This leads to total dependence on non-commercial local biomass fuels. The availability of electricity is the most important contribution to relieving pressure on biomass fuels. The electric power provided by the grid enables people to substitute electricity for fuel wood to cover basic domestic needs except for room heating. Meanwhile, the present micro and mini hydro schemes make only a small contribution to mitigating pressure, since their capacity and performance is unsatisfactory. The reforestation projects completed in recent years will also not relieve pressure on riparian forests, because their exact function has barely been defined and most reforestation plots were planted with poplar trees, which is usually used as timber and not as fuel wood. Household-based firewood cultivation, on the contrary is a productive source which provides the people with their most preferred heating resource. A higher income or an improved financial situation enables the households to purchase adequate commercial fuels, which considerably reduce the demand for local fuel wood. All in all, it must be concluded that the intensity of pressure factors largely outweighs the extent of relief. However, as seen in Figure 3.5, the dynamic characteristics of these socio-economic aspects on the one hand also offer opportunities to reduce pressure or increase the extent of relief. On the other hand, there is the danger of ignoring that a relief factor may also lose its intensity, such as electricity, when offered at increased prices that do not take into account the population's limited ability to pay. It is important not only to focus on the support of the relief factors, but also to recognize the potential to reduce the intensity of pressure. There is another crucial mechanism that has to be considered when introducing restrictions on the use of fuel wood or when commercializing biomass fuels. For example, by establishing adequate and sustainable forest management, pressure on riparian forests can certainly be mitigated, but at the same time this pressure is transferred to other freely available biomass energy resources (see Figure 3.6). Restrictions on use, and the commercialization or depletion of the fuel source results in a shift of use towards the next-preferred, freely available energy resource, since the financial situation of the majority of the population does not allow them to completely cover their energy demand with commercial fuels. Thus pressure on forestlands is transferred to dung and fruit trees, and finally to *teresken* shrubs. This leads to the conclusion that in regions, where firewood sources are under increased pressure and prone to depletion, sooner or later domestic biomass resources (i.e. dung and orchards) as well as *teresken* pastures will feel the pressure of the people's demand for energy.

# 16. The Way Out of the Crisis

The challenge is not just to provide sufficient energy resources to the population of the Tajik Pamirs, but to find adequate locally renewable energy options, which on the one hand cover the energy demand at affordable prices, and on the other hand also address the driving forces of unsustainable energy resource use, the resulting impacts on ecological and socio-economic levels, and pressure and relief factors for the local biomass resource base.

Figure 3.7 shows possibilities of decreasing the demand and increasing the supply of energy in Gorno Badakhshan. As described in the Chapters 11 and 12 the use of inadequate energy resources, such as *teresken* shrubs, results in exorbitant consumption of local biomass fuels, especially for room heating. There is certainly the potential to decrease the demand by using resources more efficiently, by using more adequate resources and appliances, and by better insulating buildings. Moreover, control of population growth is certainly another effective measure to decrease overall demand for energy. On the other hand, there are local and external options to increase the supply of energy in Gorno Badakhshan: Besides large-scale reforestation and the use of hydropower, not to mention coal quarrying, the use of passive solar power, the use of solar and wind power, the diversified use of traditional water mills, and geothermic sources such as hot springs represent possible local energy options. Gorno Badakhshan will not be able to cover its energy demand by relying only on the local energy resource base. Therefore, the use of external options has to be intensified. The extension of the Nurek grid southwestwards, the importation of coal from a newly opened mine across the border in Kyrgyzstan, or the new trading route with China over the Kulma-Pass in the Eastern Pamirs represent possibilities of increasing the supply of electricity and heating resources.

The energy options in the dark grey boxes (see Figure 3.7) are discussed below with regard to their potential to mitigate the energy crisis and relieve pressure on local biomass fuels. Two options focus on the cultivation of firewood, the most preferred biomass energy resource in the Tajik Pamirs. Large-scale reforestation and firewood tree cultivation at the household level have a major potential of mitigating degradation resulting from unsustainable energy resource use. Moreover, they offer an

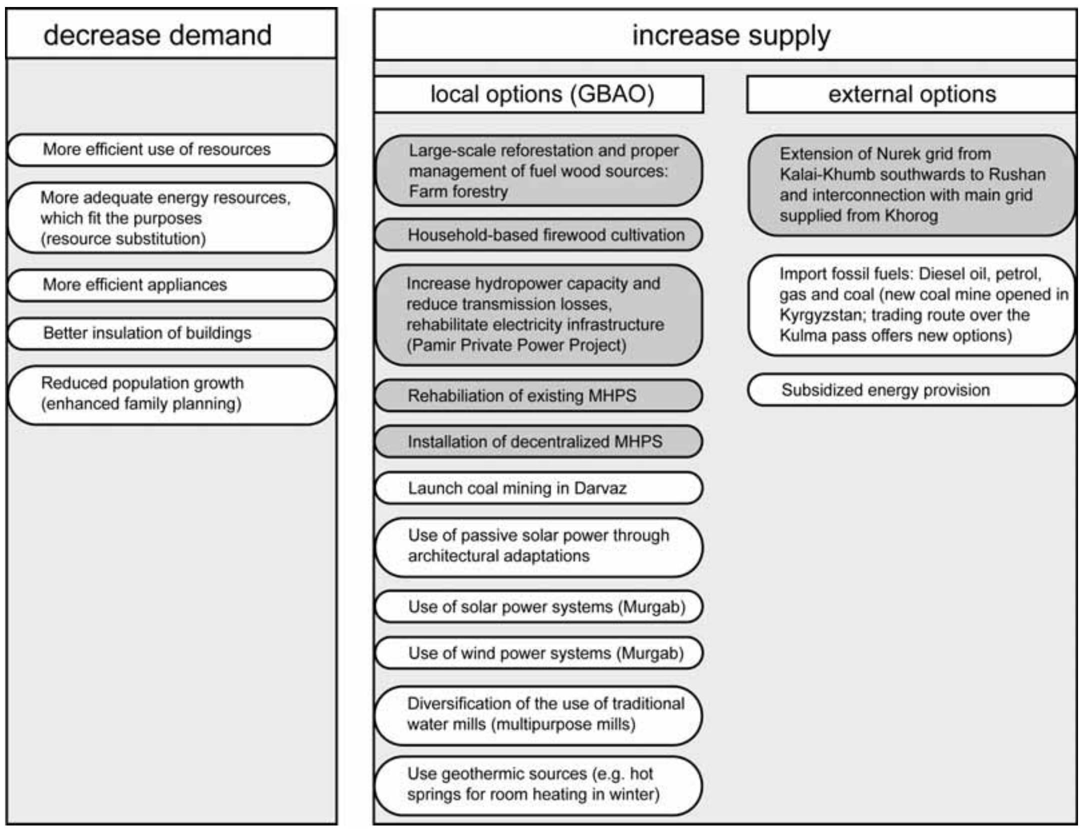



***Figure 3.7:*** *Options to Decrease Demand and Increase Supply of Energy in the Tajik Pamirs. The energy options in the dark grey boxes are assessed concerning their potential to mitigate the energy crisis and land degradation. Source: Field study 2003*

adequate and affordable energy resource to the population. Since the depletion of firewood sources and the ensuing pressure transfer to other biomass fuels trigger degradation phenomena in orchards, arable land and *teresken* areas, the restoration of the firewood source may initiate mitigation of these forms of degradation as well. Furthermore, the overuse of forestland and the resulting commercialization of this widespread heating resource lead people into a vicious circle of poverty and health deterioration. By offering the possibility of local firewood cultivation, this vicious circle could be broken. The other four energy options concentrate on the use of hydropower and its potential to substitute electricity for fuel wood. Electricity is a locally renewable, polyvalent applicable and efficient resource to cover basic domestic energy needs. The substitution of electric power for biomass fuels considerably decreases overall energy consumption and thus the need for additional energy resources. Hydropower thus offers a major potential to relieve pressure on overused fuel wood source.

## 16.1 Cultivating Firewood: One Auspicious Option

Firewood and *teresken* are by far the most commonly used domestic fuels in the rural regions in Gorno Badakhshan. Virtually every family relies on fuel wood[5], which is mainly burned in large quantities in homes and only a fraction of the overall consumption is used as timber. Thus, the disappearance of forestlands is a logical consequence. Deforestation is a main reason for other forms of degradation and can additionally promote the overuse of further resources such as *teresken* and fruit trees (see Chapter 9.1). Firewood is a local renewable energy resource which can be used in different ways (firewood, cattle fodder, timber). Moreover, well-managed firewood cultivation has the potential of generating additional income, thereby stimulating the local economy. As for its impact on climate change, fuel wood is considered as carbon dioxide neutral and does not contribute to an additional greenhouse effect. Taking all this and considerations listed below into account, it makes sense to foster a strategy towards sustainable energy resource use based on local firewood cultivation. Basically, there are two practical options for firewood cultivation which can also be combined:

1. Large-scale reforestation and community-based farm forestry
2. Household-based firewood cultivation

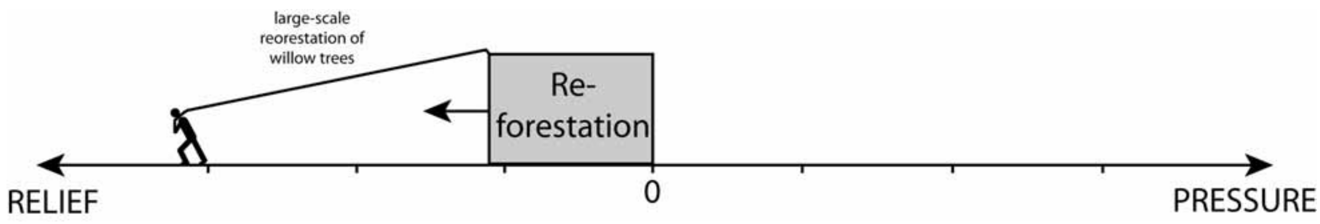
It is clear that these cannot be the only measures to solve the energy problem in the Pamirs. They must be accompanied by other measures which decrease the overall energy consumption by increasing efficiency and allowing better management of the existing resources. Additionally, the suggested area of reforestation assumes electricity supply, at least during summer time. This implies that, besides firewood cultivation, electrification has to be developed as well.

### *Large-Scale Reforestation and Community-Based Farm Forestry*

Granted that fuel wood demands, at least for room heating during winter, should be met by locally cultivated firewood, large areas have to be reforested all over Gorno Badakhshan. One auspicious method is to establish community based farm forestry. The establishment, the maintenance and the management should be accomplished at the community level. It is important that this wood will be sustainable and mainly farmed as fuel and not as timber. The following preconditions have to be fulfilled:

- Sufficient potential reforestation or existing forest area with adequate water supply. Between 0.359-0.053ha per household per year, depending on the species and the availability of other resources.
- Accurate instructions are provided to the VO and the responsible persons regarding sustainable management (community-based, integrated into VO) and proper monitoring of existing and reforested areas.
- Women play a major role in the planning, in the management and in the controlling body (female responsibility).
- Firewood from the farm forestry is not free of charge, but still affordable by the poorest households (fees can be also reimbursed by barter or labor).
- The generated income has to be reinvested for management, protection, reforestation, enlargement of the reforestation plots, credits and other community-based projects.
- Forest areas are adequately irrigated.
- Adequate protection measures of forest areas against browsing damage and illegal cutting have to be established (stone walls, fences, seedlings wrapped in thorn bushes).
- Wood is used as a firewood source to cover local domestic energy needs.
- Preferred characteristics of a firewood tree: Fast growth and high reproduction rate by high and constant sprouting ability; high resistance to diseases, drought, low temperatures, and competing weeds; deep root system, low water competition; foliage with high potential as fodder; nitrogen fixer and slope-stabilizer (Ahmed & Hussein 1994: 2).
- Highly apt trees for reforestation and firewood cultivation in the Tajik Pamirs: Russian olive (*Elaeagnus an-*

[5] Except for urban households in Khorog.




gustifolia) willow species (*Salix tetrasperma*, *Salix alba*), poplar (*Populus nigra*) no monoculture.

If these preconditions are fulfilled there is a large potential for mitigating the energy crisis. The following contributions can be made:

- The required output of the reforestation area covers at least the winter firewood requirements in a sustainable way.
- The degree of contribution to a more sustainable energy resource management depends on the available area for farm forestry and the management activities.
- Degradation of forestlands can be stopped and woods can be reestablished.
- Forest management and firewood cultivation generate additional income on a village level.
- In combination with other measures farm forestry bears a big potential to mitigate the energy crisis and land degradation, but only ten years from now.
- The role of women can be strengthened and the collecting time can be considerably reduced.
- The rehabilitated forestlands will provide habitats for vanished species.

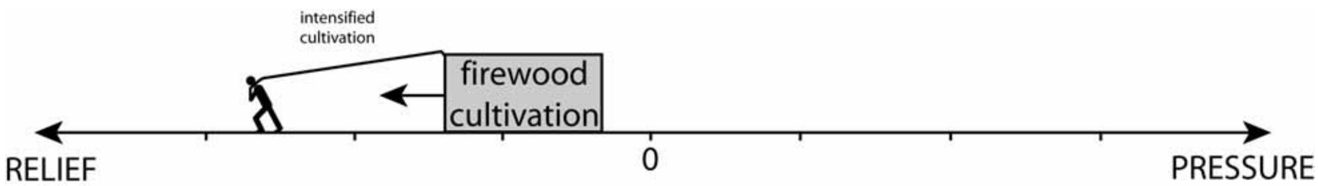
There is one substantial disadvantage: the first firewood can only be harvested in ten years at the earliest. Thus, besides reforestation, it is essential that bridgeover measures are taken.

***Household-Based Firewood Cultivation***

Another already widespread traditional method to cover a part of firewood needs is to cultivate trees as a firewood source located within the settlement area. Each household is responsible for their own firewood source (see Chapter 10.15).

Since pollarding is part of the traditionally practiced family-based firewood cultivation, it seems to be the most appropriate method in this field. It is an effective method of obtaining a sustained yield of small diameter wood over a long period of time. It encourages lateral branches by cutting the crown of the tree about two meters above the ground level. If pollarding is done repeatedly every three to four year, a somewhat expanded (or swollen) tree trunk will result, and multiple new side and top shoots will grow on it. One advantage of pollarding compared to coppicing[6] is that this type of practice can be applied in this manner in wood-pasture and grazing areas, since the trees always have a certain height so that the cattle cannot reach the branches. Consequently, such areas can fulfill multipurpose tasks (Eckholm et al. 1984: 52; Ahmed & Hussain 1994: 54). Another advantage is that the threat of the bird population pecking the crop seeds from the field can be controlled by pollarding the trees. Furthermore, the shadows of the trees narrowing the crop yield can be minimized by cutting the crown of the tree the following preconditions have to be met for a good functioning household-based firewood cultivation:

- Sufficient single tree cultivation of willow species (*Salix tetrasperma, Salix alba*) and Russian olive (*Elaeagnus angustifolia*) within the settlement area, around the houses, alongside brooks and water channels, wherever irrigation is possible.
- Being aware of conflict with crop cultivation. Trees may shadow the plots.
- Every household manages its own firewood trees.
- Trees are cultivated and cut every three to four years.
- Applying pollarding method (already practiced, well accepted).
- To cultivate various species of firewood trees.




[6] Coppicing is a traditional woodland management method, by which the young tree stems are cut down to its stump and allowing it to regrow. Normally a number of shoots replace the original single stem. But they are prone to be damaged by browsing cattle so that they never get full-grown again.

If these terms are complied with, the potential for mitigating the energy crisis is considerably high and contribute to the following issues:

- It is a reasonable measure to ensure a next-door firewood source.
- It reduces the time spent on firewood procurement and relieves the work burden since the source is right around the houses so that especially women will benefit from this resource cultivation.
- Areas cultivated with trees can be used for other purposes as well, such as fodder production or grazing areas.
- Impact on the energy supply is dependent on number of trees per household.
- To ensure full supply to cover room heating demand in winter, 30 trees/hh/year over a period of ten years are necessary.
- Realistic: Around ten trees/hh/year over a period of ten years, which make it possible to cover a third of the room heating demand in winter.

The combination of large-scale reforestation, community-based farm forestry and household-based firewood cultivation has a major potential to rehabilitate forest areas and relieve pressure on firewood sources and vegetation. Furthermore, it may revitalize biodiversity. These options constitute realistic and feasible measure with low financial investment for their completion and will return the most preferred biomass fuel to the people.

## 16.2 The Contribution of Hydropower

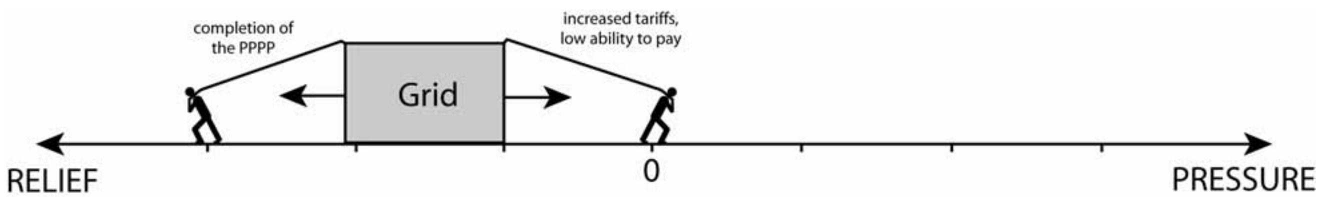
The availability of electricity, even if supply is only sufficient for lighting purposes, considerably improves the living conditions of the population. It allows additional activities in the evenings, the substitution for diesel oil used for lighting and therefore financial savings for the households. The extent to which electricity can contribute to relieving pressure on overused local biomass fuels and thus mitigate land degradation is mainly dependent on the available power capacity and the people's ability to pay for consumption. Three local hydropower options and one external option (see Figure 3.7) are discussed with regard to this aspect.

### 16.2.1 Improvement of Grid Supply in GBAO

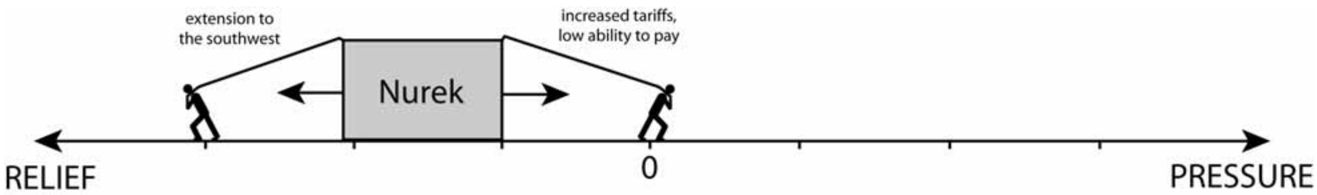
The Pamir Private Power Project (PPPP)[7] envisages the rehabilitation of the infrastructure and an increase in hydropower capacity enabling regular and steady power supply from the main grid in Gorno Badakhshan (see Chapter 8.1.3). Considering that the PPPP fulfills the anticipated improvements contemplated in the Concession Agreement of PEC (PEC 2003; see Appendix 2), it has the potential of becoming one of the major contributors to relieving pressure on local biomass fuels. Its contributions can be summarized as follows:

- It will provide regular supply with improved capacity to all customers connected to the GBAO grid.
- The city district of Khorog will enjoy steady and sufficient regular electricity supply.
- Villages connected to the grid will benefit according to their distance to the hydropower plants Pamir 1 and Khorog. In general it can be assumed that supply will be sufficient to cover all domestic needs except for room heating in winter.
- It will definitely mitigate pressure on local forestlands and allow substitution of electricity for firewood to a great extent.
- Improved electricity supply from the grid combined with firewood cultivation will make it possible to satisfy the domestic energy demand and realize a sustainable resource use.

The crucial factor constraining the impact of the PPPP is the people's limited ability to pay. In 2010 subsidies in the form of the lifeline tariff block will cease, and tariffs for electric power will have quadrupled. An assumed monthly consumption of 315kWh will cost around USD 9.5 by 2010, an amount that is not affordable for the majority of the rural population. In addition, the relatively expensive installation of adequate electricity meters allowing calculation of fees on a kWh-basis has to be borne by the customers. A realistically affordable monthly fee for rural areas at the current stage is estimated at 10 *somoni* (USD 3), which would allow a monthly consumption of 100kWh




[7] The PPPP includes the rehabilitation of electricity infrastructures, the construction of a water flow regulation structure at the Lake Yashilkul, the increase of hydropower capacity at the Pamir 1 power plant, and the establishment of the Pamir Energy Company.




per household, an amount insufficient to cover the basic domestic energy demands. It is therefore obvious that people will turn again to firewood and *teresken* shrubs to cover their demand for energy.

### 16.2.2 Extension of Nurek Grid and Interconnection with GBAO Grid

Since the Nurek storage scheme on the Wakhsh River still has spare capacity in summer, an extension of transmission lines further into GBAO territory and its interconnection with the main grid would allow a better electricity supply at least during summertime. A 35kV transmission line already exists down to Kalai-Khumb and a 10kV line runs further to the entrance of the Vanj Valley. The extension of the Nurek grid would provide the following improvements:

- In addition to Darvaz and the entrance of the Vanj Valley, the entire Vanj and Yazgulom valleys and villages on the Pandzh River could be supplied with electricity.
- Since power generation of the Nurek HPP is limited in winter, it can be assumed that there will be no or only inadequate power supply during winter months from the Nurek grid for GBAO. With the interconnection of the GBAO and the Nurek grid, these regions could also profit from winter supply from the main grid.
- This measure will allow at least adequate supply during summer and thus the substitution of electricity for fuel wood.

Adequate electricity supply in summer is a precondition for allowing a sustainable use of local biomass fuels in the Tajik Pamirs. Thus, about a third of overall fuel wood consumption could be saved. Since electric power from the Nurek grid is distributed by the PEC within GBAO territory, the crucial factors are, once again, electricity tariffs and the people's ability to pay, which determine the actual impact of this energy option.

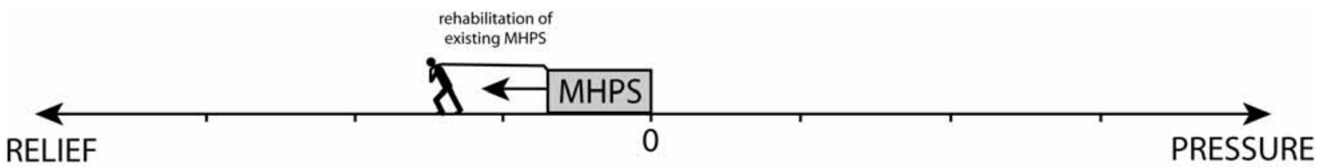
### 16.2.3 Rehabilitation of Existing MHPS

The great number of existing MHPS in Gorno Badakhshan calls for more efficient use of this hydropower source. Since the majority of these hydro schemes provide only unsatisfactory supply, the MHPS only make a limited contribution to relieving pressure on local biomass fuels (see Chapter 8.2). There is the potential to change this with the rehabilitation of the micro and mini hydropower stations. Considering that following preconditions[8] are fulfilled, …

- Costs for the rehabilitation are borne by donors.
- Contributions from the villagers to the rehabilitation project come in the form of cash, livestock, agricultural products and labor.
- Adequate equipment is installed (see Chapter 8.2).
- Rehabilitation will allow generating full output capacity.
- Proper management and maintenance structures are introduced (see Chapter 8.2).
- Women are integrated into the project and the management of the hydro scheme.
- Tariffs are set so that 315kWh cost around 5-7 *somoni* (USD 1.6-2.2), an amount affordable to almost every household.
- A competence center for hydropower is established, serving as an external support institution for decentralized MHPS.
- Additional sources of income for the MHPS (cattle etc.) are introduced to guarantee sufficient net return.
- Electricity distribution schedules are introduced to increase available power capacity per household, and allow use of all electric appliances.

… the hydro schemes in the Tajik Pamirs will provide the following contributions:

- Even operating at full capacity the majority of the existing MHPS will not be able to provide the required power capacity of 1500W per household.
- With a sophisticated electricity distribution schedule,




8 Further recommendations concerning the implementation of MHPS are mentioned in Chapter 8.2.10.

the available capacity can be increased so that it will be possible to cover to a great extent the demand for cooking, heating water, lighting and baking at least in summer.

- A complete substitution of electricity for biomass fuels will not be possible, neither in summer, nor in winter.
- The rehabilitated MHPS will make only a minor contribution to relieving pressure on firewood sources, and to mitigating women's drudgery of fuel wood procurement.

The impact of micro and mini hydro schemes on the local resource base is dependent on the available power capacity provided to each household. Despite their rather slight contribution at ecological level, the MHPS bring considerable improvements at a socio-economic level: They provide affordable electric power, allow financial savings by replacing diesel oil used for lighting, create employment possibilities, and might encourage the local population to initiate further community-based projects.

### 16.2.4 Installation of New MHPS

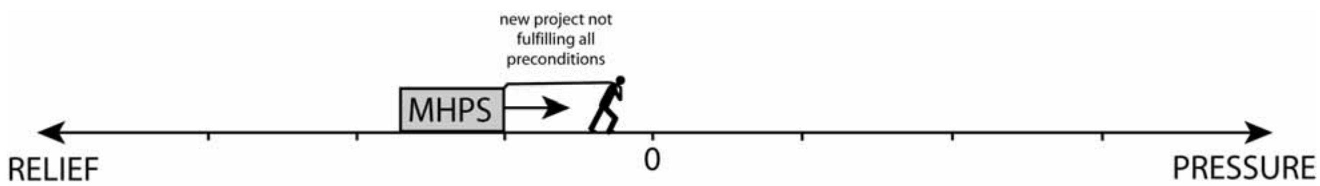
Since decentralized hydropower schemes constitute an adequate energy option for the Tajik Pamirs (see Chapter 8.2) and a large number of people are still lacking adequate electricity supply (see Chapter 8.1.4), the construction of new, properly-designed micro and mini hydropower plants is definitely an option to improve the energy situation in remote areas. Considering that the following preconditions can be fulfilled, the MHPS will have considerable positive impacts on the socio-economic and ecological levels.

- The output capacity of 1500W per customer can be provided.
- Minimum run-off in winter and a possible water user conflict with irrigation has to be addressed.
- The operational period of the MHPS should allow the monthly consumption of 315kWh per household.
- Electricity is affordable to all customers: Costs for 315kWh should not exceed 7 *somoni* (USD 2.2) at the moment.
- Introduction of adequate electricity generation and a distribution schedule.
- Installation of new and adequate hydropower equipment.
- Installation costs are borne by donors.
- Beneficiaries make contributions to the project in the form of cash, livestock, agricultural products and labor.
- Participation of the villagers, and especially of women, during the whole project and later in the management of the MHPS is guaranteed.
- Adequate management and maintenance structures are introduced and the staff is well trained.
- Additional source of income for the MHPS (cattle etc.) is introduced to guarantee sufficient net return.
- MHPS with capacities below 300kW are managed at the community level.
- Women, the main energy resource procurer and user, are integrated into the operation and management of the MHPS.
- An external support institution is established, assisting the MHPS in case of breakdowns and repairs.

New MHPS projects have a major potential to improve the living standard of the rural population and relieve pressure on local fuel wood sources. They could make the following contributions:

- The MHPS will provide sufficient power to cover energy demands in summer and winter, except for room heating.
- This allows the substitution of electricity for local biomass fuels.
- Substitution of electricity for fuel wood in summer leads to resource savings of 30%. In addition, further firewood savings can be made in winter.
- Electricity is affordable to all customers.
- The MHPS offers employment possibilities for two or more workers.
- The MHPS generates additional income for the VO. This money can used to initiate further community-based projects or can be used as credit for private projects.

It is apparent that it will be difficult to fulfill all of the above-mentioned preconditions. In many regions, for example, water is scarce and its availability varies greatly over the year, so that it is impossible to satisfactorily supply the local population with electric power. However, decentralized hydropower can be viewed as the most appropriate energy option for remote areas in the Tajik Pamirs.



# 17. Conclusion and Recommendations

## 17.1 Conclusion

The vast majority of the rural population in the Tajik Pamirs considers the shortage of energy supply as a major problem straining their livelihood. The severe, and in some regions even alarming, energy situation increasingly shows impacts with deteriorating consequences for the people's livelihood and the environment. It is time that the energy crisis in GBAO is also recognized by the decision-making authorities as a very urgent issue. The present energy situation not only hinders the further development of the Tajik Pamirs; it also continuously deteriorates its natural resource base and the living standard of the majority of its population. Thus, there is an urgent need for immediate action to mitigate the present energy crisis and its consequences, as well as for long-term measures to ensure sufficient, affordable and sustainable energy supply to rural and urban dwellers. Since the people's limited ability to pay for imported and commercial fuels is one of the major constraints on sustainable energy resource use, local and renewable energy options have to be fostered and the local population has to be placed at their disposal for management and production. Hydropower and firewood cultivation are two energy options which have a major potential to mitigate the energy crisis over a longer period. Both of these energy resources have favorable characteristics: They are locally available, renewable energy resources, they are relatively cheap compared to imported fossil fuels, they can be applied as decentralized energy options, they can be managed at community-level allowing an appropriate supply at affordable prices, and both are the preferred presently available energy resources in Gorno Badakhshan. It can be stated that, without adequate electricity supply, it will be difficult to provide sufficient and affordable energy resources, and to guarantee sustainable use of local fuel wood sources. Therefore, electricity plays an important role for mitigation of the energy crisis in GBAO. However, present and rehabilitated power infrastructures will not be able to fully cover the domestic energy demand. It is therefore important to focus also on local energy options, which allow meeting the high demand for room heating in winter. Household-based firewood cultivation and community-based farm forestry can provide, in combination with electricity, the groundwork for a satisfactory energy supply and a sustainable use of local biomass fuels in rural areas. Moreover, fostering local energy resources may also have the potential of enhancing local economic development. Sufficient and sustainable energy supply cannot be achieved immediately. Measures to foster local energy options will have an impact five to ten years from now at the earliest. Therefore immediate first-aid measures have to be introduced to bridge over this period with subsidized external provisions to relieve people of their daily drudgery of fuel wood collection and enable the severely degraded resource base to rehabilitate.

## 17.2 Stakeholder-Specific Recommendations

The following list of recommendations is a concretized result of the synthesis and conclusion. They are addressed to different actors playing an important role in terms of energy resource management in Gorno Badakhshan and should serve as a guideline for implementation towards a sustainable energy resource use. The recommendations focus on pragmatic measures that are feasible and have a considerable potential to mitigate the energy crisis and its linked problems in GBAO. The success of the proposed measures depends substantially on how they are accepted by the peasants. Hence, only with a participative implementing approach and the intrinsic incentive on the part of the peasants will these recommendations succeed. For more detailed recommendations in terms of mini hydropower schemes and energy resource use in the case-study villages. the reader is referred to Chapter 8.2.10, 10.16, 11.15 and 12.12.

***For the Villagers and the Village Organizations***

- The VO should take the initiative in focusing on farm forestry activities. Money is not the crucial factor in replanting trees.
- To create conditions regarding the plantation of firewood trees in the village. Households should be required by the VO to plant and cultivate a certain number of firewood trees every year.
- In order to bridge over the energy deficit poplar trees can also be used as firewood. Due to the decrease in population growth construction material will be less used in the future.
- To optimize the existing appliances (handmade improved coil cooker, stove) in terms of energy efficiency.
- To unplug unused appliances.
- If the village is provided with a MHPS generating at low capacity, the VO should introduce an electricity distribution schedule, regulations and restrictions regarding electricity consumption and a community centralized bakery.
- To insure further maintenance of the MHPS and establish income sources for the MHPS, other than

just fees (fruit trees, vegetable gardens, arable land, cattle).

- In cases of water use conflicts between irrigation and MHPS, to introduce stricter irrigation schedules so that the MHPS can also run in summertime. Electricity supply during summertime is a precondition to relieve pressure on other energy resources.
- To team up with other villages in the valley to exchange knowledge for repairing and maintenance work, how to manage the MHPS financially, how to increase capacity, what kind of schedule to use, etc.
- To increase the number of donkeys in the villages where women have to carry fuel wood.
- To change the division of labor for collecting *teresken*: This should not be women's work!

***For the Non-Governmental Organizations Working in the Field of Energy: AKF, MSDSP, Focus, Interassist, Milal Inter etc.***

- To implement and support reforestation activities within and around the village territory (on riparian areas, around the houses, alongside water channels, as boundary of arable land).
- To rehabilitate the existing MHPS.
- To install adequate equipment at the MHPS (turbine and generator that fit each other and also match the runoff in summer and winter).
- To insure further maintenance of the MHPS and establish income sources for the MHPS, in addition to fees (fruit trees, vegetable gardens, arable land, cattle) that can provide the MHPS with additional income (as in Vezdara).
- To establish new, well-designed (at least 1500W per household) and sustainably managed MHPS (investment for the installation has to be donated from outside), in which the peasants and especially the women participate in the planning, management and maintenance.
- To deliver fossil fuels as humanitarian aid in order to tide over the energy deficit, dependent on reforestation conditions.
- To establish a center of competence and a workshop for repairs and production of mini hydropower equipment (in cooperation with the PEC and academic institutions).
- To establish small enterprises manufacturing more efficient appliances (LED-lamps, improved coil cooker, stoves with improved water and room heating system).

***For Energy Provider: PEC, Barki Tojik***

- To conform to the requirements written in the concession agreement concerning rehabilitation of the HPS.
- To rehabilitate remote MHPS (not determined in the concession agreement).
- To install adequate equipment (turbine and generator that fit each other and also match the runoff in summer and winter), as well in decentralized MHPS.
- To also supply the rural regions (not only Khorog) with electricity during winter.
- If the PEC is unable to supply the villages in wintertime with electricity, they should a least be cooperative concerning the use of MHPS (no fees for using transmission lines during wintertime).
- To provide more incentives to reduce electricity consumption.
- The fees should not be calculated in USD (due to the exchange rate the fees will continuously increase, which is not bearable for the villagers).
- To calculate the fees according to the meter (at least in Khorog), so that the households have an incentive to use electricity more economically.
- To establish a fast repair service car in order to repair breakdowns on the spot (equipped with engineer, mechanic, welding tools, etc.).
- To rethink the tariff setting: With the anticipated tariff increase the majority of the peasants will not be able to pay bills in the future.
- Establish a mechanism of cross-subsiding to reduce the prices for electricity in rural regions.
- In the authors' opinion, the PEC could play a major role in the further development and maintenance of small HPP in GBAO.
- Maybe the PEC could be a meeting point for knowledge transfer and maintenance work for the MHPS (for a fee).

***For Educational Institutions: State University of Khorog (Department of Hydropower), UCA, Schools***

- To foster awareness in the field of ecological issues in terms of sustainable energy resource use.
- To establish practical and pragmatic study courses (school of forestry, self-sufficient agronomy).
- To benefit from synergy with local experts, traditional knowledge and other institutions.

***For Governmental Institutions: Leskhoz, Land Use Committee, Oblast Energy Department etc.***

- To lease former or still existing forestlands to the VO or to the households, while being bound to regulations of sustainable forestry management so that VO can establish farm forestry (see Chapter 16.1.1).
- To establish and intensify reforestation areas being designed as firewood sources which are well irrigated and protected against browsing damages.
- To manage the remaining forests in a sustainable way.
- To subsidize coal and diesel oil for remote villages without electricity which are bound to reforestation conditions.
- To establish a center of competence for mini hydropower (in cooperation with PEC and academic institutions).

## 17.3 Indicators for Rural Energy Appraisal

It is important to monitor the further development of the energy situation in the Tajik Pamirs and evaluate success or failure of measures implemented for its amelioration. There is thus a need for practical indicators, suitable for easy and quick field assessment, and allowing a fast appraisal of the energy situation and local energy resource use in rural areas. A practical way to assess sustainable resource use is to look for symptoms or indicators of unsustainability (see Chapter 4.3). The authors therefore compiled a list of visible indicators of unsustainable local energy resource use (see Table 3.1).

There are also several non-visible indicators, which can be identified in a rudimentary interview with the local population:

**Increasing collecting time for fuel wood;** because the

***Table 3.1:*** *Visible Indicators of Unsustainable Energy Resource Use in the Tajik Pamirs.*

| | |
|---|---|
| **1. Roofs of the Pamiri houses are covered with thick *teresken* layers:** This indicates that *teresken* is the main energy resource. This means that other energy options are not available or not affordable, since *teresken* shrubs are the least preferred energy resource. |  |
| **2. Signs of cutting on fruit trees:** This indicates that people were not able to allocate sufficient energy resources during summertime to survive hard and prolonged winters. Fruit trees provide an important and vitamin-rich contribution to the people's daily diet predominated by bread and soup. The cutting of fruit trees results in reduction or elimination of the fruit harvest. |  |
| **3. Thinning of forest cover:** This indicates that the firewood source is under severe pressure. Not only branches are collected, but entire trees are also felled. This is the first step towards a complete clearance of the forest area. |  |
| **4. Complete clearance of forestland:** This indicates that the firewood source has already been depleted, and that other locally available energy sources have to be accessed to satisfy the energy demand of the population. The cleared riparian forest areas are commonly used as grazing land for the livestock. |  |
| **5. Clearance of the surroundings (*teresken* pastures) of the village:** This indicates that people have already used *teresken* as their main energy resource for several years and have to walk to more distant areas to harvest these shrubs. *Teresken* are pulled out of the soil with their roots, so that it is easy to distinguished between browsing damage and energy resource collection in these areas. |  |
| **6. *Teresken* sliding tracks:** This indicates that people are intensively collecting *teresken* shrubs and thus using it as their main energy resource. Since these shrubs grow under arid conditions resulting in low biomass production, it is impossible to use *teresken* as the main energy resource in a sustainable way. |  |
| **7. Use of cushion plants (*tezkan*):** This indicates that people walk very far and climb to high altitudes to procure energy resources. The cushion plants have a better heating ability than the shrubby *teresken*, but demand more time and strength to be harvested. |  |

*Source: Field study 2003 (Photos: R. Droux & T. Hoeck, June 2003)*

surroundings of the village have already been cleared.
**Use of edible oil as a lighting resource;** because electricity is not available and diesel oil is not sufficiently affordable.
**Use of wood from the stable or house as fuel for heating in winter;** because the allocated energy resources are not sufficient to cover the demand for heating during hard and prolonged winters.
**Two or even more families share one room or household to survive wintertime;** because one family is not able to allocate sufficient energy resources for room heating in wintertime.

All these indicators not only provide the evidence for unsustainable energy resource use, but also can help to monitor and assess the impact of measures taken to improve the energy situation in Gorno Badakhshan.

## 17.4 Recommendations for Further Research

For the improvement of the energy situation, the fostering of local renewable energy options and for a more efficient energy resource use in GBAO, the authors propose to launch further investigations in the following fields:
**Firewood cultivation at household level (pollarding of trees):** What are best practices and appropriate management (local knowledge)? What is the annual wood production of firewood trees? What is their contribution to cover the household's energy demands? Which species are most adequate for firewood cultivation?
**Community-based farm forestry:** What are best practices for management (protection, sustainable resource use, irrigation, pricing)? What is the annual exploitable wood production from the forest? What is a suitable composition of tree species for the forest (no monoculture)?
**Large-scale reforestation projects:** What are the best practices for implementation and management of reforested plots? What is a suitable composition of tree species for the forest (no monoculture)? What functions do reforested areas fulfill (firewood source, timber source, protection against natural hazards)?
**Sustainable forest management:** What are best the management practices? Who should have what responsibilities? Who is preferably the owner of the forestland (*leskhoz*, private, VO)? Who is preferably managing the forest (*leskhoz*, private, VO)?
**Detailed inventory of existing forestland:** What is the total forest area in GBAO (dense forests, bushy forests)? What is the present state of forestland in GBAO (highly degraded, still in good condition)?
**Traditional knowledge concerning local energy resource use and management:** What are traditional management strategies? Do they offer opportunities to improve present resource management?
**Implementation of further MHPS:** Where are potential sites with adequate hydrological characteristics for additional decentralized hydropower plants?
**More efficient resource use and decrease of energy demand:** What are alternative options for room heating (water from hot springs, water heating)? How are more efficient appliances designed?
**Diversification of the use of traditional water mills:** What other purposes could water mills fulfill (activities which need mechanical power, e.g. production of fuel-briquettes)? Is there the possibility of transforming water mills into a hybrid machine, for generating mechanical and electric power?
**Fuel-briquette production:** Are there possibilities for fuel-briquette production in rural areas? What resources are suitable for the composition of fuel-briquettes (biomass wastes, shrubs, dung)? What is the optimum composition of fuel-briquettes? Is the construction of hand-operated fuel-briquette machines locally feasible?

It is important not to focus solely on further research in the field of rural energy supply, but to initiate immediate measures and relief programs. One possibility could be a combination of project implementation with scientific surveillance and monitoring.

# References


ADB [Asian Development Bank] (ed.) (2002) Technical Assistance to the Republic of Tajikistan for the Hydropower Development Strategy.

Ahmed, Javed and Hussain, Raja Walayat (1994) Biomass Production of Common Farmland Trees. Gilgit Region. Unpublished Report of the Aga Khan Rural Support Programme Pakistan (AKRSP). Gilgit.

AKF [Aga Khan Foundation] (ed.) (1996) Aga Khan Foundation Development Programme, Gorno-Badakhshan, Tajikistan. Concept Paper for Funding Twelve 600 kW HEP Stations.

AKF [Aga Khan Foundation] (ed.) (2003) Lighting up Communities. A Case Study of the Mountain Societies Development Support Programme's Mini-Hydel Projects in Gorno Badakhshan Autonomous Oblast. Evaluation Learning and Communication Unit Tajikistan: Dushanbe.

Akhunov I.I (1967). Generation of the National Income in Tajik SSR. In: Irfon. Dushanbe.

Akiner, Shirin (1998) Social and Political Reorganisation in Central Asia: Transition from Pre-Colonial to Post-Colonial Society. In: Post-Soviet Central Asia. T. Atabaki and J. O'Kane, (eds.) pp. 11-34. London: Tauris Academic Studies, International Institute for Asian Studies (IIAS).

Akiner, Shirin (2001) Tajikistan: Disintegration or Reconciliation? London: The Royal Institute of International Affairs.

Breu, Thomas and Hurni, Hans (2003) The Tajik Pamirs: Challenges of Sustainable Development in an Isolated Mountain Region. Bern: Centre for Development and Environment, University of Berne.

Clemens, Jürgen (2001) Ländliche Energieversorgung in Astor: Aspekte des nachhaltigen Ressourcenmanagements im nordpakistanischen Hochgebirge. Bonner Geographische Abhandlungen. Heft 106. Sankt Augustin: Asgard-Verlag.

Cobbold, Ralph (1898) Report on his Journeys on the Pamirs and in Chinese Turkestan. To the Foreign Office. Srinagar. Kashmir.

Cobbold, Ralph (1900) Innermost Asia. William Heinemann: London.

Degen, Muriel (2001) Local Development Profile of Basid, Tajikistan. Internal Report Pamir Strategy Project. Bern: Centre for Development and Environment, University of Berne.

Domeisen, Michael (2002) Marginalized by the Impacts of Transformation. A Study of Post-Soviet Livestock Breeding in the High Mountains of the Eastern Pamirs. Diplomarbeit. Bern: Centre for Development and Environment, University of Berne.

Dumanski, Julian and Pieri, Christian (2001) Monitoring Progress Towards Sustainable Land Management. In: Stott, D. E., Mohtar, R. H. and Steinhardt, G. C. (eds.) (2001) Sustaining the Global Farm. Selected Papers from the 10th International Soil Conservation Organization. Meeting held May 24-29, 1999 at Purdue University and the USDA-ARS National Soil Erosion Research Laboratory.

Eswaran, Hari and Sloger, Charles (1994) Considerations on Indicators for Sustainable Land Management. USDA Natural Resources Conservation Service, Washington DC and US Agency for International Development, Global Bureau.

FAO [Food and Agriculture Organization of the United Nations] (ed.) (2001) FAO and World Energy Council Call for Higher Priority to Energy Problems in Rural Areas. Press Release 00/01. www.fao.org

Fischbacher, Christa (1999) Entwicklung durch Technik. Auswirkungen der Einführung des elektrischen Stroms untersucht am Beispiel der Sherpa-Dorfgemeinschaften im Khumbu Himal, Nepal. Dissertation. ÖFSE.

Flick, U. (1999) Qualitative Forschung. Theorie, Methoden, Anwendung in Psychologie und Sozialwissenschaften. Reinbek bei Hamburg: Rowohlt Taschenbuch Verlag GmbH.

Geiger, Willhelm (1887) Die Pamir-Gebiete. Eine geographische Monographie. In: Geographische Abhandlungen. Volume 2. Eduard Hölzel: Wien.

Grevemeyer, Jan-Heeren (1982) Herrschaft, Raub und Gegenseitigkeit: Die politische Geschichte Badakhshans 1500-1883. Dissertation. Wiesbaden: Harrassowitz.

Habtetsion, Semere and Tsighe, Zemenfes (2001) Renewables and Energy for Rural Development. Current Energy Utilization and Future Options in Rural Areas. Second Draft Report. African Energy Policy Research Network (AFREPREN). Energy Research Prgramme 2000-2002.

Hafizullah Emadi (1998) Politics of Transformation and Ismailis in Gorno-Badakhshan, Tajikistan. In Internationales Asienforum International Quarterly for Asian Studies. Volume 29, 1-2/98.

Hangartner, Judith (2002) Dependent on Snow and Flour. Organization of Herding Life and Socio-economic Strategies of Kyrgyz Mobile Pastoralists in Murghab, Eastern Pamir, Tajikistan. Lizentiatsarbeit. Institut für Ethnologie. Universität Bern.

Harvey, Adam (1993) Micro-Hydro Design Manual. A Guide to Small-Scale Water Power Shemes. London: Intermediate Technology Publications.

Herbers, Hiltrud (2001a) Transformation im tadschikischen Pamir. Vom Proletariat zum Bauerntum. In: Geographische Rundschau, Vol. 53, No. 12: 16-22.
Herbers, Hiltrud (2001b) Transformation in the Tajik Pamirs: Gornyi-Badakhshan – An Example of Successful Restructuring? In: Central Asian Survey, Vol. 20, No. 3: 367-381.
Herbers, Hiltrud (2002) Ernährungs- und Existenzsicherung im Hochgebirge: der Haushalt und seine Livelihood strategies – mit Beispielen aus Innerasien. In: Petermanns Geographische Mitteilungen, Vol. 146, No. 4: 78-87.
Herweg, K., Slaats, J. and Steiner, K. (1998) Sustainable Land Management – Guidelines for Impact Monitoring. Working Document for Public Discussion. Workbook and Toolkit. Berne.
Herweg, Karl and Steiner, Kurt (2002) Impact Monitoring and Assessment. Instruments for Use in Rural Development Projects with a Focus on Sustainable Land Management. Volume 2: Toolbox. Bern: CDE.
Hurni, H., Wiesmann, U. and Kohler, T. (1999) Mitigating the syndromes of desertification: The requirements for transdisciplinary research and information exchange. Book of contributions, EU Workshop on “Information Requirements and Organizational Approaches to Support Interdisciplinary Research on Desertification”, held in Alghero, Sardinia, 9-11 October 1999, pp. 7-55.
Hurni, Hans (1997) Concepts of Sustainable Land Management. In: ITC Journal 1997 3/4, pp. 210-215.
Hurni, Hans (2000) Assessing Sustainable Land Management (SLM). In: Agriculture, Ecosystems and Environment 81 (2000), 83-92.
Hurni, Hans et al. (1996) Precious Earth: From Soil and Water Conservation to Sustainable Land Management. Berne: International Soil Conservation Organization, and Centre for Development and Environment.
ICIMOD [International Centre for Integrated Mountain Development] (ed.) (2001) Energy Issues in the Hindu Kush Himalayas. Mini/Micro Hydropower for the Mountains. International Centre for Integrated Mountain Development, Kathmandu, Nepal. http://www.icimod.org/focus/energy/energy_mmhp.htm
IFC [International Finance Corporation] (ed.) (1999) Gorno-Badakhshan Energy Development Project. Review of the Pamir HPP. Preliminary Draft. Zürich: Electrowatt Engineering.
IFC [International Finance Corporation] and GoT [Government of Tajikistan] (eds.) (2001) Evaluation of the GBAO Electric Networks and Assistance in Project Preparation. Volume 3, Environmental and Socio-Economic Measures. Elektrowatt Engineering Ltd.
IHTSSR [Institute of Hydropower of the Tajik SSR] (ed.) (1984) Compilation of a list of small and large-scale hydropower projects in Gorno Badakhshan. Dushanbe.
Jodha, N. S. (2001) Interacting Processes of Environmental and Social Vulnerabilities in Mountain Areas. Issues in Mountain Development, 2001/2. ICIMOD Publication. www.icimod.org/publications/imd/imd 2001/imd2000-2.htm 18.11.2002
Johnston, Charles (1892) Darwaz and Karategin: An Ethnographical Sketch. In: The Asiatic quarterly review. Volume 3.
Junejo, Anwar A. (1997) Development of Mini- and Micro-hydropower: Issues and Constraints. Issues in Mountain Development, 1997/2. ICIMOD Publication. www.icimod.org/publications/imd/issue972.htm 18.11.2002
Kadian, Promila and Kaushik, Sushma (2003) Rural Energy for Sustainable Development. Participatory Assessment of Energy Resources. New Dehli: Deep & Deep Publications ltd.
Kim, Esther and Karky, Bhaskar Singh (2002) Water Resources Use in the Annapurna Conservation Area: Case Study of Micro-Hydropower Management in Sikles and Chhomrong. Case study on "Mountain infrastructure: access, communications, energy", Mountain Forum E-consultation for the UNEP / Bishkek Global Mountain Summit.
Kleandrov I.M. (1974) The Economy of the Soviet Badakhshan. In: Irfon. Dushanbe.
Kleinn, Eva (2002) Report on the Survey on the Use of Fuel Resources on the Territory of GBAO Districts. GTZ.
Kleinn, Eva (2003) Unpublished Report on Teresken Acquisition in Murgab Center (Eastern Pamirs). GTZ.
Knox, Paul et al. (2001) Humangeographie. Spektrum Akademischer Verlag. Heidelberg.
Krader, Lawrence (1963) Social Organization of the Mongol-Turkic Pastoral Nomads. Indiana University Publications, Uralic and Altaic Series. Volume 20. The Hague: Mouton & Co.
Lambert, Caroline (2003). At the Crossroads. A Survey of Central Asia. In : The Economist, July 26th 2003. New York: Newspaper Group Inc.
Luknitsky, Pavel (1954) Soviet Tajikistan. Moscow: Foreign Languages Publishing House.
Markoff, A. (1900) On the Afghan Frontier: A Reconnaissance in Shugnan. Notes from a Journal of the Russian Officer Lieut.-Colonel A. Serebrennikov in 1894. In: Geographical Journal, Vol. 16, No. 6 (Dec. 1900): 666-679. www.jstor.org
Masov R.M. (1981) Essays on Soviet Badakhshan history. In: Irfon. Dushanbe.

Messerli, B. and Ives, J. D. (eds.) (1997) Mountains of the World. A Global Priority. New York: The Parthenon Publishing Group.
MSDSP [Mountain Society Development and Support Programme] (ed.) (2001) Annual Report 2001 of the Mountain Society Development and Support Programme. Dushanbe.
MSDSP [Mountain Society Development and Support Programme] (ed.) (2002) List of accomplished micro and mini hydropower projects in Gorno Badakhshan. MSDSP Khorog.
MSDSP [Mountain Society Development and Support Programme] (ed.) (2003) Demographic Statistics of Gorno Badakhshan Autonomous Oblast 2003. Mountain Society Development and Support Programme. Dushanbe.
NABU [German Society for Nature Conservation] (ed.) (2002) Biodiversity Assessment and Overview. A Subproject of the Pamir Strategy Project, Centre for Development and Environment. German Society for Nature Conservation. Edited by Eva Kleinn.
Nazarshoev, M.N. (1970) Partial Organization of Pamir in Struggle for Socialism and Communism. In: Irfon. Dushanbe
NCCR N-S [National Centre of Competence in Research North South] (ed.) (2002) Publication on the National Centre of Competence in Research North-South: Research Partnerships for Mitigating Syndromes of Global Change. Berne: NCCR North-South c/o Centre for Development and Environment (CDE), Institute of Geography, University of Berne.
OSIENALA [Friends of Lake Victoria] and GFN [Global Nature Fund] (eds.) (2004) Renewable Energy for Fisherfolks of Lake Victoria. A joint East African Training Programme for Technicians for the Conservation of Lake Victoria Resources and the Environment. A Project of OSIENALA (Friends of Lake Victoria) in Collaboration with Global Nature Fund (GNF). Final Proposal Version 2.0.
Ott, Cordula and Wymann, Susanne (1993) Salleri Electricity Utilization Project. Impact Status Report 1992. Prepared for the Swiss Development Coorporation (SDC). Berne: Centre for Development and Environment (CDE).
Papola, T. S. (1996) Integrated Planning for Environment and Economic Development in Mountain Areas: Concepts, Issues and Approaches. Issues in Mountain Development, 1996/1. ICIMOD Publication. www.icimod.org/publications/imd/issue1.html 18.11.2002
PEC [Pamir Energy Company] (ed.) (2002) Concession Agreement Between Government of the Republic of Tajiistan and Pamir Energy Company. Dushanbe May 24th 2002.
PEC [Pamir Energy Company] (ed.) (2003) Statistics of Power Generation and Distribution in Gorno Badakhshan 2003. Khorog: PEC.
Piana, Grazia (2002) The Role of Energy in Sustainable Development: Rio, Johannesburg and beyond. Proposal for a new study. Environment and Natural Resources Service. Sustainable Development Department and Food and Agriculture Organization of the United Nations. www.fao.org
Polo, Marco (2000) Von Venedig nach China. Die grösste Reise des 13. Jahrhunderts. Thienemann Verlag.
Raju, KV. (2001) Eco-Friendly Hydro-Electric Power in Himalaya Mountain Regions: Implications for Development. World Mountain Symposium 2001. Paper presented in the World Mountain Symposium 2001, Interlaken, Switzerland. Sep 30 - Oct 04, 2001.
Renner, Georg (1977) Biwak auf dem Dach der Welt: Auf Bergpfaden durch Tadschikistan. VEB F.A. Brockhaus Verlag. Leipzig.
Rijal, Kamal (1998) Sustainable Energy Use for Mountain Areas: Community-Level Energy Planning and Management. Issues in Mountain Development, 1998/4. ICIMOD Publication. www.icimod.org/publications/imd/imd98-4.htm 18.11.2002
Rijal, Kamal (ed.) (1999) Energy Use in Mountain Areas. Trends and Patterns in China, India, Nepal and Pakistan. Kathmandu: International Centre for Integrated Mountain development (ICIMOD).
Schultz von, Arved (1911) Zur Kenntnis der arischen Bevölkerung des Pamir. In: Orientalisches Archiv. Illustrierte Zeitschrift für Kunst, Kulturgeschichte und Völkerkunde der Länder des Osten. Volume 2. Giessen.
Schultz von, Arved (1914) Die Pamirtadschik. Veröffentlichung des Oberhessischen Museums und der Gail'schen Sammlung zu Giessen (Abteilung für Völkerkunde). 1. Heft. Giessen: Verlag von Alfred Töpelmann (vormals J. Rickmers).
Schweizer, Petra and Preiser, Klaus (1997) Energy Resources for Remote Highland Areas. In: Messerli, B. and Ives, J. D. (eds) Mountains of the World. A Global Priority. New York: The Parthenon Publishing Group.
SCSRT [State Committee on Statistics of the Republic of Tajikistan] (ed.) (2002) Tajikistan in Figures. The Brief Digest. Dushanbe.
Seco [Swiss State Secretariat for Economic Affairs] (ed.) (1999) Project Identification in the Energy Sector in Gorno-Badakhshan, Tajikistan. Final Report August 13th 1999. Elektrowatt Engineering.
Seco [Swiss State Secretariat for Economic Affairs] (ed.) (2003) Pamir Private Power Project Tajikistan. A Project Description. Bern: Eidgenössisches Volkswirtschaftsdepartement.

SFOE [Swiss Federal Office of Energy] (2002) General Energy Statistics 2002. Bern. http://www.energie-schweiz.ch/imperia/md/content/statistikperspektiv-en/gesamtenergie/9.pdf

SFOS [Swiss Federal Office of Statistic] (2003) Press release: Population. According to the census of 2000.

Shrestha, Ganesh Ram (2001) Energy Technologies for Mountain Communities. World Mountain Summit 2001.

Sinclair, John A. (2003) Assessing the Impacts Of Micro-Hydro Development in the Kullu District, Himachal Pradesh, India. In: Mountain Research and Development. Vol. 23, No. 1, February: 11-13.

Snessareff, A (1908) Religion und Gebräuche der Bergvölker des westlichen Pamir. In: Revue orientale pour les études ouralo-altaïques. Journal du comité hongrois de l'assocation inernationale pour l'exploration de l'asie centrale de l'extreme-orient. Budapest.

Stein, Sir Aurel (1982) On Ancient Central-Asian Tracks. Taipei: Southern Materials Center. Reprint (Original: 1933).

Stocking, Michael and Niamh Murnaghan (2001) Handbook for Field Assessment of Land Degradation. London: Earthscan Publications Ltd.

Stoffel, M., Monbaron, M., Maselli, D. (2002) Mountains and Lowlands: Enemies or Partners? Example of the High Atlas, Morocco. A Joint Publication of SDC, OSS, UniFR and CDE. University of Fribourg.

Umarov, Khojamakhmad (1998) The Demographic Boom and its Impact on the Mountain Regions of Tajikistan. In: Akiner, S., Tideman, S. and Hay, J. (eds.) (1998) Sustainable Development in Central Asia. New York: St. Marin's Press.

Wennemann, Mathias (ed) (2002) Pamir Expedition 2002. Bielefeld – Bonn – Dushanbe 27.07.-24.08.2002. Expeditionsbericht. Universität Bielefeld.

Wiesmann, U. (1998) Sustainable Regional Development in Rural Africa: Conceptual Framework and Case Studies from Kenya. Geographica Bernensia. University of Berne, Switzerland.

World Bank (ed.) (2002) Tajikistan Pamir Private Power Project. Environment and Social Impact Assessment. Executive Summary.

World Bank and IFC [International Finance Corporation] (eds.) (2002) Project Appraisal Document on a Proposed International Development Association in the Amount of up to SDR 7.9 Million to the Goverment of Tajikistan and on International Finance Corporation Financing Consisting of: An „A" Loan in the Amount of up to US$ 4.5 Million and an Equity Subscription of up to US$ 3.5 Million to Pamir Energy Company for the Pamir Private Power Project in the Republic of Tajikistan. May 31st 2002.

ZERKALO [Sociological Research Centre] (ed.) (2000) Social Research Report, GBAO October 2000. Dushanbe: Sociological Research Centre.

Zibung, Daniel (2002) Eine integrale Analyse der Infrastrukturausstattung und Energieversorgung in der Grossregion Gorno-Badakhshan, Tajikistan. Diplomarbeit. Bern: CDE.

***Internet Sources***

http://www.energie-schweiz.ch/imperia/md/content/statistikperspektiven/gesamtenergie/9.pdf
http://www.icimod.org/focus/energy/energy_mmhp.htm
http://vwww.icimod.org/publications/imd/imd2001/imd2000-2.htm
http://www.icimod.org/publications/imd/imd98-4.htm
http://www.icimod.org/publications/imd/issue1.html
http://www.icimod.org/publications/imd/issue972.htm
http://www.un.org/esa/sustdev/agenda21chapter13.htm
http://www.un.org/esa/sustdev/sdissues/energy/enr.htm
http://www.undp.tj/publications.html
http://www.videncenter.dk/groenne%20trae%20haefte/Groen_Tysk/trae-DE04.pdf
http://varorud.org/english/herald/pulse101003.html

***Useful Links***

www.adb.org
www.akdn.org
www.asiaplus.tajnet.com
www.bioenergiehof.de
www.cde.unibe.ch
www.fao.org
www.geographischerundschau.de
www.globalmountainsummit.org
www.icimod.org
www.jstor.org
www.mrd-journal.org
www.mtnforum.org
www.nccr-north-south.unibe.ch
www.worldbank.org
www.worldenergy.org

# Appendix 1
# Methods

*Research Procedure in the Case-Study Villages*
*Questionnaire for Interview with Village Organization*
*Questionnaire for Household-Interviews*
*Energy Matrix for First Session of the Household Interview*
*Land and Resource Degradation*
*Checklist with Indicators for Unsustainable Land Management*

# Research Procedure in the Case-Study Villages

1. Contact with VO-President to inform about our studies, and to get in contact with local informants for transect walk. Ask for a meeting with the representatives of the VO.
2. Participatory transect walk with a local informant:
3. Interview with representatives of Village Organization (VO)
4. Selection of six households for Interviews based on information obtained from the VO.
5. Household interviews
6. Announcement of the interview one day in advance
7. First session: Household visit in order to get an overview of energy infrastructure. Structured Inventory and quantification interview will be performed.
8. Second session: Perform semi-structured household interviews
9. Visit to the MHPS (interview with operator)
10. Participatory Observation of fuel wood procurement
11. Group interviews with Women's Committee
12. Participatory degradation assessment
13. Geo-referencing walk (MHPS, watermill, channels, …)

# Questionnaire for Interview with Village Organization

### General information about the village

- What is the set up of your VO (president, accountant, VO-president, …)?
- When did you establish the VO?
- How many inhabitants, households are there in your village at the moment?
- What is the male-female-ratio in this village?
- What is the average area of arable land in this village?
- What about migration in your village?
- Household categories?

### Energy resource use

- Do you have any energy resource problems?
- Are there public areas, which are managed by the VO?
- Is there any energy resource management conducted on a local level (woody resources, …)?
- How do you assess the situation of the woody resources in your village?
- Are there reforested areas on the village territory?
- Is there any woodland on the village territory?

### MHPS

Have you noticed any great changes since installation of the MHPS concerning:

- Labor time (cooking, collecting fuel wood, …)?
- Housework (handcrafts, washing, cleaning, …)?
- Study habits?
- Sleeping time, waking time?
- Personal income?
- Local prestige?
- Leisure time?
- Sanitary and health situation?
- Migration into the village (immigration/emmigration)?
- Local trade, industry?
- Wooden resources in and around the village?

# Questionnaire for Household-Interviews

Joint Diploma Thesis of Roman Droux and Tobias Hoeck, final version

***Procedure***

1. Announcement of the interview one day in advance.
2. First session: Household visit in order to obtain an overview of the energy infrastructure. Structured Inventory and quantification interview will be performed.
3. Second session: Perform semi-structured household interviews and record it on MiniDisc.

***Announcement***

- Who we are, what we are doing and what the expected results are.
- Topic of the interview.
- Ask if they would be willing to volunteer for an interview.
- Date and time, duration of interview.
- There will be two sessions (longer interview and household visit).
- Which persons should be at home at that time: husband, wife, perhaps children.
- We would like to record the interview on tape. Ask if they agree with that.
- We would like to take pictures of their home or of objects inside their home. Ask if they agree with that.
- We will treat all provided information confidentially.
- Perhaps ask them if they could prepare some data concerning energy resource use or consider the quantities used in their household.

## 1. First session

### 1.1 Introduction

- Short repetition of what we are going to do in this session, etc.

***General Information***

Date:
Time:
Household:
Village:
Jamoat:
District:

***Interview Partner(s)***

*Husband:*
Name
First name
Age
Education
Occupation

*Wife:*
Name
First name
Age
Education
Occupation

### 1.2 Household

- How many children do you have? How old are your children? What do they do (go to school, work, etc.)?
- How many members belong to this household (summary of persons who are regularly having dinner in this house)?
- Who is the owner of this house?
- How many years do you already live in this house/village?
- Do you have a regular income? From which occupation(s)? How much do you earn per month? Do you have alternative incomes (relatives, friends, …)?
- What was your main profession during the Soviet era? How much did you earn per month during that time?
- Amount of arable land, livestock and cattle?

### 1.3 Present Inventory and Quantification of Energy Resources and Consumption (see Energy Matrix)

See Energy Matrix for First Session of the Household Interview.

- Which energy resources[1] do you use in your household? (Do you use … in your household?) Which did you use during Soviet times and during the years of the civil war?
- What quantity of fuelwood, etc. do you need per day/month/season?
- How much did you use of the different energy resources during the soviet era? Was it more, less, equal, half or double?
- Are there seasonal differences (summer/winter) concerning the use of energy resources? How much of this energy resource do you use in winter compared to the consumption in summer?
- Where do you get the energy resources used? Do you buy them? Do you collect them? Or do you hire someone to collect the resource for you?
- How much money do you spend on energy resources per week/month? How many hours per day/week do you spend on collecting/preparing the energy resource?
- Who is responsible for the procuration of the energy resource?
- Who usually utilizes this energy resource?
- For what purpose[2] do you use this energy resource?
- Is this energy resource available in or around the village? If not, from where does it have to be imported?

### 1.4 Good Bye, see you soon!

- Thank you for the Interview!
- Announcement of the second session.

## 2. Second Session

### 2.1 Introduction

- Short review of what we are going to do in this session etc.

### 2.2 Detailed Focus on Individual Energy Resources

***Fuel wood***

- Could you afford fuel wood during the Soviet era? How much did it cost at that time?
- Who usually collects the fuel wood?
- Where and when do you collect it? Do you cut it, or just collect it?
- Which species do you use (preferences, trees, bushes, shrubs)?

| **English** | **German** |
|---|---|
| Poplar | Pappel |
| Juniper | Wacholder |
| Birch tree | Birke |
| Sallow thorn | Sanddorn |

1 Different energy resources: Fuel wood, animal dung, agricultural residues, other biomass, electricity (mini/hydropower, wind generators, solar photovoltaic systems, thermal, diesel generator, batteries) industrial waste, coal (charcoal, briquettes), crude oil, natural gas, biogas, diesel oil, kerosene, furnace oil, paraffin wax, ethanol, methanol, geothermic energy (ICIMOD 1999).

2 Lighting, cooking, water heating, room heating, communications (radio, television. walkie-talkie, computer), cooling, transport, mechanization in agriculture.

| | |
|---|---|
| Willow | Weide |
| Mulberry tree | Maulbeerbaum |
| Fruit tree | Obstbaum |
| Apple tree | Apfelbaum |
| Walnut tree | Nussbaum |
| Pine tree | Föhre |
| Meadow (= Aue) | Auenwald |
| Bush, shrub | Busch |

- Do you also cut fruit trees for firewood?
- What is the best firewood?
- Do you pay for fuel wood (buy it, where, what unit (bundle,…, what price)? hire a person)?
- Is it a lot of work (hard work) to prepare the wood for use as firewood? What needs to be done?
- Have there been any changes concerning the quantity of consumed fuel wood during the last years? Do you need the same amount of fuel wood every year or are there any yearly differences? On what does this difference depend? What was the situation during the years of civil war?
- Do you store the fuel wood for the use in winter? What amount, and how frequently do you collect it in wintertime?
- Would you prefer to use another energy resource to cook, heat, etc. instead of firewood?
- Do you think you could use the fuel wood more efficiently, so that you would need less but with the same results?
- Are there any visible problems caused by the slash of fuel wood? Have the varieties of plants and animals changed in the last ten years? Did some of them disappear during the last years?
- Is it getting increasingly difficult to get firewood? Do you have to spend more time for its procurement?
- Do you think there's enough firewood to supply the coming generations? Is there sufficient for the next years?

***Animal Dung***
- How do you prepare it? Who collects and prepares it? Do you buy it?
- Where do you collect it? Is it only from your own cattle?
- Do you use it (only) in combination with firewood?
- Do/did you use animal dung as fertilizer? Why not?
- Do you use other, additional fertilizers on your land? How long?
- Has the yield changed since using dung cakes instead of artificial fertilizer or artificial fertilizer instead of dung cakes?
- Since you use dung as fire material, do you have respiratory problems?

***Electricity***
- Since when do you have electricity in your household? Did you have electricity during the years of civil war?
- Is your household supplied in all seasons with electricity?
- Are there periods when you don't have electricity (when)? Electricity supply schedule?
- How much electricity do you consume per month, season, year (kWh)?
- Do you have a meter which tallies the consumed kWh?
- Do you pay for electricity, how much? How much does 1 kWh cost? Is it cheap?
- How much would/could you pay for electricity?
- How much did the electrical installation cost?
- What electrical appliances do you use? When did you begin use?
- How many hours do you use them in a day/week (light, radio, iron, television, cooker, room heater, refrigerator, others)?
- Where do you buy the electrical appliances?
- Are there any problems concerning the use of electricity (any incidents, unreliable supply)
- Is it important for you to have electricity?
- What are the advantages and disadvantages of electricity?
- Are you satisfied with the quality of the electricity (too weak, unstable supply)?
- Is an MHPS an adequate option to solve the energy problem?
- Are you sufficiently supplied with electricity?
- What would be the next electrical appliance you would buy if affordable and available?

***Since the installation of electricity have you noticed any changes (in your household, in your village) concerning (impacts):***

- Labour time (cooking, collecting fuel wood, …)?
- Housework (handcrafts, washing, cleaning, …)?
- Study habits?
- Sleeping time, waking time?
- Personal income?
- Local prestige?
- Leisure time?
- Sanitary and health situation?
- Migration in the village (immigration/emigration)?
- Local trade, industry?
- Wood resources in and around the village?
- Celebrations?

***Before the Installation of Electricity:***

- Which fuels did you use for lighting and other purposes (amount and costs)?
- What types of lamps did you use?
- Did you use batteries, and if yes how many (amount and costs) and for what purposes?

***Electricity (Households without Electricity)***

- What do you think would change in your daily live if you had electricity?
- Do you think that would improve your livelihood?
- For what purposes would you use electricity?
- How much would you be willing to pay for the electricity?
- Would you take the initiative for an MHPS-Project?
- Would you contribute some money to finance the project?

### 2.3 Khaipas

- Kolokhi bisior for the interview!
- Hand out a present as a Thank You.

# Energy Matrix for First Session of the Household Interview

| HH?cat?Village: name | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Energy Resource | Used in this household today (yes/no) | Quantity (kg, l, kWh, bundle, don-key load) per day/ month | Schedule (daily) | Consumption during the soviet time (more, less, equal, half, double) | Seasonal differences (summer/ winter) | Resource acquisition: purchased, hiring a labourer, collected | Expenses (Somoni / Dollar per month, hours) | Who procures resource? | Main User | Purpose/ end-use device (cooking...) | Available end-use devices in this hh | Locally (in village) available (y/n), where? | Imported from where? | Additional information |
| Fuel Wood | | | | | | | | | | | | | | |
| Animal Dung | | | | | | | | | | | | | | |
| MHPS Electricity | | | | | | | | | | | | | | |
| Grid (PEC) Electricity | | | | | | | | | | | | | | |
| Coal | | | | | | | | | | | | | | |
| Diesel oil | | | | | | | | | | | | | | |
| Kerosene | | | | | | | | | | | | | | |
| Others | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |

# Land and Resource Degradation

Date:

Place:

Coordinates:

Description: Kind of degradation, degree and extension

***Checklist for Land Use and Ecological Aspects:***

*Woodland*

Rate of deforestation, illegal cutting.

*Cropland*

Monoculture, inappropriate crop rotation, abandonment of cropland, cultivation of marginal land (steep land with shallow soils), fertilizers used, rate of irrigation, fodder production.

*Pastureland*

Overgrazing, bare soil, trampled area, poor plant cover, increase in unpalatable species.

*Soils:*

Soil fertility: Light pale soil colour, indicator plants, low root density, limited rooting depth, exposed plant roots, erosion rills, gullies and large accumulations. Salinity colour of leaves. Compactation: Crust formation, difficult to plough.

*Water:*

Water availability, shortage, drying wells, dying trees, flash floods. Water quality.

*Vegetation:*

Biodiversity, minimal variety of species. Biomass and nutritive value, low crop yield, high yield variability. Plant growth, low plant height, diseases, light green or yellow colour of leaves.

*Animals:*

Quantity, overstocking, low grass cover, encroachment on cropland. Quality: Malnutrition, diseases, high mortality rate, fodder shortage.

*Natural Hazards:*

Rockfalls, mudflows, debris flows, floods, avalanches, landslides.

***Checklist Community Level***

Indirect indicators, which can provide an indication of degradation risk potential. Examples: Conflict over natural resources, distance to markets, access to resources, gender related observations, percentage of landless people, wealth distribution, unemployment rate, crime, social conflicts between generations.

# Checklist with Indicators for Unsustainable Land Management

| Signs of unsustainable land management | Indicators (what to observe) | Issues |
|---|---|---|
| **Soil fertility decline** | Changing colour of plants<br>Reduced plant cover / production<br>Salt on the soil surface<br>Abandonment of the cropland<br>Soil colour changes<br>Decreasing root density<br>Poor soil drainage<br>Compaction: crust thickness, strength (when broken by hand)<br>Difficult to plough<br>Indicator plants<br>Few soil fauna (worms, chafers, …)<br>Cultivation of marginal land (steep land, shallow soils) | Use of fertilisers/ animal dung<br><br>Inappropriate crop rotation |
| **Soil erosion by water** | Exposed plant roots (cm)<br>Rills, gullies and accumulations (No., density, volume)<br>Reduced topsoil depth (spade or drill)<br>Change in soil colour indicates subsoil exposure<br>Increasing runoff, periodical flash floods (time)<br>Sedimentation of reservoirs, deposition during low water<br>Water turns brown<br>Increased seeding rate<br>Increasing stone cover (topsoil already washed away) | Soil loss<br><br>Erosion features<br><br>Vulnerability to heavy rainfall and storms |
| **Wind erosion** | Dust storms, mobile dunes (pegs as reference points)<br>Nutrient depletion (incl. acidity), toxicity (pH) | |
| **Degradation of plant resources** | Changing colour of plant leaves (yellow)<br>Pests and disease<br>Low plant ground cover (estimation in %)<br>Low variety of plants (species compositions)<br>Browsing damage<br>Trampling and fouling<br>Wood-chopping marks<br>Low plant height | Succession of vegetation (climax vs. pioneers)<br>Increase of unpalatable species<br>Overgrazing<br>Livestock density<br>Illegal cutting |
| **Degradation of animal resources** | Changing no. of livestock per household<br>Malnutrition / shortage of fodder<br>Animal disease<br>High mortality rate | Diet preferences of livestock |
| **Scarcity of water** | Dying trees,<br>Flash floods | |
| **Decline in wildlife** | | |
| **Land use changes (indirect indicators)** | Increasing percentage of cropland<br>Deforestation<br>Decreasing fallow period<br>Pasture turned into cropland<br>Conflict over natural resources,<br>Distance to markets,<br>Access to resources<br>Gender related observations<br>Percentage of landless people,<br>Wealth distribution<br>Unemployment rates<br>Social conflicts between generations | Carrying capacity dynamics due to social change |

# Appendix 2
# Hydropower

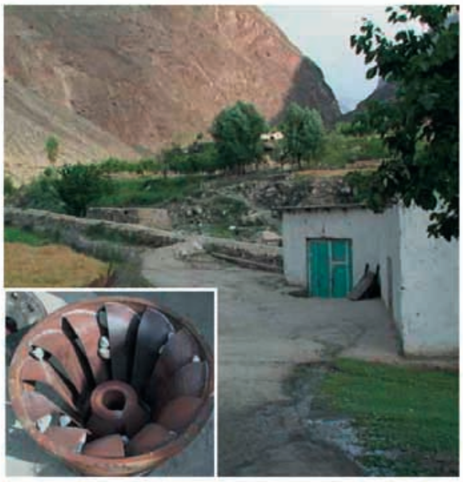
*Documentation of 30 MHPS in GBAO*
*List of Hydropower Stations in GBAO*
*Planned Soviet Hydropower Stations*
*PEC Consession Agreement*

# Documentation of 30 MHPS in GBAO

## *MHPS Ajirkh (Basid/ Rushan) completed*

| | |
|---|---|
| *Date of inspection* | 18.6.2003 |
| *Year of completion* | May 2003 |
| *Damaged at date of inspection?* | No/ working steadily |
| *Installed capacity/ actual output* | 20kW/ average 10kW/ too many hh connected, grid is overloaded |
| *Type (turbine and generator)* | Pump as turbine, horizontal, high-pressure |
| *Owner* | VO Ajirkh |
| *Head/ pipe length/ water channel length/* | 72m/ 120/ 0.18m/ 120m/ |
| *Generated power/day kWh (hours x average capacity)* | Winter: 220kWh: 10 kW x 22 hours<br>Summer: 180kWh: 10 kW x 18 hours |
| *Seasonal differences in power generation* | No seasonal differences |
| *Project financed by* | SDC, Holland, Food for Work (4.5 tons of flour) |
| *Installation costs* | USD 13,514 |
| *Initiative taken by* | Villagers of Ajirkh |
| *Maintenance costs* | Only one person (10 *somoni*/month) |
| *Schedule for power distribution* | Breaks: 13.00-19.00 (summer), 13.00-15.00 (winter) |
| *Connected villages/ households/ people* | Ajjirkh/ 25 hh/ 94 persons |
| *Electricity fee per month or kWh* | 90 *diram* /month/hh (USD 0.79) |
| *Major problems* | Running 3 years without problems. Rockfalls sometimes block the canal, but villagers clean it again. They once had problems with the generator (short circuit).) |
| *Number of workers at the MHPS* | Only one person |
| *Village connected to PEC grid* | No |
| *Electricity usage purposes* | Mainly for light, only few hh are using it for cooking, no use for heating (lack of energy). Only 10% of the hh can heat water |
| *Construction proceedings* | Villagers bought with 18 cattle (270kg meat: 540 *somoni* or USD 171): turbine, generator, switch board. Every hh contributed one head of cattle |
| *GPS point* | 011, elev. 2240m, N 38º06'40.5", E 072º02'58.7" |
| *Further information* | Turbine could produce 75kW. Generates not sufficient for cooking, heating. From MSDSP supported with cement, reinforcement, poles, transmission lines. |

## MHPS Andarbak (Yazgulom/ Vanj) completed



| | |
|---|---|
| *Date of inspection* | 9.7.2003 |
| *Year of completion* | 1999 |
| *Damaged at date of inspection?* | Yes, turbine was being transported to Khorog |
| *Installed capacity/ actual output* | 300kW (average: 280kW) |
| *Type (turbine and generator)* | Horizontal, lateral, mid-pressure; turbine: rofo 300 gf 60 |
| *Owner* | PEC |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 18m/ 258m/ 1035mm/ 100m/ no pool |
| *Generated power/month kWh (hours x average capacity)* | 90,000-100,000kWh/month (villager's figure) June 2003: 112,000kWh (PEC's figure) |
| *Seasonal differences in power generation* | Lack of water in March/February (only 120kW) |
| *Project financed by* | SDC (USD 38'695), Japan ODA (USD 87'000), SDC (USD 1239), Food for Work. Total: USD 126'934 (villagers didn't pay anything) |
| *Initiative taken by* | MSDSP, hand over to PEC. |
| *Maintenance costs* | All the costs are subsidized by PEC (repair, maintenance) |
| *Schedule for power distribution* | There are two lines (one up, one down), 24h one line, 24h the other line. |
| *Connected villages/ households/ public buildings* | upper line: Andarbak (132hh); Jamak (150hh). Down line: Vishkharv (83hh); Budun (103hh); Shavud (44hh); Motravn (168hh): Total: 635hh/ 5513 inhabitants |
| *Electricity fee per month or kWh* | PEC tariffs Before PEC: 5 *diram*/kWh (<250 kWh); 11 *diram*/kWh (>250kWh) |
| *Major problems* | It worked a maximum of 2 months. Problems with the canal, rocks damaging the concrete and a lot of stones damaging the turbine. |
| *Number of workers at the MHPS* | 10 men, 70-100 *somoni*/month from PEC (before from *hukumat*) |
| *Village connected to PEC grid* | No. During Soviet times it was provided by Vanj MHPS. The lines were destroyed during civil war. |
| *Electricity usage purposes* | It's not well working. Not enough for heating, only for light, TV, radio |
| *Construction proceedings* | It was initiated by MSDSP, handed over to PEC. |
| *GPS point* | 020: elevation 2097m; N 37°48'01,7" E071°35'55,5" |
| *Further information* | The canal goes straight into the tube. They would need about 4.5kW/hh (for heating, cooking, baking). There would be enough water to construct a bigger one (longer tube, bigger pool) |

### *MHPS Barchidev (Savnob/ Rushan) completed*

| | |
|---|---|
| *Date of inspection* | 1.7.2003 |
| *Year of completion* | 2000 |
| *Damaged at date of inspection?/ working since when* | Yes/ only ran 3 months (May to July 2001), it has been broken since July 2001. |
| *Installed capacity/ actual output* | 40kW/ 40kW |
| *Type (turbine and generator)* | Turbine and generator in one, transformer inside the MHPS |
| *Owner* | VO Barchidev |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 11m/ 110m/ 0.80m/ -/ - |
| *Generated power/day kWh (hours x average capacity)* | 240kWh: 40kW x 6h (18 to 24h) |
| *Seasonal differences in power generation* | Running all year, sufficient run-off all the times |
| *Project financed by* | Food for Work (MSDSP), SDC (USD 24,274) |
| *Installation costs* | USD 24,274 |
| *Initiative taken by/ when* | Villagers of Barchidev |
| *Maintenance costs* | Monthly salaries for 2 workers 12 *somoni* (USD 3.81) |
| *Schedule for power distribution* | 18-24h, because of old generator, which cannot handle a larger load. |
| *Connected villages/ households/ public buildings* | Barchidev (30, 184) |
| *Electricity fee per month or kWh* | 0.50 *somoni*/month/hh (USD 0.16), would increase the fee to 3-5 *somoni*/month/hh |
| *Major problems* | Turbine and generator are broken, lack of knowledge |
| *Number of workers at the MHPS* | 2 workers with 5 and 7 *somoni* salary per month |
| *Village connected to PEC grid* | No |
| *Electricity usage purposes* | Light bulbs, coil cooker, iron, TV, welding tool, radio, tape, video |
| *Construction proceedings* | Villagers submitted a project to the MSDSP which was accepted. The MSDSP provided all equipment. |

## MHPS Bardara (Basid/ Rushan) completed

| | |
|---|---|
| *Date of inspection* | 2.7.2003 |
| *Year of completion* | 1998 |
| *Damaged at date of inspection?/ working since when* | Yes/ it was running irregularly for about 4 years. It has been broken since April 2003 |
| *Installed capacity/ actual output* | 60kW/ average 5-10kW |
| *Type (turbine and generator)* | Horizontal turbine, generator, accumulator |
| *Owner* | VO Bardara |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 27m/ 60m/ 0.40m/ -/ - |
| *Generated power/day kWh (hours x average capacity)* | 60kWh: 10kW x 6h (18 to 24h) |
| *Seasonal differences in power generation* | All year, water availability is good |
| *Project financed by* | Food for Work (MSDSP), SDC (US 3019), German Embassy (USD 20,000) |
| *Installation costs* | USD 23,019 (of it USD 2670 fuel and USD 3780 FFW) |
| *Initiative taken by/ when* | Villagers of Bardara/ 1997 |
| *Maintenance costs* | Monthly salaries for 2 workers: 24 *somoni* (USD 7.62), and 1500 *somoni* (USD 476.20) for spare parts during the last 2 years |
| *Schedule for power distribution* | 18-24h, because of old equipment |
| *Connected villages/ households/ public buildings* | Bardara (83, 493) |
| *Electricity fee per month or kWh* | 0.35 *somoni*/month/hh (USD 0.11) |
| *Major problems* | Turbine is broken, turbine and pipes are leaking, water freezes even inside the building, water channel needs to be cemented. Turbine and generator do not fit eachother. |
| *Number of workers at the MHPS* | 2 |
| *Village connected to PEC grid* | No |
| *Electricity usage purposes* | Lighting |
| *Construction proceedings* | In 1997 villagers submitted a project to the MSDSP. |
| *GPS point* | 018, elev. 2801m, N 38º06'36.0", E 072º17'34.1 |
| *Further information* | A 60kW turbine is required. |

### *MHPS Barmev (Tusyan/ Roshtkala) completed*

| | |
|---|---|
| *Date of inspection* | 10.6.2003 |
| *Year of completion* | February 2003 |
| *Damaged at date of inspection?/ working since when* | Yes/ worked only from February to April 2003 |
| *Installed capacity/ actual output* | 33kW/ 33kW/ but 75kW generator, horizontal unit |
| *Owner* | VO Barmev |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 45m/ 110m |
| *Generated power/day kWh (hours x average capacity)* | 792kWh: 33kW x 24 hours |
| *Seasonal differences in power generation* | Should run entire year |
| *Project financed by* | Villagers (USD 476), MSDSP (flour and cement), KALAM (pipes) |
| *Installation costs* | 1500 Somoni (USD 476) for turbine, generator, switchbox and transportation |
| *Initiative taken by/ when* | Villagers of Barmev |
| *Maintenance costs* | Monthly salary for 2 workers (and maybe 10-15 *somoni*/hh for using the transmission lines belonging to PEC) |
| *Schedule for power distribution* | All day and night |
| *Connected villages (households/ inhabitants) public buildings* | Barmev (27, 230), Shosh (44, 345), total (71, 575), with transformer they could supply another 40 hh. |
| *Electricity fee per month or kWh* | 1 *somoni*/month/hh (USD 0.32) |
| *Major problems* | Pool is damaged and too small, requiring a bigger one. Turbine is not anchored because of lack of material. |
| *Number of workers at the MHPS* | 2 |
| *Village connected to PEC grid* | Yes, during summertime (May to December) |
| *Electricity usage purposes* | Actual capacity so far only for lighting |
| *Construction proceedings* | They want to have electricity during wintertime, too. Fees from the PEC are too high, so they want to become independent of the PEC. |
| *GPS point* | 004, elev. 2688, N 37 º21'35.6", E 071º39'56.8" |
| *Further information* | Have sufficient run-off all year, even for higher capacity |

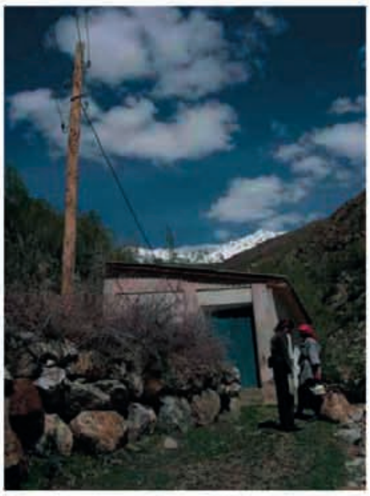
## MHPS Barrushan (Barrushan/ Rushan) completed

| | |
|---|---|
| *Date of inspection* | 17.7.2003 |
| *Year of completion* | 2003 |
| *Damaged at date of inspection?/ working since when* | No/ working since Jan 2003 with 75 KW set, 2nd and 3rd set still under construction. Completion planned for end of 2003 |
| *Installed capacity/ actual output* | 305kW/ expected 305kW/ 3 sets of 75kW, 100kW and 130kW |
| *Type (turbine and generator)* | Pump as turbine and Pelton turbine ("the best one!"), horizontal |
| *Owner* | VO Barrushan |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 132m/ -/ -/ 920m/ - |
| *Generated power/day kWh (hours x average capacity)* | 7320kWh: 305kW x 24 hours |
| *Seasonal differences in power generation* | Only running in wintertime, whenever there is no supply from the PEC |
| *Project financed through* | SDC, UN, Japan, villagers (USD 698, cattle, food) |
| *Installation costs* | From donors USD 42,770 |
| *Initiative taken by/ when* | Villagers of Barrushan |
| *Maintenance costs* | Monthly salary 25 *somoni* (USD 7.94) per capita |
| *Schedule for power distribution* | None |
| *Connected villages/ households/ public buildings* | Barrushan (413, 2332) |
| *Electricity fee per month or kWh* | 2 *somoni*/month/hh (USD 0.63), after completion fee according to the meter |
| *Major problems* | Can cope with the problems they have |
| *Number of workers at the MHPS* | 6 workers (2 at each MHPS) |
| *Village connected to PEC grid* | Yes, during summertime |
| *Electricity usage purposes* | Lighting, TV, shop, phone, handcrafts workstation. |
| *Construction proceedings* | On July 27th 2001 construction of the big MHPS began. A 35kW MHPS was completed in 2000. A cascade of 3 MHPS is planned. 1st with 35kW, 2nd with 305kW and 3rd with ?kW |
| *GPS point* | 024, elev. 2140m, N 37°56'43.3", E 071°27'11.1" |
| *Further information* | Will establish a garden at the MHPS. Will plant fruit-trees and make jam out of the fruit as income for maintenance. |

## *MHPS Basid (Basid/ Rushan) completed*

| | |
|---|---|
| *Date of inspection* | 19.6.2003 |
| *Year of completion* | 2001, worked for a total of 18 months, the rest of the time it was broken, regularly working since March 2003 |
| *Damaged at date of inspection?/ working since when* | No/ working since December 1999 |
| *Installed capacity/ actual output* | 100kW/ low 70kW in March and April |
| *Type (turbine and generator)* | Horizontal turbine and generator with flywheel |
| *Owner* | VO Basid |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 27m/ 62m/ 0.80m/ - |
| *Generated power/day kWh (hours x average capacity)* | 1680kWh: 70kW x 24 hours |
| *Seasonal differences in power generation* | Not running in very cold months (January, February), because the water freezes in the pool. |
| *Project financed by* | Food for Work (MSDSP), UK Embassy (USD 35,000), SDC (USD 5994) |
| *Installation costs* | USD 40,994 (of it USD 7910 FFW) |
| *Initiative taken by/ when* | Villager of Basid/ 1993 |
| *Maintenance costs* | Monthly salaries for 4 workers: 120 *somoni* (USD 38.10) and about 60 *somoni* (USD 19.05) for maintenance and spare parts |
| *Connected villages/ households/ public buildings* | Basid (134, 680), school, hospital, *hukumat*, club |
| *Electricity fee per month or kWh* | 2 *somoni*/month/hh (USD 0.63), but also in potatoes (4kg/month), socks (1 pair/month), tobacco (200gr./month) or wheat (3kg/month) |
| *Major problems* | Water channel is not cemented, pool freezes in winter, causing cracks, erosion from the pool down the pipe, old equipment |
| *Number of workers at the MHPS* | 4, stay night and day |
| *Village connected to PEC grid* | No |
| *Electricity usage purposes* | Cooking, heating water, lighting, tape recorder, baking, TV, |
| *Construction proceedings* | Turbine and generator from MSDSP, villagers contributed labor, no money. Started in 1999, were working 1 year on the channel and 1 year on the MHPS |
| *GPS point* | 012, elev. 2423m, N 38º05'53.1", E 072º09'03.2" |
| *Further information* | Three transformers in the village |

## *MHPS Bodom (Tavdem/ Roshtkala) completed*



| | |
|---|---|
| *Date of inspection* | 2.6.2003 |
| *Year of completion* | December 1998 |
| *Damaged at date of inspection?/ working since when* | No/ working since December 1998 |
| *Installed capacity/ actual output* | 2 turbines: 25kW & 18kW, one used at a time depending on run off, generator 50Hz, horizontal unit |
| *Owner* | VO Bodom |
| *Generated power/day kWh (hours x average capacity)* | 600kWh: 25kW x 24 hours (0-24h) |
| *Seasonal differences in power generation* | Only running in wintertime (October to April), whenever there is no supply from the PEC |
| *Project financed by* | Food for Work (MSDSP), SDC (USD 5449), MSDSP |
| *Initiative taken by/ when* | Qudrat (VO president Bodom/ 1994 |
| *Maintenance costs* | No salary for the worker, but he received a plot around the MHPS as a gift from the villagers. |
| *Schedule for power distribution* | Wintertime 8-17h school provided, 17-8h all hh supplied. |
| *Connected villages/ households/ public buildings* | 4: Bodom (19, 173), Pish (22, 161), Dolchaden (15, 46), Bodomi Bolo (32, 234), Total (88, 614) |
| *Electricity fee per month or kWh* | 2 *somoni*/hh/year(USD 0.63) |
| *Major problems* | Not with turbine or generator. Every year they have to repair the wall of the building, which is damaged by melting snow. |
| *Number of workers at the MHPS* | 1 (VO president) |
| *Village connected to PEC grid* | Yes, during summertime. Was connected to the grid in 1962 and had permanent supply till 1993. |
| *Electricity usage purposes* | Lighting, tape recorder, radio, TV, occasionally cooking or heating water. |
| *Construction proceedings* | Qudrat bought generator and turbines in 1993 from Russian soldiers in Porshnev. In 1998 the MSDSP helped with further materials and construction work. |
| *GPS point* | 002, elev. 2179m, N 37º25'32.1'', E 071º39'08.0'' |
| *Further information* | They would like to have a 2nd or even 3rd MHPS in order to have good capacity for other purposes such as cooking. |

### *MHPS Chadud (Basid/ Rushan) completed*

| | |
|---|---|
| *Date of inspection* | 19.6.2003 |
| *Year of completion* | December 1996 |
| *Damaged at date of inspection?* | Yes, since two months |
| *Installed capacity/ actual output* | 12kW (the lines would melt); (normally: 4kW) |
| *Type (turbine and generator)* | Horizontal, high pressure, pump |
| *Owner* | VO Chadud |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 27 m/ 60 m/ -/200m/ very small pool |
| *Seasonal differences in power generation* | No seasonal differences |
| *Project financed by* | Villagers |
| *Installation costs* | Every hh contributed 20 *somoni* (also paid with livestock) about 3000 *somoni* (USD 1000) |
| *Initiative taken by/when* | Villagers of Chadud/1995 |
| *Maintenance costs* | The bearings must be changed often |
| *Schedule for power distribution* | 18-24h |
| *Connected villages/ households/ public buildings* | Chadud, 20 hh; 120 persons (not all hh are connected: 174 villagers, 31 hh) |
| *Electricity fee per month or kWh* | They don't pay anything |
| *Major problems* | Lack of transmission lines. They would melt if they would produce 12kW (full capacity). Wrong installation of lines: short circuit. At the time of observation a flood washed away the intake of the canal. Every month new bearings must be purchased (not centred axle). |
| *Number of workers at the MHPS* | Engineer earns 20 *somoni*/month (Gulbek) |
| *Village connected to PEC grid* | No |
| *Electricity usage purposes* | Mainly for light |
| *Construction proceedings* | Initiated by Mirso Kabilov, who constructed a small one for his hh (tractor dynamo). This sparked interest among the people, who wanted an MHPS for the whole village. All villagers helped to construct it (although not all are supplied) |
| *GPS point* | 013: elev. 2435m; N 38°07'28,2"; E 072°11'45,3" |
| *Further information* | They would need 15-17km of transmission lines (good ones) |

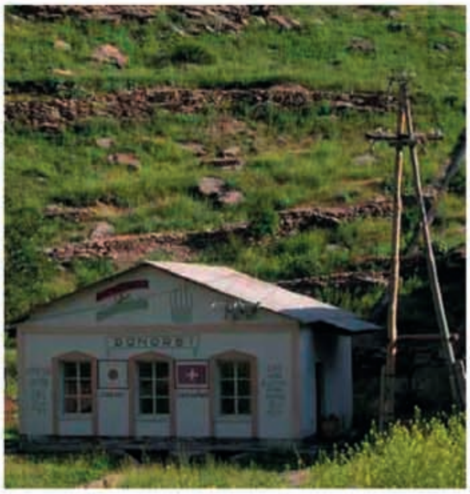
## MHPS Darjomch/ Chowoj (Bartang/ Rushan) completed

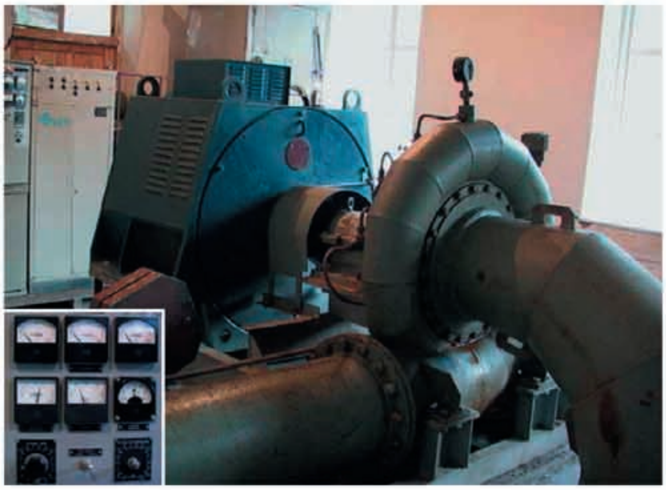
| | |
|---|---|
| Date of inspection | 18.6.2003 |
| Year of completion | February 2002 |
| Damaged at date of inspection? | Yes |
| Installed capacity/ actual output | 200kW/ max. ever produced output: 120kW |
| Type (turbine and generator) | Handmade in Khorog, horizontal, high pressure, half automatic |
| Owner | VO Darjomch |
| Head/ pipe length/ water channel length/ pool volume/ discharge | 175m/ 420m/ no water canal/ 30 $m^3$/ at least 100 $m^3$/s |
| Generated power/day kWh (hours x average capacity) | 30'000kWh (in May 2003), 60,000 kWh/month (winter) |
| Project financed by | SDC, food for work |
| Installation costs | USD 50,621 |
| Initiative taken by/ when | Kurbonali (PEC) |
| Maintenance costs | Is paid by the VO |
| Schedule for power distribution | Not running during lunch time |
| Connected villages/ households/ public buildings | Darjomch (48/237), (Ravivd 36/167), Razuj (50/249); 2 schools; 2 med-points; total: 134hh/ 653p |
| Electricity fee per month or kWh | USD 0,0023/kWh (each hh pays the same amount) |
| Major problems | Wear on ball bearings |
| Village connected to PEC grid | No |
| Electricity usage purposes | Light, cooking, baking, even for heating in some hh |
| Construction proceedings | Initiated by Kurbonali, MSDSP looked for donors |
| GPS point | 010: N 38°05'43,3"; E 071°55'20,5" |
| Further information | The turbine is a prototype. Since the beginning they have continuously increased the output (from 60-120kW). There is a spare area for a second turbine. This MHPS could generate more electricity than is needed |

## *MHPS Deh (Shidz/ Rushan) completed*


| | |
|---|---|
| *Date of inspection* | 17.7.2003 |
| *Year of completion* | 1999 |
| *Damaged at date of inspection?/ working since when* | No/ operating since 1999 |
| *Installed capacity/ actual output* | 37kW/ average 37kW, in wintertime lack of water |
| *Type (turbine and generator)* | Twin pump, horizontal, high pressure |
| *Owner* | VO Deh |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 84m/ 225/ -/ 800m/ - |
| *Generated power/day kWh (hours x average capacity)* | 888kWh: 37kW x 24 hours: from April to November |
| *Seasonal differences in power generation* | Running from April to November, in winter lack of water, so out of order. |
| *Project financed by* | Food for Work (USD 1050), MSDSP (fuel USD 850), SDC (USD 2384), about 50 sheep from villagers (or 30-40 *somoni* per hh) |
| *Installation costs* | Switchboard USD 150, generator USD 300, cement and fuel from MSDSP |
| *Initiative taken by/ when* | Villagers of Deh |
| *Maintenance costs* | Monthly salaries for 2 workers 50 *somoni* (USD 15.87) |
| *Schedule for power distribution* | None |
| *Connected villages/ households/ public buildings* | Deh (71, 398) |
| *Electricity fee per month or kWh* | 0.03 *somoni*/kWh (USD 0.01) |
| *Major problems* | Water channel not cemented, bearing gets damaged through vibrations, lack of water in wintertime |
| *Number of workers at the MHPS* | 2 (salary: 25 *somoni*/month/capita) |
| *Village connected to PEC grid* | No, up to 1993 connected to Nurek lines. |
| *Electricity used for what purposes* | Lighting, radio, TV, kettle, stove |
| *Construction proceedings* | Construction work took 3 months |
| *GPS point* | 026, elev. 2150m, N 38º03'19.8", E 071º18'04.8" |
| *Further information* | The transmission lines connecting Deh to the Nurek grid were destroyed during the period of civil war. |

## *MHPS Emts (Rushan/ Rushan) completed*





| | |
|---|---|
| *Date of inspection* | 17.6.2003 |
| *Year of completion* | July 2001 |
| *Damaged at date of inspection?* | No |
| *Installed capacity/ actual output* | 100kW/ 100kW |
| *Type (turbine and generator)* | Horizontal, high pressure |
| *Owner* | VO Emts |
| *Head/diameter/discharge/pool volume/ canal length* | 32m/ 50cm/ 0.4m$^3$/s/ 27 m$^3$/ 180m |
| *Generated power per day* | 2400kWh: 100kW x 24h |
| *Project financed by* | USD 31,586 (SDC), USD 31,986 (Canton of Geneva), USD 20,657 (Japan), USD 4000 (UN, 12 tons of flour: FFW), others |
| *Installation costs* | Total: USD 88,229 |
| *Initiative taken by/ when* | MSDSP supported |
| *Maintenance costs* | Monthly salary (30 *somoni* (USD 9.2), a few ball bearings |
| *Schedule for power distribution* | Running day and night (no schedule) |
| *Connected villages/ households/ inhabitants* | Emts (101/467), Bagu (28/141); Total: 135 hh |
| *Electricity fee per month or kWh* | <200 kWh/month: 0,75 *diram*/kWh (USD 0.24 cents); >200 kWh/month: 2.25 *diram* (USD 0.71 cents) |
| *Major problems* | After 5 days operation, there was a huge rockfall, which damaged the canal. Now: no more problems. |
| *Number of workers at the MHPS* | 5 |
| *Village connected to PEC grid* | Since there is an MHPS the village is disconnected from the Shujand grid |
| *Electricity usage purposes* | Lighting, baking, cooking |
| *Construction proceedings* | Before, villagers installed a small one (37kW) on their own. "The sound of the hammer was heard by the MSDSP", and construction was supported by the MSDSP |
| *GPS point* | 008, elev. 2077m, N 38°00'26.2", E 071°40'00.5" |
| *Further information* | The capacity from Shujand grid was not sufficient. They had to collect a lot of firewood from the forest (now they use much less). If they would have more money, they could construct a bigger one: 150kW, automatic. Each hh has a meter. |

## MHPS Khidorjev (Tavdem/ Roshtkala) completed

| | |
|---|---|
| *Date of inspection* | 10.6.2003 |
| *Year of completion* | 1997 |
| *Damaged at date of inspection?/ working since when* | No/ working since 1997 |
| *Installed capacity/ actual output* | 25kW/ depending on run off up to 30kW |
| *Type (turbine and generator)* | Pump as turbine, horizontal unit |
| *Owner* | Owner of the car repair service |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 150m/ -/ -/ 1000m/ - |
| *Generated power/day kWh (hours x average capacity)* | 600kWh: 25kW x 24 hours |
| *Seasonal differences in power generation* | Only running in wintertime (November to April), when there is no electricity supply from PEC |
| *Project financed by* | Villagers, MSDSP |
| *Initiative taken by/ when* | Owner of car repair service/ 1997 |
| *Maintenance costs* | Volunteer work, no salaries |
| *Schedule for power distribution* | Wintertime: 6 to 24 h |
| *Connected villages/ households/ public buildings* | Khidorjev (42, 302), Rijist (10, 70), Total (52, 372) |
| *Electricity fee per month or kWh* | None, it is for free |
| *Major problems* | Problems with the bearing, but they are able to repair it. |
| *Number of workers at the MHPS* | 2 (stay over night, and are on duty every second day) |
| *Village connected to PEC grid* | Yes, in summer |
| *Electricity usage purposes* | Lighting, radio |
| *Construction proceedings* | The owner of a car repair service also needed electricity during wintertime in order to continue his business. |
| *GPS point* | 005, elev. 2319m, N 37°24'11.4", E 071°38'25.1" |
| *Further information* | A carpentry enterprise is also connected to the MHPS, and another small enterprise is waiting to be connected. They want to construct a bigger MHPS with 100kW capacity. |

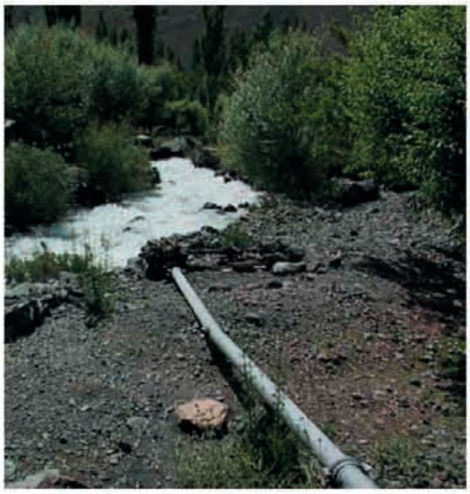
## *MHPS Khidorjev (Tavdem/ Roshtkala) completed*

| | |
|---|---|
| *Date of inspection* | 10.6.2003 |
| *Year of completion* | 1991 |
| *Damaged at date of inspection?* | No |
| *Installed capacity/ actual output* | About 15kW |
| *Type (turbine and generator)* | Twin pump as turbine, horizontal unit |
| *Owner* | Villager |
| *Head/ pipe length/ water channel length* | 10m/ 25m/ 100m |
| *Seasonal differences in power generation* | Only running in wintertime (November to April), when there is no supply from PEC grid |
| *Project financed by* | Owner |
| *Initiative taken by/ when* | Villager/ 1991 |
| *Maintenance costs* | Volunteer work, no salaries |
| *Schedule for power distribution* | Wintertime 6-24 h |
| *Connected villages/ households* | About 30 neighbouring hh |
| *Electricity fee per month or kWh* | None, it is for free |
| *Major problems* | Only minor problems, and they are able to repair it |
| *Number of workers at the MHPS* | Only one |
| *Village connected to PEC grid* | Yes, during summertime |
| *Electricity usage purposes* | Lighting, radio |
| *Construction proceedings* | After 1991 the village was only supplied with electricity during summer time. Inventor took initiative to have at least light during wintertime. |
| *Further information* | The canal is covered with scrap metal in order to protect the water from freezing in wintertime. The creator installed another one a little bit further up the brook. When something gets broken, other households contribute labor or money to repair it |

## MHPS Pasor (Savnob/ Rushan) completed

| | |
|---|---|
| *Date of inspection* | 20.6.2003 |
| *Year of completion* | May 2000 |
| *Damaged at date of inspection?* | Yes, it never worked properly |
| *Installed capacity/ actual output* | 100kW/ 30-40kW |
| *Type (turbine and generator)* | High-pressure, horizontal |
| *Owner* | VO Pasor |
| *Head/ pipe length/ diameter/ water channel length/* | 25m/ 55m/ ca.1m/ 500m |
| *Seasonal differences in power generation* | There is no lack of water in winter |
| *Project financed by* | SDC, Food for Work |
| *Installation costs* | USD 50,961 |
| *Initiative taken by/ when* | MSDSP, without participation of the villagers. |
| *Connected villages/ households/ public buildings* | Pasor (30hh), Bopasor (24hh), Gudara (57hh); 3 schools, 2 med-points; Total: 111hh/ 652p |
| *Electricity fee per month or kWh* | 1 *somoni*/month (only when it works) |
| *Major problems* | Petrol is required to run the welding torch. Half of the poles to Gudara are broken (bad wood). They first installed the turbine, and the generator did not fit and turned the wrong way. They then had to obtain a gear unit (small picture) changing the direction of turning. Major conflicts among villages connected to the system. Pasor can only run the generator on low capacity (for self-consumption), and it would get damaged if they would supply the other villages. They will have soon violent clashes. |
| *Number of workers at the MHPS* | 3 people are working |
| *Village connected to PEC grid* | No |
| *Electricity usage purposes* | Only for light |
| *Construction proceedings* | In 1992 they could not find any donors, and thus started in March 1999, completing construction in November 1999. Wanted to have electricity all year. |
| *GPS point* | 016: elev. 3020; N 38°24'35,1"; E 072°35'34,3" |
| *Further information* | Engineer: Olem Polnasarov (hired by the MSDSP). Even if they could weld the broken part, it would last only for some weeks and would supply only their village. Max. period of operation: 2 months |

## *MHPS Pastbadjuv (Pastkhuf/ Rushan) completed*



| | |
|---|---|
| *Date of inspection* | 16.6.2003 |
| *Year of completion* | 2000 |
| *Damaged at date of inspection?* | No |
| *Installed capacity/ actual output* | 5kW/ 4-5kW |
| *Type (turbine and generator)* | Twin pump, high pressure, horizontal |
| *Owner* | VO Pastbadjuv |
| *Head/ pipe length/ water channel length/* | 10 m/ 95 m (some parts are used for irrigation canal)/ 30 m |
| *Generated power per day* | 30kWh: 5kW x 6 hours |
| *Seasonal differences in power generation* | It works 5 months (during wintertime: beginning of November-end of April) when the village is not connected to the PEC grid. |
| *Project financed by* | Villagers; each hh donated one sheep which equals 25 *somoni* (USD 7.90) |
| *Cost for installation* | Turbine: 150 *somoni* (USD 47.60); generator: 150 *somoni* (USD 47.60); tube: donated by the MSDSP; gear: 80 *somoni* (USD 25.40), Each hh donated one sheep (25 *somoni*) |
| *Initiative taken by/ when* | Villagers of Pastbadjuv. Initiator: Dilovar Lutivishoev |
| *Maintenance costs* | 40 *somoni*/year for lubricant, oil, bearings |
| *Schedule for power distribution* | Only running in winter (beginning of November- 24. of April) from 18–24h |
| *Connected villages/ households/* | Only for some hh in Pastbadjuv |
| *Electricity fee per month or kWh* | 1 *somoni*/month (only the connected hh pay the fee) |
| *Major problems* | They do not have any cement. Tube is too narrow. Bearings sometimes get broken. |
| *Number of workers at the MHPS* | Two persons: 10 *somoni*/month (USD 3.10), only during wintertime |
| *Village connected to PEC grid* | Yes, it is connected from end of October till beginning of March |
| *Electricity usage purposes* | Light (1-2 bulbs/hh), radio, TV, tape recorder |
| *Construction proceedings* | Villagers gathered money and purchased the equipment in Khorog (private). They constructed it because they had a lack of diesel for the lamps. |
| *GPS point* | 020: elevation 2097m; N 37°48'01,7" E071°35'55,5" |
| *Further information* | Village would have water for 75kW generator. New project: 75-100kW generator; construction of an engine room. This would allow use coil cookers, stoves and heaters. USD 300 would be needed for this. Capacity of 1kW/hh would be sufficient. |

## *MHPS Pastkhuf (Pastkhuf/ Rushan) completed*

| | |
|---|---|
| *Date of inspection* | 16.7.2003 |
| *Year of completion* | 2000 |
| *Damaged at date of inspection?/ working since when* | No/ working since 2000 |
| *Installed capacity/ actual output* | 2 in 1: 35kW & 60kW/ separate distribution |
| *Type (turbine and generator)* | Pump as turbine, horizontal, two pipes lead to the turbines |
| *Owner* | VO Pastkhuf |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 45m/ 90m/ -/ 400m/ 31.5m$^3$ |
| *Generated power/day kWh (hours x average capacity)* | 2280kWh: 95kW x 24 hours |
| *Seasonal differences in power generation* | Only running in wintertime (November to May), whenever there is no supply from the PEC |
| *Project financed by* | MSDSP (USD 12,000), villagers (worked for free), gathered money (5 *somoni*/hh) and agricultural products |
| *Initiative taken by/ when* | Maxim from Pastkhuf/ 1992 |
| *Maintenance costs* | Salary: 8 *somoni* (Usd 2.54)/month/capita |
| *Schedule for power distribution* | None, restriction: forbidden to use for heating |
| *Connected villages/ households/ public buildings* | 35kW set: Pastkhuf (120, 600), 60kW set: Pastkhuf (85, 425), Bobolangar (9, 45) |
| *Electricity fee per month or kWh* | 1 *somoni*/month/hh (USD 0.32) |
| *Major problems* | Problems with the bearing. The turbine sometimes turns back into a pump, pumping the water up to the pool again. |
| *Number of workers at the MHPS* | 6, 2 teams of 3 workers. Each of them responsible for one set. |
| *Village connected to PEC grid* | Yes, during summertime (May to November) |
| *Electricity usage purposes* | Lighting |
| *Construction proceedings* | Started in 1999, completed in 2000 and are now finishing the building. Only in 2003 did the MSDSP help them with wood and cement for the building. |
| *GPS point* | 021, elev. 2075m, N 37º52'00.4", E 071º36'43.9" |
| *Further information* | The water channel for the MHPS is the irrigation channel for the village of Yoz. |

## MHPS Poimazor (Rovand/ Vanj) under construction

| | |
|---|---|
| *Date of inspection* | 18.7.2003 |
| *Year of completion* | Expected date of completion: End of 2003 |
| *Damaged at date of inspection?/ working since when* | Under construction. Started on Mai 20th 2002 |
| *Installed capacity/ actual output* | 100kW/ 100kW expected |
| *Type (turbine and generator)* | Handmade turbine, horizontal |
| *Owner* | VO Poimazor |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 50m/ 320/ 0.42m/ -/ - |
| *Generated power/day kWh (hours x average capacity)* | 2400kWh: 100kW x 24 hours |
| *Seasonal differences in power generation* | Planned: all year, day and night. |
| *Project financed by* | MSDSP, UK Embassy (USD 61,016), VO (salary), SDC (USD 10,555) |
| *Cost for installation* | USD 71,571 |
| *Initiative taken by/ when* | Villagers of Poimazor |
| *Maintenance costs* | Monthly salary for 2 workers: 28 *somoni* (USD 8.88) |
| *Schedule for power distribution* | None |
| *Connected villages/ households/ public buildings* | Poimazor (56, 376), Van Vani Bolo (44, 280), Van Vani Poyon (16, 105), Sumgad (13, 69), total (129, 830) |
| *Electricity fee per month or kWh* | Not yet decided, but according to the meter |
| *Major problems* | Destruction of water channel by mud flow |
| *Number of workers at the MHPS* | Planned, 5 |
| *Village connected to PEC grid* | No, but Poimazor was connected from 1973 to 1991 to Vanj center HPS. During civil war power lines were damaged by avalanches and rockfalls. |
| *Electricity usage purposes* | Expected to run all appliances |
| *Construction proceedings* | In a VO meeting wishes for electricity were expressed and the request was accepted by the British Embassador. |
| *GPS point* | 030, elev. 2093m, N 28°39'31.1", E 071°58'16.9" |
| *Further information* | Mud flow in July 2003 postponed the completion planned for August 2003, killing two workers, washing away parts of the water channel and a lot of equipment. |

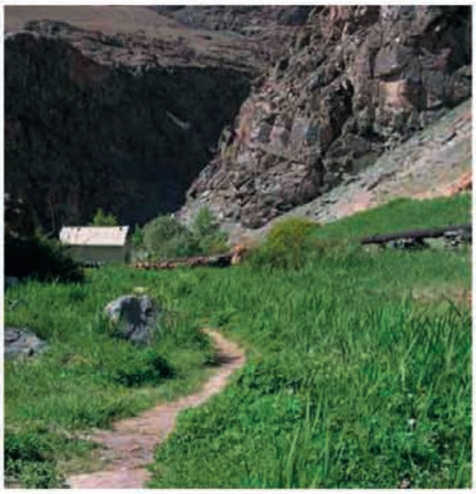
## MHPS Rijist (Tavdem/ Roshtkala) completed

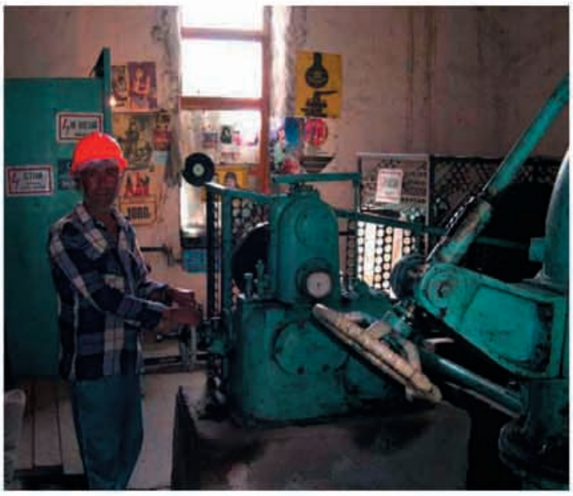
| | |
|---|---|
| *Date of inspection* | 10.6.2003 |
| *Year of completion* | 1999 |
| *Damaged at date of inspection?/ working since when* | No/ working since 1999 (during wintertime) |
| *Installed capacity/ actual output* | 10kW/ 7kW with low run off, horizontal unit |
| *Owner* | Muborakhshov |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 46m/ - |
| *Generated power/day kWh (hours x average capacity)* | 180kWh: 10kW x 18 hours (6 to 24h) |
| *Seasonal differences in power generation* | Only running in wintertime (November to March) |
| *Project financed by* | Villagers provided food and cash to purchase turbine and generator, MSDSP provided 3 pipes. |
| *Initiative taken by/ when* | Villager of Rijist/ 1998 |
| *Maintenance costs* | No salary, in case of repair maybe some food |
| *Schedule for power distribution* | Wintertime 6-24 h |
| *Connected villages/ households/ public buildings* | Rijist (70hh) |
| *Electricity fee per month or kWh* | No regular fee. In case of repair hh provide cash or food as payment. |
| *Major problems* | Needs another pipe. Turbine and generator are not fixed to the ground, so that vibration damages the bearing. No building to cover the infrastructure. |
| *Number of workers at the MHPS* | No regular workers |
| *Village connected to PEC grid* | Yes, during summertime (April to October) |
| *Electricity usage purposes* | Lighting |
| *Construction proceedings* | Sahid, an electrician, took the initiative 5 years ago. Purchased generator from the village of Tavdem and turbine from Khorog. Food and money was collected from the hh to purchase the equipment. |
| *GPS point* | 006, elev. 2350m, N 37º24'25.4", E 071º38'02.6" |

## *MHPS Roshorv (Savnob/ Rushan) completed*

| | |
|---|---|
| *Date of inspection* | 2.7.2003 |
| *Year of completion* | September 1998 |
| *Damaged at date of inspection?/ working since when* | Yes, it only operated 23 days |
| *Installed capacity* | 128kW (50Hz), it never generated very much. |
| *Type (turbine and generator)* | High pressure, Horizontal |
| *Owner* | VO Roshorv |
| *Head/ Pipe length* | 25m/ 68m |
| *Project financed by* | Villagers |
| *Cost for installation* | USD 18'000 |
| *Initiative taken by/ when* | Villagers of Roshorv/ 1998 |
| *Seasonal differences* | Always sufficient water |
| *Schedule for power distribution* | It worked only at night: 18.00-24.00 |
| *Connected villages/ households* | Roshorv/ 165 hh |
| *Electricity fee per month or kWh* | They never collected money |
| *Major problems* | Need to replace some rubber parts on the bearing every 3 days |
| *Number of workers at the MHPS* | 2 (stay over night, are on duty every second day) |
| *Village connected to PEC grid* | Yes, during summertime (May to October) |
| *Electricity usage purposes* | Light, TV, radio |
| *Construction proceedings* | Period of construction: 1989-1991. Villagers used to have a diesel generator (mainly for light), but after the cessation of diesel supply villagers took initiative to construct an MHPS. Villagers sold their cattle to purchase the turbine. They got the generator from the diesel plant, and brought it down by caterpillar (no road to the MHPS). They received 5 tons of cement from the MSDSP. |
| *GPS point* | 017: elev. 2759 N 38°17'57"; E 072°19'59,6" |
| *Further information* | The engineer became ill, went to Khorog and did not come back. The engine house is not covered. Villagers had problem transporting the generator (1200kg) to the site. |

## *MHPS Savnob (Savnob/ Rushan) completed*





| | |
|---|---|
| *Date of inspection* | 20.6.2003 |
| *Year of completion* | 1989 |
| *Damaged at date of inspection?/ working since when* | No/ working since 1989 |
| *Installed capacity/ actual output* | 80kW/ average 40kW because of lack of water |
| *Type (turbine and generator)* | VOITH St. Polten 1950, horizontal unit |
| *Owner* | PEC |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | -/ 300m/ 0.30m/ -/ - |
| *Generated power/day kWh (hours x average capacity)* | Summertime: 280kWh: 40kW x 7 hours (17 to 24h)<br>Wintertime: 560kWh: 40kW x 14 hours (5 to 12h & 17 to 24h),<br>May 2003: 11,809kWh, June 2003: 7210kWh, |
| *Seasonal differences in power generation* | Running year round. |
| *Project financed by* | Soviet Union |
| *Maintenance costs* | Monthly salaries for 2 workers: 110 *somoni* (USD 34.92) |
| *Schedule for power distribution* | Summertime: 17-24h, wintertime: 5-12h & 17-24h |
| *Connected villages/ households/ public buildings* | Savnob (58, 341), hospital, school, guesthouse, Hukumat |
| *Electricity fee per month or kWh* | PEC fees |
| *Major problems* | Lack of water and thus low capacity |
| *Number of workers at the MHPS* | 2, change duty every 3 days |
| *Village connected to PEC grid* | No |
| *Electricity usage purposes* | Cooking, heating water, lighting, tape recorder, baking, TV, lighting, iron |
| *Construction proceedings* | It took 1.5 years to complete construction. Villagers were paid for the labor. |
| *GPS point* | Point 015, elev. 2630m, N 38°18'53.5", E 072°24'16.0" |
| *Further information* | Wanted to connect the neighbouring village of Nisur, but no transmission lines were available. |

## *MHPS Shipad (Shidz/ Rushan) completed*

| | |
|---|---|
| *Date of inspection* | 17.7.2003 |
| *Year of completion* | 1993 |
| *Damaged at date of inspection?/ working since when* | No/ working since 1993 without major problems |
| *Installed capacity/ actual output* | 37kW/ summertime 37kW, wintertime 30kW (generator 37kW, turbine 100 kW), horizontal unit |
| *Owner* | VO Shipad |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 13m/ 160m/ 0.40m/ 350m/ - |
| *Generated power/day kWh (hours x average capacity)* | 888kWh: 37kW x 24 hours |
| *Seasonal differences in power generation* | Year round, night and day |
| *Project financed by* | MSDSP (USD 2340), villagers |
| *Initiative taken by/ when* | Villagers/ MSDSP |
| *Maintenance costs* | Monthly salary for 1 worker: 15 *somoni* (USD 4.76). Two years ago they a new generator was purchased for 1000 *somoni* (USD 317.50). |
| *Schedule for power distribution* | None |
| *Connected villages/ households/ public buildings* | Shipad (26hh) & Dasht (18hh) plus 5hh under construction |
| *Electricity fee per month or kWh* | 0.05 *somoni*/kWh (USD 0.016 ) |
| *Major problems* | Lack of water, leaking pipe |
| *Number of workers at the MHPS* | 1 |
| *Village connected to PEC grid* | No, but obtained electricity from Nurek from 1983 up to 1992. |
| *Electricity usage purposes* | Lighting, TV, sometimes for heating water in summer. In wintertime only lighting, because the pipes are too big, and cannot get high pressure on the turbine (lack of run-off). |
| *Construction proceedings* | Villagers made a request for electricity. MSDSP implemented the project. Shipad was one of the first villages to have an MHPS. |
| *GPS point* | 027, elev. 1946m, N 38º06'30.3'', E 071º20'01.6'' |
| *Further information* | Conflict with a neighboring village over the use of water. New irrigation channel was built to solve the problem. |

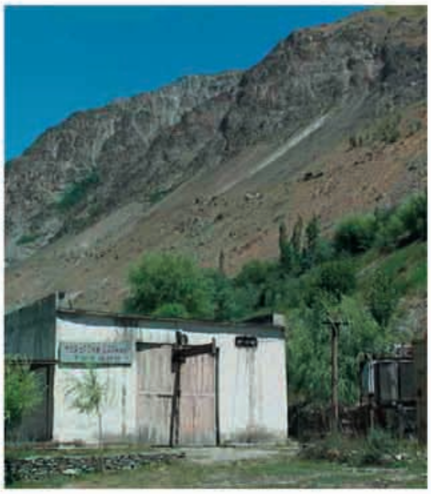
## *MHPS Shujand(Rushan/ Rushan) completed*

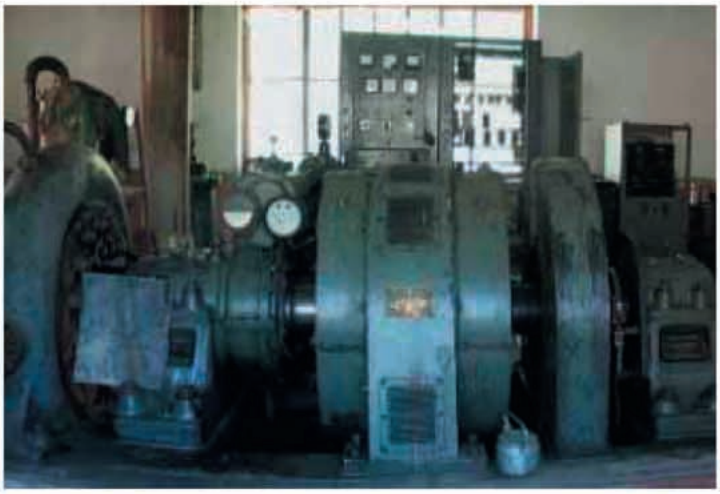
| | |
|---|---|
| *Date of inspection* | 17.6.2003 |
| *Year of completion* | 1969 |
| *Damaged at date of inspection?* | No |
| *Installed capacity/ actual output* | 2x400kW/ 600kW |
| *Type (turbine and generator)* | Vertical turbine, low pressure |
| *Owner* | PEC |
| *Head / water channel length/ discharge* | 9m/ 4km/ 10m$^3$/s |
| *Generated power/ month kWh* | 300,000kW/ month (in summer) 250,000kW/month (in winter); June 2003: 349,440 kWh |
| *Seasonal differences in power generation* | During winter months 20% less production |
| *Project financed by* | *Hukumat* |
| *Initiative taken by/ when* | *Hukumat* |
| *Maintenance costs* | Workers used to earn officially 60-70 *somoni*/month (USD 19-22), in fact: 20-45 *somoni*/month (USD 6-15), since it belongs to the PEC they receive a regular salary: 80-90 *somoni*/month (USD 25-30) |
| *Schedule for power distribution* | During winter (end of November-beginning of March) the sub grids are scheduled (with some areas cut during a certain time) |
| *Connected villages/ households/ public buildings* | Shujand (197hh/960p), Rushan (734hh/4051p); Total (931hh/ 5011p) |
| *Electricity fee per month or kWh* | USD 0.25 cents/kWh (new PEC price), 0,5 *diram* (old price) |
| *Major problems* | In spring when water level increases the river sometimes washes away the intake of the channel |
| *Number of workers at the MHPS* | 10 persons, two permanent (24h running), and always two people working (only men) |
| *Village connected to PEC grid* | No |
| *Electricity usage purposes* | Lighting, TV, radio (not sufficient for heating, in winter there is insufficient capacity) |
| *Construction proceedings* | Project was initiated by Rushani people, and mainly local people constructed it. |
| *GPS point* | 007, elev. 2370m, N 37º57'50.2", E 071º37'29.3" |
| *Further information* | During Soviet time (1980's) there were diesel generators (3x800kW). "It is better to belong to a big company." People cannot heat water during winter. |

## *MHPS Siponj (Bartang/ Rushan) completed*

| | |
|---|---|
| *Date of inspection* | 18.6.2003 |
| *Year of completion* | 1992 |
| *Damaged at date of inspection?/ working since when* | No/ working since 1992 |
| *Installed capacity/ actual output* | 2x80kW/ average 70kW/ one set has been broken since 1996, the other one not working at full capacity |
| *Type (turbine and generator)* | Horizontal, high pressure |
| *Owner* | PEC |
| *Generated power/day kWh (hours x average capacity)* | 1680kWh: 70kW x 24h, May 2003: 39,442 kWh, June 2003: 37,600 kWh |
| *Seasonal differences in power generation* | Running all year. In wintertime (December to April) lack of water, thus only 60kW output |
| *Project financed by* | Hukumat |
| *Maintenance costs* | Monthly salary for 7 employees 350 *somoni* (USD 111.11) |
| *Schedule for power distribution* | None |
| *Connected villages/ households/ public buildings* | Khidjez (38, 240), Dasht (37, 172), Visav (31, 167), Siponj (96, 442), total (202, 621) |
| *Electricity fee per month or kWh* | PEC fees/kWh |
| *Major problems* | One set is broken, resulting in too much excess water, stones in the turbine, pool freezes, avalanches and rock falls damaging the building |
| *Number of workers at the MHPS* | 7 employees, including 4 workers (salary: 50 *somoni*/month/capita equals USD 15.87) |
| *Village connected to PEC grid* | No |
| *Electricity usage purposes* | Lighting, TV, radio |
| *GPS point* | point 009, elev. 2171m, N 38º03'25.8", E 071º51'47.0" |
| *Further information* | Insufficient capacity to cover needs |

## *MHPS Tekharv/ Udob (Tekharv/ Vanj) completed*





| | |
|---|---|
| *Date of inspection* | 18.7.2003 |
| *Year of completion* | 1993, building was already constructed during Soviet times |
| *Damaged at date of inspection?/ operating since when* | Yes, avalanche damaged the canal. Last time running in January 2003 |
| *Installed capacity/ actual output* | 450kW/ 200kW |
| *Type (turbine and generator)* | High pressure, horizontal turbine made in England (1937) |
| *Generated power* | Mai 2003: 94,100kWh |
| *Owner* | PEC |
| *Pipe length/ water channel length* | More than 500m/3km |
| *Seasonal differences in power generation* | Low capacity during winter time: 120kW (lack of water) |
| *Project financed by* | *Hukumat* |
| *Initiative taken by/ when* | MSDSP. Responsible engineer: Nazarkhudo (Khorog) |
| *Maintenance costs* | Monthly salary for 2 workers 28 *somoni* (USD 8.88) |
| *Schedule for power distribution* | Wintertime: Upper line and down line on alternate days. Normally operating day and night. |
| *Connected villages/ households* | Upper line: Garmchashma: 60hh; Udob: 107hh; Gidjovast: 90 hh; Shirgovad: 129hh; Murgatka: 48hh; Mudekharv 115 hh; Rovand: 48 hh; Ghumast: 65hh; Starg: 43hh; Dursher: 151hh; Vishkharvak: 37hh; Chikhokh: 60hh. Down line: Tekharv: 74hh; Sed: 42hh; Sadvadg: 32hh; Khaspo: 17hh; Ravgada: 28hh; Baravn: 25hh; Jovid: 79hh; Sidnarkh: 13hh; Ubgo: 23hh; Ardobak: 12hh; Rov: 63hh; Potov: 32hh; Arnovad: 2hh; Shavru: 24hh (not connected: Poimazor: 56 hh; Van Vani Bolo: 44 hh; Van Vani Poion: 16 hh; Sungad: 13 hh; Said: 14 hh); total: 1284hh/ 9740p |
| *Electricity fee per month or kWh* | 2.5 *somoni*/month (not according to the meter). Before PEC it was according to the meter. |
| *Major problems* | Last year it did not work for 5 months: something with the axle was wrong (PEC and villagers paid for it) |
| *Number of workers at the MHPS* | 15 persons: 60-80 *somoni*/month (USD 20-25) |
| *Village connected to PEC grid* | No |
| *Electricity used for what purposes* | Winter: only for lighting. Summer: lighting, baking, cooking. |
| *GPS point* | 029: elevation 2046m N 38°32'14,3"; E 071°41'44,4" |
| *Further information* | Most meters are working |

## MHPS Vamar, Langar (Rushan/ Rrushan) completed

| | |
|---|---|
| *Date of inspection* | 16.7.2003 |
| *Year of completion* | 2002 |
| *Damaged at date of inspection?/ working since when* | No/ operating steadily since autumn 2002 |
| *Installed capacity* | 45kW |
| *Type (turbine and generator)* | High pressure, horizontal |
| *Owner* | Some people from Langar |
| *Head/ pipe length/ diameter/ water channel length* | 50m/ 300/ 0.3m/ 30m |
| *Generated power per day* | 1080kWh: 45kW x 24 hours |
| *Seasonal differences in power generation* | No differences |
| *Project financed by* | Villagers |
| *Iinstallation costs* | Generator: 400 *somoni* (USD 127); turbine: was used as pump, was a gift; tube: for free |
| *Initiative taken by/ when* | Villagers of Vezdara/ 1992 |
| *Maintenance costs* | 50-70 *somoni*/month (USD 16-22) for lubricant, bearings |
| *Schedule for power distribution* | Only used during wintertime (October-June). They do not let it run during high water periods because of stones entering the tube. It is operating day and night. |
| *Connected villages/ households* | Only a part of Langar/ 50 hh (the nearest to the MHPS) |
| *Electricity fee per month or kWh* | They pay according to the meter: 0,05 *diram*/kWh, 5-8 *somoni*/month. Fees are not sufficient to maintain it. |
| *Major problems* | No transformer (no stable output): TV, video player got broken. During winter the canal was damaged, and they had to repair it. |
| *Number of workers at the MHPS* | 4 people: 15 *somoni*/month (USD 4.70) |
| *Village connected to PEC grid* | Connected to Shujand, very low capacity (like a small diesel oil lamp) |
| *Electricity usage purposes* | Cooking, light, TV, radio, baking, no heating |
| *Construction proceedings* | Initiative: Ahmamadbek (Vamar), gathered money from the hh: first 10 *somoni* (USD 3.10) then 30 *somoni* (USD 9.50). |
| *GPS point* | 023: elevation 2093m; N 37°57'28,3" E 071°33'25,7" |
| *Further information* | Villagers use less wood since they have the MHPS. |

## *MHPS Vamd (Barrushan/ Rushan) completed*

| | |
|---|---|
| *Date of inspection* | 17.7.2003 |
| *Year of completion* | 1998 |
| *Damaged at date of inspection?/ working since when* | Yes/ they will replace the handmade turbine. Working since 1998. |
| *Installed capacity/ actual output* | 60kW/ average 25kW, because of lack of water |
| *Type (turbine and generator)* | Handmade turbine, horizontal unit |
| *Owner* | VO Vamd |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 122m/ 244m/ 0.30m/ pressure 13 atmph. |
| *Generated power/day kWh (hours x average capacity)* | 600kWh: 25kW x 24 hours |
| *Seasonal differences in power generation* | Only running in wintertime (November to April), whenever no supply from PEC |
| *Project financed by* | Food for Work (MSDSP), SDC (USD 8672) |
| *Installation costs* | USD 8672 (of it USD 2'835 FFW and USD 3500 for fuel); door, wood, generator, turbine were financed by the villagers themselves. Collected cattle from the hh. |
| *Initiative taken by/ when* | Villagers of Vamd/ 1998 |
| *Maintenance costs* | Monthly salaries for 4 workers 40 *somoni* (USD 12.70) |
| *Schedule for power distribution* | All day and night |
| *Connected villages/ households/ public buildings* | Vamd (118, 730) |
| *Electricity fee per month or kWh* | 1 *somoni*/month/hh (USD 0.32) |
| *Major problems* | Handmade turbine needed to be welded once in a while. But do not have electricity on the spot. Get a new turbine. |
| *Number of workers at the MHPS* | 4: salary 10 *somoni*/month/capita (USD 3.20) |
| *Village connected to PEC grid* | Yes, during summertime (April to November) |
| *Electricity usage purposes* | Lighting, TV station, phone station. During heavy use periods the capacity is too low for watching TV. |
| *Construction proceedings* | They started in 1998 and completed it the same year. MSDSP implemented the project. |
| *GPS point* | 025, elev. 2120m, N 37°55'05.1", E 071°23'11.1" |

## *MHPS Vanj (Vanj/ Vanj) completed*

| | |
|---|---|
| *Date of inspection* | 18.7.2003 |
| *Year of completion* | 1968 |
| *Damaged at date of inspection?/ working since when* | No/ working since 1968 |
| *Installed capacity/ actual output* | 1300kW (2x650)/ average 450kW/ max. 900kW because of old equipment. |
| *Type (turbine and generator)* | RO 211-84, high pressure, vertical unit |
| *Owner* | PEC |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 22m/ 36m/ 1.20m/ 2300m |
| *Generated power/day kWh (hours x average capacity)* | 10,800kWh: 450kW x 24 hours, May 2003: 565,900kWh, June 2003: 555,600kWh |
| *Seasonal differences in power generation* | Running all around the year |
| *Project financed by* | State of Soviet Union |
| *Schedule for power distribution* | Only in wintertime (3 hours off, 3 hours on per quarter), only Vanj center is supplied. |
| *Connected villages/ households/ public buildings* | Bunai (226, 1695), Bovud (59, 462), Odesht (62, 452), Vanj (503, 4107), total (850, 6716) |
| *Electricity fee per month or kWh* | PEC fees |
| *Major problems* | Old equipment, so not full capacity |
| *Number of workers at the MHPS* | 54 employees, of it 16 workers (100 *somoni*/month/capita) |
| *Village connected to PEC grid* | No |
| *Electricity used for what purposes* | Lighting, cooking, baking, radio, TV, no heaters, in Vanj center people even heat their houses |
| *GPS point* | 028, elev. 1765m, N 38º22'46.9'', E 071º28'58.6'' |
| *Further information* | Temporarily supplied by Vanj HPS because of damaged (27th of June 2003) transmission lines from Nurek are: Dashti Rog (42, 378), Uskrog (92, 675), Rog (96, 795), Paishanbeobod (44, 351) |

## *MHPS Vezdara (Barvoz/ Roshtkala) completed*

| | |
|---|---|
| *Date of inspection* | 7.6.2003 |
| *Year of completion* | November 1999 |
| *Damaged at date of inspection?/ working since when* | No/ working since December 1999 |
| *Installed capacity/ actual output* | 32kW/ average 20kW/ too many hh connected, grid is overloaded |
| *Type (turbine and generator)* | Pump as turbine, synchronic generator, horizontal |
| *Owner* | VO Vezdara |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 47m/ -/ 0.18m/ 115m/ 9m$^3$ |
| *Generated power/day kWh (hours x average capacity)* | 360kWh: 20kW x 18 hours (6 to 24h) |
| *Seasonal differences in power generation* | Only running in wintertime (October to April/ May), whenever there is no supply from PEC |
| *Project financed by* | Food for Work (USD 3210), SDC (USD 10,798) |
| *Installation costs* | USD 18,000 |
| *Initiative taken by/ when* | Villagers of Vezdara/ 1992 |
| *Maintenance costs* | Monthly salary for 2 workers: 28 *somoni* (USD 8.88) |
| *Schedule for power distribution* | Wintertime 6 to 24 h |
| *Connected villages/ households/ public buildings* | Vezdara (28hh)/ school, library, med point, HUKUMAT, electric saw, Anjin (10hh), Anbaw (10hh) |
| *Electricity fee per month or kWh* | 2.5 *somoni*/ month/ hh (USD 0.79) |
| *Major problems* | Need to replace some rubber parts on the bearing every 3 days |
| *Number of workers at the MHPS* | 2 (stay over night, are on duty every second day) |
| *Village connected to PEC grid* | Yes, during summer (May to October) |
| *Electricity used for what purposes* | Cooking, boiling water, fridge, heating, lighting, tape recorder, baking, TV, |
| *Construction proceedings* | In 1992 they could not find any donors, so that it started in March 1999, completed in Novemer 1999 with construction. Wanted to have electricity the year round. |
| *GPS point* | 118, elev. 2836m, N 37º12'17.7'', E 071º50'06.5'' |
| *Further information* | MHPS owns 20 cattle as a fund for maintenance. |

## MHPS Yapshorv (Savnob/ Rushan) completed

| | |
|---|---|
| *Date of inspection* | 19.6.2003 |
| *Year of completion* | 1998 |
| *Damaged at date of inspection?/ working since when* | Yes/ worked only during 2 years, no more working since July 2002 |
| *Installed capacity/ actual output* | 30kW/ running on 5kW, because of lack of water |
| *Type (turbine and generator)* | Turbine, generator, accumulator, condenser, horizontal unit |
| *Owner* | VO Yapshorv |
| *Head/ pipe length/ diameter/ water channel length/ pool volume* | 10m/ 30m/ 0.30m/ 100m/ - |
| *Generated power/day kWh (hours x average capacity)* | 90kWh: 5kW x 18 hours (6 to 24h) |
| *Seasonal differences in power generation* | All around the year |
| *Project financed by* | Food for Work (MSDSP), SDC (USD 10,170), MSDSP |
| *Installation costs* | USD 10,170 (of it USD 2065 FFW, and USD 2746 fuel) |
| *Initiative taken by/ when* | 1992 |
| *Maintenance costs* | Monthly salaries for 2 workers |
| *Schedule for power distribution* | 6-24 h |
| *Connected villages/ households/ public buildings* | Yapshorv (38, 225) wanted to connect another village (Dakhsht-Varyakh) but had no transmission lines |
| *Electricity fee per month or kWh* | 20 *diram*/hh/month (USD 0.06) |
| *Major problems* | People do not know what is broken! |
| *Number of workers at the MHPS* | 2 workers |
| *Village connected to PEC grid* | No |
| *Electricity usage purposes* | Lighting |
| *Construction proceedings* | In 1992 the OKC provided them with a turbine and generator as HA. In 1995 they transported the equipment to Yaphsorv. In 1998 a specialist from the MSDSP helped with installation of an MHPS. |
| *GPS point* | 014, elev. 2554m, N 38º17'43.3", E 072º20'17.7" |
| *Further information* | In summer conflict between irrigation and MHPS water supply |

# List of Hydropower Stations in GBAO

## Hydro Power Stations in Gorno Badakhshan in 2003 (Source: AKF/MSDSP reports, field study 2003, Pamir Energy Company)

Field study conducted in June and July 2003 by R. Droux and T. Hoeck, NCCR-North-South, CDE, Univrsity of Berne.

| No. | village | Jamoat | district | installed capacity (kW) | output capacity (kW) | connected to PEC main grid | owned by | Donor | benificial to number of villages (hh, inhabitants) | benificial to number of persons | beneficial to number of households (customers) | Completion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Khost | Kalai-Khumb | Darvoz | 160 | - | no, but to Nurek | Barki Tojik | SDC | 1 | 132 | 20 | 1998 |
| 2 | Shikev | Nulvand | Darvoz | 100 | - | | VO | JapanODA, SDC | 1 | 228 | 29 | 2001 |
| 3 | Oluni (close to Kulumbai Poyon and Kalai Hussein) | Sagridasht | Darvoz | 40 | - | no, but to Nurek | Barki Tojik | SDC | 1 | 32 | 8 | 2001 |
| 4 | Kalai-Khumb | Kalai-Khumb | Darvoz | 208 | 120 | no | PEC | - | 1 | 2187 | 293 | 1959 |
| 5 | Namadgut | Ishkashim | Ishkashim | 2500 | 1600 | no | PEC | SDC (repairs) | 4: Ishkashim (center) (480, 3072) , Rin (148, 1030), Namadguti Bolo (127, 1042), Namadguti Poyon (40, 352), total (795, 5496), at night 7 additional villages supplied, total (1056, 7629) | 5496 (day), 7629 (night) | 795 (day), 1056 (night) | 1974, rehab. 2000 |
| 6 | Langar | Zong | Ishkashim | 65 | 60 | no | | SDC | 1 | 1670 | 224 | 2001 |
| 7 | Yamchun | Pitup | Ishkashim | 160 | 160 | no | | SDC | 3: Yamchun (60, 544), Vichkut (35, 287), Tughgoz (52, 473) | 1304 | 147 | 2001 |
| 8 | Bodom | Tavdem | Roshtkala | 25 | 20 | yes | VO | SDC | 4: Bodom (19, 173), Pish (22, 161), Dolchaden (15, 46), Bodomi Bolo (32, 234) | 614 | 88 | 1998 |
| 9 | Barmev | Tusyon | Roshtkala | 33 | 33 | yes | VO | - | 2: Barmev (27, 230), Shosh (44, 345) | 575 | 71 | 2003 |
| 10 | Andarv | Tavdem | Roshtkala | - | - | yes | villager | - | 1 | - | - | - |
| 11 | Sumjev | Tavdem | Roshtkala | 3 | - | yes | villager | - | 1 | 35 | 5 | - |
| 12 | Rijist | Tavdem | Roshtkala | 10 | - | yes | VO | - | 1 | 412 | 60 | 1999 |
| 13 | Khidorjev | Tavdem | Roshtkala | 15 | - | yes | villager | - | 1: Khidorjev (30, 210) | 210 | 30 | 1991 |
| 14 | Khidorjev | Tavdem | Roshtkala | 25 | - | yes | villager | - | 2: Khidorjev (42, 302), Rijist (10, 70) | 372 | 52 | 1997 |
| 15 | Vezdara | Barvoz | Roshtkala | 32 | 20 | yes | VO | SDC | 3: Vezdara (28, 197) & 6 public buildings, Anbaw (13, 103), 10 hh in Anjin? or Tsorj (26, 168) | 425 | 57 | 1999 |
| 16 | Shipad | Shidz | Rushan | 37 | 37 | no | VO | HA | 1: Shipad (26hh) & Dasht (18hh) +5hh under construction | 272 | 44 | 1993 |
| 17 | | | | 5 | - | | VO | - | | | | 2001 |
| 18 | Bajuv | Pastkhuf | Rushan | 15 | - | yes | VO | - | 1 | 423 | 70 | 2001 |
| 19 | | | | 37 | - | | VO | - | | | | 2001 |
| 20 | Pastbadjuv | Pastkhuf | Rushan | 5 | 5 | yes | VO | - | 1 | 240 | 40 | 2000 |
| 21 | Vamd | Barrushan | Rushan | 60 | 25 | yes | VO | SDC | 1 | 730 | 118 | 1998 |
| 22 | Deh (Site Jiltan) | Shidz | Rushan | 37 | 37 | no | VO | SDC | 1 | 398 | 71 | 1999 |
| 23 | Barrushan | Barrushan | Rushan | 305 | 305 | yes | VO | UK, SDC, Japan | 1 | 2332 | 413 | 2003 |
| 24 | Barrushan | Barrushan | Rushan | 35 | 35 | | VO | SDC, UN, Japan | 1 | construction work | construction work | 2000 |
| 25 | Vamar, Rushan Center (Site Langar) | Rushan | Rushan | 45 | - | no, but to Shudjand | VO | UK, SDC | 1: part of Langar | 300 | 50 | 2002 |
| 26 | Vamar, Rushan Center (Site Langar) | Rushan | Rushan | 200 | - | no, but to Shudjand | VO | | Rushan Center | - | - | not yet completed |
| 27 | Pastkhuf | Pastkhuf | Rushan | 35 | 35 | yes | VO | HA | 1: Pastkhuf (120, 600) | 600 | 120 | 2000 |
| | | | | 60 | 60 | | | HA | 2: Pastkhuf (85, 425), Bobolangar (9, 45) | 470 | 94 | |
| 28 | Derdeh | Pastkhuf | Rushan | 37 | 37 | yes | VO | HA | 1 | 470 | 93 | 1998 |
| 29 | Bardeh | Pastkhuf | Rushan | 20 | 20 | yes | VO | HA | 1 | 494 | 98 | 1999 |
| 30 | Shujand | Rushan | Rushan | 800 | 600 | no | PEC | | 2: Shudjand (197, 690), Rushan Center (734, 4051) | 4741 | 931 | 1969 |

| Completion | Number of hh in the corresponding village (Source: MSDSP 2003) | Inhabitants in the corresponding village (Source: MSDSP 2003) | Potential watts per beneficial person | Average members per Household | Potential watts per average household (customer) | actual available watts/hh | damaged at the moment of inspection | comment | source | installation costs (US$) | cost US$/kW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998 | 20 | 132 | 1212.1 | 7 | 8000.0 | - | not visited | Switching substation connected to Nurek | MSDSP report 1996-2002 | - | - |
| 2001 | 29 | 228 | 438.6 | 8 | 3448.3 | - | not visited | | MSDSP report 1996-2002 | 82'800 | 828 |
| 2001 | - | - | 1250.0 | - | 5000.0 | - | not visited | Switching substation connected to Nurek | MSDSP report 1996-2002, Abudullo (MSDSP) | - | - |
| 1959 | 293 | 2187 | 95.1 | 7 | 709.9 | 409.6 | not visited | | PEC, estimation | - | - |
| 1974, rehab. 2000 | 40 | 352 | 454.88 (day), 327.70 (night) | 9 | 3144 (day), 2367 (night) | 2012 (day), 1515 (night | no | working all around the year | MSDSP report 1994-2001, own inverstigations, PEC | - | - |
| 2001 | 224 | 1670 | 38.9 | 7 | 580.4 | 535.7 (summer) 446.4 (winter | no | 24 h one part and the next 24 h second part supplied, working all around the year | MSDSP report 1996-2002, own investigations | 84'782 | 1251 |
| 2001 | 60 | 544 | 122.7 | 9 | 1088.4 | 1088.4 (summer), 816.3 (winter | no | working all around the year | MSDSP report 1996-2002, own investigations | 115'543 | 722 |
| 1998 | 19 | 173 | 144.5 | 9 | 284.1 | 227.3 | no | only working in wintertime | own investigation | - | - |
| 2003 | 27 | 230 | 57.4 | 9 | 464.8 | 464.8 | yes | village wants to get independent from PEC. Working all around the year | own investigation | - | - |
| - | 26 | 228 | - | 9 | - | - | not visited | | own investigation | - | - |
| - | 70 | 481 | 85.7 | 7 | 600.0 | - | not visited | | own investigation | - | - |
| 1999 | 60 | 412 | 24.3 | 7 | 166.7 | - | no | only working in wintertime | own investigation | - | - |
| 1991 | 42 | 302 | 71.4 | 7 | 500.0 | - | no | only working in wintertime | own investigation | - | - |
| 1997 | 42 | 302 | 67.2 | 7 | 480.8 | - | no | only working in wintertime | own investigation | - | - |
| 1999 | 28 | 197 | 75.3 | 7 | 561.4 | 350.9 | no | only working in wintertime | own investigation | 18'000 | 337 |
| 1993 | 45 | 272 | 136.0 | 6 | 840.9 | 840.9 (summer), 681.8 (winter) | no | 5hh under construction will be connected as well after completion. Working all around the year. | own investigation | - | - |
| 2001 | | | | | | | no | only working in wintertime | | - | - |
| 2001 | 70 | 423 | 118.2 | 6 | 714.3 | - | no | only working in wintertime | own investigation | - | - |
| 2001 | | | | | | | no | only working in wintertime | | - | - |
| 2000 | 70 | 420 | 20.8 | 6 | 125.0 | 125.0 | no | only working in wintertime | own investigation | 124 | 25 |
| 1998 | 118 | 730 | 82.2 | 6 | 508.5 | 211.9 | yes | only working in wintertime, they will install a new turbine | own investigation | 8'672 | 145 |
| 1999 | 71 | 398 | 93.0 | 6 | 521.1 | 521.1 | no | were connected to Nurek lines till 1993. Not working in wintertime due to lack of water. | own investigation | - | - |
| 2003 | 413 | 2332 | 150.1 | 6 | 847.5 | - | no | 75 kW set already working, 130 & 100 kW sets under construction. Only working in wintertime | own investigation | 43'468 | 143 |
| 2000 | 413 | 2332 | - | - | - | - | no | serves as electricity source for construction of new MHPS. only working in wintertime | own investigation | - | - |
| 2002 | 734 | 4051 | 150.0 | 6 | 900.0 | - | no | only working in wintertime | own investigation | - | - |
| not yet completed | 734 | 4051 | - | 6 | - | - | - | under construction | own investigation | - | - |
| 2000 | 205 | 1100 | 58.3 | 5 | 291.7 | 291.7 | no | only working in wintertime, two sets in one MHPS, but with separate distribution system | own investigation | - | - |
| | | | 127.7 | 5 | 638.3 | 638.3 | no | | | - | - |
| 1998 | 93 | 470 | 78.7 | 5 | 397.8 | 397.8 | not visited | only working in wintertime, working without bigger problems | own investigation | - | - |
| 1999 | 98 | 494 | 40.5 | 5 | 204.1 | 204.1 | not visited | only working in wintertime, working without bigger problems | own investigation | - | - |
| 1969 | 197 | 960 | 168.7 | 5 | 859.3 | 644.5 | no | working steadily all around the year | MSDSP report 1994-2001, own investigations, PEC | - | - |

| No. | village | Jamoat | district | installed capacity (kW) | output capacity (kW) | connected to PEC main grid | owned by | Donor | benificial to number of villages (hh, inhabitants) | benificial to number of persons | beneficial to number of households (customers) | Completion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | Pasor | Savnob | Rushan | 100 | 40 | no | VO | SDC | 3: Pasor & Bopasor (54, 325), Gudara (57, 327) | 652 | 111 | 2000 |
| 32 | Roshorv | Savnob | Rushan | 128 | less | no | VO | | 1 | 997 | 170 | 1998 |
| 33 | Barchidev | Savnob | Rushan | 40 | 40 | no | VO | SDC | 1 (in addition school, med point) | 184 | 30 | 2000 |
| 34 | Savnob | Savnob | Rushan | 80 | 40 | no | PEC | | 1 (in addition school, hospital, Hukumat, guest house) | 341 | 58 | 1989 |
| 35 | Bardara | Basid | Rushan | 60 | 10 | no | VO | German Embassy, SDC | 1 | 493 | 83 | 1998 |
| 36 | Yapshorv | Savnob | Rushan | 30 | 5 | no | VO | SDC | 1 | 225 | 38 | 1998 |
| 37 | Ravmed | Bartang | Rushan | 30 | 7 | no | VO | | 1 | 353 | 62 | - |
| 38 | Ajirkh | Basid | Rushan | 20 | 10 | no | VO | SDC | 1 | 93 | 21 | 2000 |
| 39 | Devlokh | Basid | Rushan | 5 | 5 | no | VO | | 1 | - | 10 | 2001 |
| 40 | Basid | Basid | Rushan | 100 | 70 | no | VO | UK Embassy, SDC | 1 | 680 | 134 | 2001 |
| 41 | Darjomch | Bartang | Rushan | 200 | 120 | no | VO | SDC | 3: Ravivd (36, 176), Darjomch (48, 237), Razuj (50, 249) | 662 | 134 | 2002 |
| 42 | Emts | Rushan | Rushan | 100 | 100 | no | VO | SDC, Canton Geneva, JapanODA | 2: Bagu (28, 141), Emts (101, 467) | 608 | 129 | 2001 |
| 43 | Siponj (center) | Bartang | Rushan | 160 | 70 | no | PEC | | 4: Khidjez (38, 240), Dasht (37, 172), Visav (31, 167), Siponj or Bartang (96, 442) | 621 | 202 | 1992 |
| 44 | Chadud | Basid | Rushan | 12 | 4 | no | VO | | 1 | 120 | 20 | 1996 |
| 45 | Andarbak | Yazgulom | Vanj | 300 | 280 | no | PEC | SDC, JapanODA | 7: upper line; Andarbak (132,1170), Jamak (150, 1237), ?Zaich (12, 89). Down line; Vishkharv (83, 713), Budun (103, 985), Shavud (44, 339), Motravn (168, 1522) | 2496 up, 3559 down, 6055 tota | 294 up, 398 down, 692 total | 1999 |
| 46 | Tekharv (Site Udob) | Tekharv | Vanj | 360 | 200 | no | PEC | HA | 26: Garmchashma (60, 507), Udob (107, 938), Gidjovast (90, 658), Shirgovad (129, 848), Murgatka (57, 401), Mudekharv? (115 hh), Rovand (48, 388), Gumast (65, 498), Sitakh (43, 279), Dursher (151, 920), Vishkharvak (37, 280), Chikhokh (60, 530), Tekharv (74, 564), Sed (42, 322), Sadvadg (32, 293), Khaspo (17, 149), Ravgada (28, 222), Baravn (25, 187), Jovid (79, 577), Sidnarkh? (13 hh), Ubgo (23, 171), Ardobak (12, 97), Rov (63, 485) Potov (32, 256), Arnovad? (2hh), Shavrukh (24, 188) | 9758 | 1298 | 1993 |
| 47 | Vanj (center) | Vanj | Vanj | 1300 | 450 | no | PEC | HA | 4: Bunai (226, 1695), Bovud (59, 462), Odesht (62, 452), Vanj (503, 4107) | 6716 | 850 | 1968 |
| 48 | Poimazor (Chkalov) | Rovand | Vanj | 100 | - | no | VO | UK, SDC | 4: Poy Mazor (56, 376), Van Vani Bolo (44, 280), Van Vani Poyon (16, 105), Sumgad (13, 69) | 830 | 129 | not yet completed |
| 49 | Viruyjak (between Gozhak and Nivodak) | ? | Shugnan | 100 | | | | SDC | | 81 | 18 | 2002 |
| 50 | Sokhcharv | Sokhcharv | Shugnan | 3 | 3 | yes | villager | | 1: part of Sokhcharv | 60 | 10 | - |
| 51 | Khorog | Khorog | Khorog | 8700 | 7000 | main grid | PEC | | supplying Gunt Valley, Khorog city, Roshtkala Valley, down the Pandzh River up to Voznavd (Shidz, Rushan) | | | 1970 |
| 52 | Pamir 1 (Site Tang) | Suchan | Shugnan | 14000 | 14000 | main grid | PEC | | | | | 1994 |
| 53 | Ak-Suu | Murgab | Murgab | 640 | 200 | no | PEC | Japan | 1: Murgab | 6770 | 1483 | 1964, rehab. 2003 |
| | total | | | 31677 | | | | | | | | |

| Completion | Number of hh in the corresponding village (Source: MSDSP 2003) | Inhabitants in the corresponding village (Source: MSDSP 2003) | Potential watts per beneficial person | Average members per Household | Potential watts per average household (customer) | actual available watts/hh | damaged at the moment of inspection | comment | source | installation costs (US$) | cost US$/kW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 54 | 325 | 153.4 | 6 | 900.9 | 360.4 | yes | it's working unregularly , only supplies Pasor, transmission lines are broken to Bopasor and Gudara | report 1994-2001, own investigations | 50'961 | 510 |
| 1998 | 170 | 997 | 128.4 | 6 | 752.9 | <752.9 | yes | only worked for 2 months | own investigation | 18'000 | 140 |
| 2000 | 27 | 184 | 217.4 | 6 | 1333.3 | 1333.3 | yes | not working. Working all around the year | own investigation | 24'274 | 607 |
| 1989 | 54 | 341 | 234.6 | 6 | 1379.3 | 689.7 | no | working without problems, but on low capacity due to lack of water | own investigation, PEC | - | - |
| 1998 | 90 | 525 | 121.7 | 6 | 722.9 | 120.5 | yes | broken since April 2003. Working all around the year | own investigation | 23'019 | 384 |
| 1998 | 38 | 225 | 133.3 | 6 | 789.5 | 131.6 | yes | broken since July 2002. Working all around the year | MSDSP report 1996-2002, own investigations | 10'170 | 339 |
| - | 62 | 353 | 85.0 | 6 | 483.9 | 112.9 | no, not visited | it's working, but with low capacity | own investigation | - | - |
| 2000 | 21 | 93 | 215.1 | 6 | 952.4 | 476.2 | no | working, supplying only light | MSDSP report 1996-2002, own investigations | 13'514 | 676 |
| 2001 | - | - | - | - | 500.0 | 500.0 | not visited | | own investigation | - | - |
| 2001 | 134 | 680 | 147.1 | 5 | 746.3 | 522.4 | no | not working in very cold months (Jan., Feb. due to frozen water) | MSDSP report 1996-2002, own investigations | 40'994 | 410 |
| 2002 | 48 | 237 | 302.1 | 5 | 1492.5 | 895.5 | no | working all around the year | MSDSP report 1996-2002, own investigations | 50'621 | 253 |
| 2001 | 101 | 467 | 164.5 | 5 | 775.2 | 775.2 | no | working very well | MSDSP report 1996-2002, own investigations | 88'229 | 882 |
| 1992 | 96 | 442 | 257.6 | 5 | 792.1 | 346.5 | no | one set was out of order and under repair The other set was working only on 70 kW. | own investigation, PEC | - | - |
| 1996 | 33 | 175 | 100.0 | 5 | 600.0 | 200.0 | yes | not all hh are connected | own investigation | 1000 | 83 |
| 1999 | 132 | 1170 | summer: 120.2 up, 82.3 down, 49.5 total | 9 | 1020.4 up, 753.8 down, 433.5 total | summer: 952.4 up, 703.5 down, 404.6 total, winter: 408.2 up, 301.5 down, 173.4 total | yes | schedule: 24h down line, then 24h upper line. Turbine had to be repaired | own investigation, PEC | 126'934 | 423 |
| 1993 | 74 | 564 | 36.9 | 8 | 277.3 | 154.1 | yes | working all around the year | own investigation, PEC | - | - |
| 1968 | 503 | 4107 | 193.6 | 8 | 1529.4 | 529.4 | no | Temporarly supplied by Vanj HPS because of damage (27th of June 2003) at transmission lines from Nurek are: Dashti Rog (42, 378), Uskrog (92, 675), Rog (96, 795), Paishanbeobod (44, 351) | own investigation, PEC | - | - |
| not yet completed | 56 | 376 | 120.5 | 7 | 775.2 | - | - | under construction. mud flow postponed the completion planned for Aug. 2003 | own investigation | 71'571 | 716 |
| 2002 | | | | | 5555.6 | | not visited | Transformator, Pamir1 | MSDSP report 1996-2002 | - | - |
| - | 149 | 934 | 50.0 | 6 | 300.0 | 300.0 | no | in the 1950ies the Russian military base constructed a small MHPS. Some guys from the village reinstalled it. Only working in wintertime | own investigation | - | - |
| 1970 | | | | | | | no | | PEC | - | - |
| 1994 | | | | | | | no | | PEC | - | - |
| 1964, rehab. 2003 | 1483 | 6770 | 94.5 | 5 | 431.6 | 431.6 | no, not visited | rehabilitated in July 2003. Now working properly. | PEC, Abudullo (MSDSP) | - | - |

# Planned Soviet Hydropower Stations

***List of Potential Small Hydropower Scheme***

| | Site | District | Capacity (MW) | Costs (Mio. Ruble) | Costs (Mio. USD) |
|---|---|---|---|---|---|
| 1 | Uskhorog | Shugnan | 2.00 | 8.90 | |
| 2 | Rog | Shugnan | 4.56 | 9.95 | |
| 3 | Pastchid | Shugnan | 0.46 | 1.01 | |
| 4 | Pastkhuf | Rushan | 0.91 | 2.25 | |
| 5 | Obi Humbow | Darvoz | 5.23 | 6.07 | |
| 6 | Sariob | Darvoz | 0.82 | 1.30 | |
| 7 | Sagirdasht | Darvoz | 0.30 | 0.66 | |
| 8 | Zigar | Darvoz | 0.46 | 1.01 | |
| 9 | Zaich | Vanj | 1.10 | 2.43 | |
| 10 | Podkinob | Darvoz | 0.90 | 1.99 | |
| 11 | Shirg | Darvoz | 4.36 | 9.77 | |
| 12 | Vishkharw | Darvoz | 1.16 | 2.04 | |
| 13 | Kurgovad | Darvoz | 0.91 | 2.25 | |
| 14 | Ravgada | Vanj | 4.46 | 6.33 | |
| 15 | Sumgad | Vanj | 0.46 | 0.69 | |
| 16 | Bajuv | Rushan | 0.37 | 0.76 | |
| 17 | Murgab | Murgab | 1.66 | 11.41 | |
| 18 | Madiyan-1 | Murgab | 1.16 | 6.85 | |
| 19 | Madiyan-2 | Murgab | 0.75 | 4.82 | |
| 20 | Motravn | Vanj | 0.58 | 0.60 | |
| 21 | Pamir GES-2 | Shugnan | 24.00 | | 55.00 |
| 22 | Pamir GES-3 | Shugnan | 14.00 | | 32.00 |
| 23 | Madiyan-1 | Murgab | 7.00 | | 8.40 |
| 24 | Yapshorv | Rushan | 0.15 | | 0.09 |
| 25 | Garmchashma | Ishkashim | 0.65 | | 0.25 |
| 26 | Ravmed | Rushan | 1.60 | | 180.00 |
| 27 | Madiyan-2 | Murgab | 24.00 | | 0.60 |
| 28 | Bardara | Rushan | 0.50 | | 30.00 |
| 29 | Shitam | Shugnan | 7.00 | | |
| 30 | Gudara | Rushan | 8.00 | | |
| 31 | Tokhtamishbek | Murgab | 3.20 | | |
| 32 | Andargak | Vanj | 0.70 | | |
| 33 | Kozide | Ishkashim | 0.55 | | |
| 34 | Andarv | Roshkala | 0.35 | | |
| 35 | Dargisei | Darvaz | 0.45 | | |
| 36 | Alichur | Murgab | 0.55 | | |
| 37 | Guliston | Vanj | 0.65 | | |
| 38 | Ak-Baital | Murgab | 0.27 | | |
| 39 | Tanimas | Murgab | 3.20 | | |
| 40 | Pshikharv | Vany | 7.00 | | |

**Total 136.43 MW**

Source: IHTSSR (1984)

***Planned Large Scale Hydropower Plants on the Pandzh River (1984)***

| | Name of the HPS | District | Capacity (MW) |
|---|---|---|---|
| 1 | Barshorskaya | Ishkashim | 300 |
| 2 | Anderobskaya | Ishkashim | 650 |
| 3 | Pishskaya | Shugnan | 320 |
| 4 | Khorogskaya | Shugnan | 250 |
| 5 | Ruschanskaya | Rushan | 3000 |
| 6 | Yazgulyamskaya | Vanj | 850 |
| 7 | Granitnie Vorota | Darvaz | 2100 |
| 8 | Schirgovadskaya | Darvaz | 1900 |
| 9 | Khostavskaya | Darvaz | 1200 |

**Total: 10.570 MW**

Source: IHTSSR (1984)

# PEC Consession Agreement

**Extracts from the Concession Agreement between Government of the Republic of Tajikistan and Pamir Energy Company (May 24th 2002) (PEC 2002).**

Appendix C
to the Concession Agreement

## PROJECT PLANS

### 1. Detailed Plans and Specifications.

(a) As soon as possible after the execution of this Agreement, the Project Company shall deliver to the Empowered Agency the Detailed Plans and Specifications, which shall thereafter be reviewed and approved by the Technical Review Committee within the two weeks immediately following the receipt thereof, or such other timeframe as the Parties may agree; provided, however, that failure of the Technical Review Committee to approve the Detailed Plans and Specifications within such time period shall not be deemed approval of the Detailed Plans and Specifications.

(b) Subject to the rights set forth in Section 1(a) of this Appendix C, the Government hereby agrees and acknowledges that the Detailed Plans and Specifications will be based on international design practices and standards.

### 2. Summary of Project Plans.

Pending receipt and approval of the Detailed Plans and Specifications, the remainder of this Appendix C summarizes the plans for the Project.

(a) **Scope of Work.** The Project includes the Hydro-project and the partial rehabilitation of the electricity generation, transmission and distribution system in the city of Khorog and in surrounding areas of the GBAO.

(1) **The Hydro-project.** The Hydro-project shall consist of (a) the Regulating Structure and (b) the Pamir I Plant.

(A) **Regulating Structure.** The regulating structure shall be constructed at the outlet of Lake Yashilkul. Lake Yashilkul has two natural outlets flowing over a very large rock-slide which formed the lake several centuries ago. The main natural outlet passes over sand, gravel and stones of the old rock-slide along the left bank, and the secondary outlet passes over very large boulders near the right bank. It is foreseen to construct a temporary diversion channel and a spillway at the location of the secondary outlet and to build a permanent outlet regulating structure at the main natural outlet. The objective is to regulate the lake outflow to increase the water available to the Pamir I Plant in winter, during low flow period in the Gunt River, and to retain the water in the summer – thus enabling additional water to be released to the power plant in winter. The lake's level may be lowered from the present natural elevation of approximately 3,720.0 meters above sea level (**"masl"**) down to 3,719.0 masl (the minimum. water level in summer). The maximum allowable draw-down level of the lake in winter will be 3,713.5 masl. Furthermore, the following works will form an integral part of the Project:

(i) An access road to the diversion/spillway area;
(ii) A small channel at the spillway/diversion area to temporarily lower the water level of the lake to 3,717.0 masl during construction; and
(iii) A control house and related accommodation facilities for operation and maintenance of the gates.

(B) **The Pamir I Plant.** The existing Pamir I Plant power scheme comprises a diversion structure at the Gunt River, a combined sedimentation/compensation basin, a power intake, a headrace tunnel, a surge shaft, a penstock and a power plant with four generating units of 7 MW each, two of which are operational and two of which are partially installed.

The present scheme will be modified and expanded as follows:

(i) Minor finishing work to the intake/diversion structure (barrage) on the Gunt River;
(ii) Division of the compensation basin by a submerged wall or embankment to retain sediments and thus to reduce the admission of sand into the intake to the headrace and/or the installation of a permanent dredging raft in the basin;

(iii) *Access tunnels.* During proposed work on the headrace tunnel, some plugs between access and headrace tunnel will be removed and concreted again;
(iv) The partly completed access tunnel to the top of the surge tank will be completed;
(v) *Headrace Tunnel.* The main damage to the tunnel lining will be repaired to allow for the higher water velocity related to the increase in operational discharge from 20 to 40 m3/s. Unsafe sections will be modified with a shotcrete or concrete lining, or by repairing the existing lining;
(vi) *Surge Tank.* The existing surge tank is incomplete and too small for the increased tunnel discharge. The volume shall be enlarged by completing the chamber excavation at the upper section which is presently only in the form of a pilot shaft. The completed shaft chamber will be lined with concrete or shotcrete and the existing rock trap modified. The surge tank will have no gates in front of the penstocks;
(vii) *Penstocks.* At present only one of the foreseen two steel concrete encased penstocks is installed (to Units 1 and 2). The second penstock to Units 3 and 4 will be installed in the same way as the first one;
(viii) *Unit 3 and 4 in the Powerhouse.* At present only two of four units (Units 1 and 2) are installed and operational. The installations of the third and fourth units are partially complete and the main equipment is on site. Installation works on Units 3 and 4 will be completed and the units commissioned; and
(ix) *Powerhouse Area.* Minor completion work will be carried out.

(2) **Rehabilitation of the Generation, Transmission and Distribution System.**

(A) **Generation.**

The following power stations shall be rehabilitated:

(i) the Pamir I Plant, Units 1 and 2 (general overhaul, new turbine governors, upgrading of control and protection system);
(ii) Khorog (complete replacement of the turbine governing systems on all units, upgrading/replacement of broken instrumentation and monitoring devices, supply of five new turbine runners, redesign and replacement of the turbine bearings and possibly shafts, general thorough overhaul of turbines, generators and intake valves, upgrading/replacement of control and monitoring instrumentation, generating unit switchgear);
(iii) Vanj (complete replacement of the control and protection system, complete replacement of the turbine governing system, supply of two new turbine runners, upgrading/replacement of broken instrumentation and monitoring devices, general thorough overhaul of turbines and generators, generating unit sitchgear); and
(iv) Namangut (complete replacement of the turbine governing systems on both units, upgrading/replacement of broken instrumentation and monitoring devices, supply of two new turbine runners, redesign and replacement of the turbine bearings and possibly shafts, general thorough overhaul of turbines, generators and intake valves, generating unit switchgear)

(B) **Transmission.**

The scope of work shall include:

(i) Erection of a new 35 kV line between the Pamir I Plant and the substation in Khorog;
(ii) Rehabilitation of the 35 kV line between Khorog and Andarob; and
(iii) General rehabilitation of critical sections of other 35 kV and 10 kV lines within the Khorog area.

(C) **Distribution.**

The distribution network within the Khorog area will be rehabilitated as required by the system and as the project budget permits.

(b) **Project Schedule.** The Project Schedule is attached at the end of this Appendix C.

(c) **Technical Specifications and Design Criteria.** The main objectives of the Hydro-project are to:

(i) increase the output of the Pamir I Plant, especially in winter;
(ii) mitigate environment impact and avoid any additional safety risks to the local population; and
(iii) carry out most of the work with local staff to generate additional income for the native population as long as they are competitive in cost, quality and time.

In principal, cost effective international design practices and standards shall be applied to the Project. Standards used for the original design will be retained only for portions of the work where they prove, under present conditions of the market, to be still cost effective.

Local materials will be used insofar as they are competitively priced and their physical properties meet the required standards or insofar as the design of structures can be economically adapted to allow for the actual properties of locally available material.

(1) **Regulating Structure at Lake Yashilkul.**

(A) The design criteria in respect to the operation of the outlet structure are:

(i) Normal lake full supply level (FSL) of 3,719.0 masl;

(ii) Allowable minimum operating level (MOL) of 3,713.5 masl;

(iii) The top of the spillway shall be designed in such a way that it could be equipped with stoplogs in order to enable the structure to hold higher lake levels in case future operational experience indicates that higher lake levels and consequently larger storage capacity are feasible;

(iv) Water flow measuring equipment shall be installed at the Regulating Structure and it shall function at all times especially in winter with thick ice formation on the lake; and

(vi) The discharge shall be regulated manually in response to requests for water from the Pamir I Plant operator. The Pamir I Plant operator shall note the daily trend in the annual recession in flow in the Gunt River at the Pamir plant, and in conjunction with the anticipated energy load, shall give three days notice to the operator at Lake Yashilkul to increase the release, and by how much.

(B) The criteria with respect to operational safety are:

(i) The Regulating Structure must be operable under extreme climatic conditions and permanent flow of water. Some parts of the gate structure may require to be heated;

(ii) The Regulating Structure must have living quarters for a minimum of two members of staff, radio telephone, and two (2) 10 kW standby portable diesel generator units;

(iii) A deep 500 mm diameter penstock will be installed in the bottom of the outlet structure. This will allow installing a small mini-hydro plant in future without major change on the civil structure;

(iv) The riverbed downstream of the gate structure shall be protected from erosion by placement riprap of local boulders; and

(v) Access by vehicle may sometimes not be possible in winter. In this case the outlet structure must be reachable on foot or by snow mobile.

(C) The static safety requirements for the outlet structure will be applied in compliance with safety principles according to international standards respectively practised for:

(i) Uplift;

(ii) Sliding and slope stability;

(iii) Internal erosion (piping);

(iv) Stresses caused by water and earth pressure; and

(v) Earthquake, snow and wind load.

(2) **The Pamir I Plant.**

(A) **Headrace Tunnel.** The main objectives for the tunnel rehabilitation are to:

(i) Reduce the risk of a major collapse of the tunnel;

(ii) Reduce the risk of a rock-fall (which could require temporary shut down of the plant, and drainage of the tunnel for cleaning). This objective shall be met by the judicious and economical lining of the tunnel, only to extent needed to achieve low probability of rock fall. The final scope of the lining works must be defined during the work progress, according to the condition of the existing lining and the unlined rock surface, by an experienced geo-technical engineer;

(iii) Have minimum losses of water (seepage);

(iv) To allow an increase of discharge rate from the present 20 to 40 m3/s with possibly low head losses;

(v) Prevent sand or stones from entering the turbines; and

(vi) Enable the passage of maintenance vehicles along the entire .

(B) **Surge Tank.** The main objectives for the enlargement of the surge tank are to:

(i) Limit the water hammer within the hydraulic passages resulting from emergency shut down of the Pamir I Plant at the maximum design discharge rate of 40 m3/s to the originally assumed maximum design value; and

(ii) The surge tank design must be reviewed under optimistic and pessimistic assumptions of head losses, for the following cases of operation:

- Start of operation - the units are started (without load) one after another within a time period of 2 minutes and 20 seconds for each unit,
- Emergency shut down - this can happen for all units simultaneously, and

- Waiting time after emergency shut down - the hydraulic designer, depending on the behaviour of the system, must still formulate this restriction.

(d) **Testing Procedures.** No later than six (6) months prior to the scheduled commencement of the testing phase of the Hydro-project, each of the following tests shall be developed, designed and performed by the Project Engineer with the approval of the Independent Engineer, in consultation with the State Committee on Acceptance of Completed Projects. Thereafter, the Independent Engineer shall evaluate the results of such tests.

(1) **Regulating Structure.** Construction of the Regulating Structure shall be considered complete when it is demonstrated that a constant flow of 10 m3/s is running for at least 72 hours; **provided**, such test must be conducted in February; and when it is demonstrated that Lake Yashilkul has returned to its natural level; provided, such test must be conducted in July.

(2) **The Pamir I Plant.** The Pamir I Plant shall be considered completed when:

(A) The installation of the Units 3 and 4 is finished and such units have passed all required commissioning, load and load rejection tests;

(B) Units 1 and 2 are rehabilitated and re-commissioned; and

(C) The Pamir I Plant as a whole is capable of producing load of at least 28 MW with an average tolerance level of plus or minus ten (10) percent with all units on line (compensation basin filled to the top), and each of the units have passed a 72-hour reliability run at maximum possible load (within design limits) and an additional run of five (5) consecutive days for ten (10) hours each, in parallel operation with other units or in single operation, the continuity of such 72-hour test and the additional test runs depending on water availability and on power demand.

(3) **Rehabilitation of the System.**

(A) *Generation.* Rehabilitation of Khorog, Vanj and Namangut shall be considered complete when these plants have been rehabilitated in compliance with the pre-defined scope of rehabilitation and have been re-commissioned.

(B) *Transmission*. Construction of the new 35 kV line shall be considered complete when it has passed the commissioning test.

Appendix E
to the Concession Agreement

## RATES FOR ELECTRIC POWER

1. **General Principles**. The electricity prices to be applied by the Project Company are intended to achieve three objectives:
   a. Be sufficiently high to enable financing of the Project pursuant to the Detailed Plans and Specifications and the provisions of Appendix C;
   b. Be affordable to the citizens of the GBAO; and
   c. Be in accordance with the general principles negotiated between the Government and the Asian Development Bank.
2. **Invoicing.** The Project Company will invoice, on the first day of each calendar month, the electricity sold to customers during the previous month at electricity rates where the Weighted Average (defined below) does not exceed the Maximum Average Price (defined below). The electricity rates will be determined in United States Dollars but will be applied in Tajik Somoni, and the conversion of electricity rates from United States Dollars to Tajik Somoni will be determined on the first day of each month at the average exchange rate of United States Dollars to Tajik Somoni for the previous month as published in Business and Politics, a newspaper published in Dushanbe, Tajikistan, or in another comparable newspaper of significant circulation published in a given month; provided, however, that if no such newspaper is published in a given month or if such newspaper is otherwise not available, the applicable exchange rate shall be the rate of United States Dollars to Tajik Somoni for the relevant month as notified in writing by any

branch of the Central Bank of Tajikistan. The **"Weighted Average"** of the rates will be the sum of the products of the electricity rates applicable to each category of consumer and the proportion of consumption by that category of consumer. Payments for electricity consumed shall be due within thirty (30) days from the date of the relevant invoice.

3. **Maximum Average Price for Electricity**. The maximum authorized average price (**"Maximum Average Price"**) that can be charged to customers during any twelve-month period from January 1 to December 31 of any year listed below is as follows:

| **Year** | **Price in United States Cents (US¢) per KWh** |
|---|---|
| 2002 | 0.75 |
| 2003 | 0.88 |
| 2004 | 1.10 |
| 2005 | 1.37 |
| 2006 | 1.71 |
| 2007 | 1.97 |
| 2008 | 2.27 |
| 2009 | 2.61 |
| 2010 and beyond | 3.00 |

4. **Starting Tariff.** The Government undertakes to increase the Weighted Average price charged to customers in the GBAO to the amount set forth for 2002 in Section 3 of this Appendix E prior to the Effective Date.
5. **Adjustment for Inflation.** The Maximum Average Price for years 2005 and beyond will be adjusted no more than once per calendar year for price inflation, and then only when the annual Inflation Index (as determined by the following methodology) exceeds 1.02 for such year:

$$II = (0.33 * CPI_n / CPI_{n-1} + 0.67 * PPI_n / PPI_{n-1})$$

Where:

II = Inflation Index;

$CPI_n$ = Consumer Price Index, as published by the Bureau of Labor Statistics of the US Department of Labor, corresponding to the month "m-2", "m" being the first month of the year n;

$CPI_{n-1}$ = Consumer Price Index, as published by the Bureau of Labor Statistics of the US Department of Labor, corresponding to the month "m-2", "m" being the first month of the year n-1;

$PPI_n$ = Producer Price Index, as published by the Bureau of Labor Statistics of the US Department of Labor, corresponding to the month "m-2", "m" being the first month of the year n; and

$PPI_{n-1}$ = Producer Price Index, as published by the Bureau of Labor Statistics of the US Department of Labor, corresponding to the month "m-2", "m" being the first month of the year n-1.

6. **Tariff Structure Supplement.** No later than three (3) months after the date set forth in the preamble, the Project Company shall provide the Government with a supplement to this Appendix E describing in detail the structure (by consumer category and season) of the rates to be charged by the Project Company under the Concession, and which will elaborate further on, and be consistent in all respects with, the provisions of this Appendix E.
7. **Lifeline Tariff.** This Section 7 summarizes the anticipated structure of the Lifeline Tariff to be established under the IDA Loan Documents. It is the Government's intention to ensure a level of social protection for the consumers in the GBAO by covering the difference between the residential tariffs contemplated by this Appendix E and a tariff (the **"Lifeline Tariff"**) of US¢0.25 per KWh for the first 200 KWh per month of each residential customer's consumption during the period of November 1 through March 31 and for the first 50 KWh per month per residential customer during the period of April 1 through October 31. These levels of consumption are herein called the **"Lifeline Amounts"**. The Project Company will bill the residential customers for consumption up to these Lifeline Amounts, with such customers being billed at the Lifeline Tariff. For amounts over the Lifeline Amounts, such customers will be billed in full

according to the tariff otherwise applicable under this Appendix E. A separate invoice detailing the volume of residential consumption and subtracting the amounts billed directly at the Lifeline Tariff will be sent to and paid by the Government. In support of this obligation to pay, the Government will agree to establish a bank account (the **"Social Protection Account"**) solely for this purpose pursuant to the IDA Loan Documents.

To meet the costs of this program, the Government will agree to fund the Social Protection Account as follows. Initially, the funding will come from two sources. First, the difference between the interest rate payable by the Government to IDA under the IDA Loan Documents and the rate at which the Government onlends this credit to the Project Company shall be paid into the Social Protection Account. Second, the Social Protection Account shall be supplemented by a grant support from the government of the Swiss Federation to the Republic (expected to be approximately US$5 million) which is not required for the Early Years Tariff (described below). Funds in the Social Protection Account are expected to be adequate to ensure the Lifeline Amounts can be provided for 7 - 10 years. The first source of these funds, the spread between the IDA rate to Government and the onlending rate, will continue for 10 years, after which the spread will no longer be channelled through the Social Protection Account. The second source, Swiss Government support to the Republic, will continue until the initial amount and any interest earned on it has been fully disbursed in supporting the Lifeline Amounts and the Early Years Tariff. After depletion of the Social Protection Account, the Government will work to ensure that new arrangements are in place to provide an adequate lifeline amount to residential customers.

As an additional measure of social protection and to shield consumers from an increase in tariffs which is too rapid, the Government, through the Social Protection Account, will agree to cover the difference between the tariffs under this Appendix E and those agreed between the Republic and the Asian Development Bank for the period from the Effective Date until the earlier of December 31, 2007 and the date of revision of the agreement with the Asian Development Bank (the **"Early Years Tariff"**).

8. **Tariff Adjustment for Actual Project Costs.** For each one percent that Actual Project Costs are greater than Estimated Project Costs up to a maximum of ten (10) percent, the Maximum Average Price in each year from 2005 and beyond will be adjusted upwards by 0.5 percent. For each one percent that Actual Project Costs are less than Estimated Project Costs, the Maximum Average Price in each year will be reduced by 0.5 percent. However, prior to implementing any adjustment described herein, the Project Company shall deliver to the Empowered Agency an audited accounting of Actual Project Costs and other appropriate documentation sufficient to establish the basis for such adjustment. Thereafter, applicable tariff adjustments shall take effect as of the next billing date, subject to further notification requirements imposed by Applicable Law.
9. **Minimum Tariff.** The Maximum Average Price shall always be the greater of the amount listed in Section 3 of this Appendix E plus applicable adjustments and the Weighted Average price charged to customers in Dushanbe, Tajikistan.
10. **Purchase Power from Barqui Tajik.** Electricity which is produced outside the GBAO and purchased by the Project Company from Barqui Tajik shall be priced at an amount per kWh equal to the estimated sale price to the average end-consumer less the estimated cost of distribution and commercialization. For initial purposes, this would be fixed at fifty (50) percent of the estimated resale cost.
11. **Surcharge for Change in Law.** In the event of a Change in Law or a lapse of or modification to a consent that requires a material modification or a material capital addition to the Project or the Concession, the Project Company shall be entitled to charge a tariff surcharge in addition to the Maximum Average Price in an amount that will enable the Project Company to recover its costs of completing or operating the Project or Concession.
12. **Future Expansion and Remote Area.** In the event that the Project Company undertakes a rehabilitation investment program in the Remote Areas or a future expansion of assets beyond the Main Interconnected System, the Project Company will be allowed to renegotiate with the Government the Maximum Average Price or a special tariff for the affected area.
13. **Tariff Adjustment for Value Added Taxes.** If, pursuant to Section 6.8 of this Agreement, the exemption from value added taxes set forth in Article 6 of this Agreement is deemed to have terminated, the Project Company shall be entitled to adjust the Maximum Average Price in an amount that will enable the Project Company to pass through to consumers the actual costs of such taxes.

# Appendix 3
# Energy Consumption Patterns

*Specifications of Teresken Bundles*
*Conversion Factors*
*Estimation of Electricity Consumption*

# Specifications of Teresken Bundles

## Measurements, Volume, Weight and Density of Different Teresken Procurement Units

*Teresken Procurement Units in Savnob*

| Unit | Measurements (m) | Volume ($m^3$) | Weight (kg) | Density ($kg/m^3$) |
|---|---|---|---|---|
| Bundled donkey load | 0,6x0,9x0,6 | 0.324 | 27 | 83.33 |
| Bundled donkey load | 1x0,6x0,5 | 0.300 | 25 | 83.33 |
| Loose head load | 0,75x0,43x1,37 | 0.442 | 25 | 56.58 |
| Bundled head load | 0,73x0,60x0,91 | 0.399 | 25 | 62.72 |
| Bundled head load | 0,53x0,43x1,20 | 0.273 | 18 | 65.82 |
| Bundled head load | 0,59x0,64x1,14 | 0.430 | 28 | 65.05 |
| | | 0.361 | 24.7 | 69.47 |

*Teresken Procurement Units in Nisur*

| Unit | Measurements (m) | Volume ($m^3$) | Weight (kg) | Density ($kg/m^3$) |
|---|---|---|---|---|
| Loose head load | 0,75x0,86x0,67 | 0.432 | 20 | 46.28 |
| Bundled children load | 0,60x0,95x0,58 | 0.331 | 15 | 45.37 |
| Bundled head load | 1,8x0,8x0,4 | 0.576 | 30 | 52.08 |
| Bundled head load | 0,6x0,9x0,5 | 0.270 | 16 | 59.26 |
| Bundled head load | 0,75x1,04x0,58 | 0.452 | 28 | 61.89 |
| | | 0.402 | 20.3 | 52.98 |

*Average Figures*

| | | | Average | Rounded |
|---|---|---|---|---|
| Loose head load | | | 51.43 | 50 |
| Bundled head load | | | 61.14 | 65 |
| Bundled donkey load | | | 83.33 | 83 |
| Bundled children load | | | 45.37 | 45 |
| Average | | | | 60.75 |
| Adjusted figure used for calculation | | | | 65 |

Source: Field study 2003

# Conversion Factors

| Resource | Unit | MJ | kg/ m³ (bundled) | kg/ha | plants/m² |
|---|---|---|---|---|---|
| Firewood (willow) | 1kg | 15 | 250 | clemens | clemens |
| *Teresken* shrubs | 1kg | 15 | 65 | 300-1350 | 4-6 |
| Animal dung (dried) | 1kg | 12 | | | |
| Diesel | 1 liter | 36 | Icimod | | |
| Kerosene | 1 liter | 35 | Icimod | | |
| Electricity | kWh | 3.6 | Icimod | | |

Source: Rijal (1999); Domeisen (2002); Kleinn (2003);www.worldenergy.org; www.asystems.ch; www.bioheiztechnik.de; www.worldbank.org; www.videncenter.dk; field study 2003

# Estimation of Electricity Consumption

*Estimated monthly electricity consumption to cover the basic domestic needs of an average household in summer, considering the most common electric appliances and a realistic application of the devices in terms of time.*

| **Potential monthly electricity consumption of an average household, assuming coverage of all domestic energy needs in summer (realistic assumptions)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Electrical appliances | Number | Capacity in watts | Operational time h/day | Operational time h/month | Consumption in Wh/day | Consumption in kWh/day | Consumption in kWh/month |
| Bulbs | 5x100 W | 500 | 5 | 150 | 2500 | 2.5 | 75 |
| Coil cooker | 1 | 1000 | 4 | 120 | 4000 | 4 | 120 |
| TV | 1 | 40 | 4 | 120 | 160 | 0.16 | 4.8 |
| Tape recorder | 1 | 5 | 3 | 90 | 15 | 0.015 | 0.45 |
| Electric oven | 1 | 1300 | 2 | 60 | 2600 | 2.6 | 78 |
| Electric kettle | 1 | 1200 | 1 | 30 | 1200 | 1.2 | 36 |
| Total | | 4045 | | | 10475 | 10.475 | 314.25 |
| Costs per month in *somoni* (based on PEC tariffs[3] in 2003) | | | | | | | 4.8 |

*Estimated monthly electricity consumption to cover the basic domestic needs of an average household in summer, considering the most common electrical appliances and more frequent use of the devices.*

| **Potential monthly electricity consumption of an average household, assuming coverage of all domestic energy needs in summer (generous assumptions)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Electrical appliances | Number | Capacity in watts | Operational time h/day | Operational time h/month | Consumption in Wh/day | Consumption in kWh/day | Consumption in kWh/month |
| Bulbs | 5x100 W | 500 | 5 | 150 | 2500 | 2.5 | 75 |
| Coil cooker | 2 | 1000 | 8 | 240 | 8000 | 8 | 240 |
| TV | 1 | 40 | 4 | 120 | 160 | 0.16 | 4.8 |
| Tape recorder | 1 | 5 | 3 | 90 | 15 | 0.015 | 0.45 |
| Electric oven | 1 | 1300 | 2 | 60 | 2600 | 2.6 | 78 |
| Electric kettle | 1 | 2500 | 1 | 30 | 2500 | 2.5 | 75 |
| Total | | 4045 | | | 15775 | 15.775 | 473.25 |
| Costs per month in *somoni* (based on PEC tariffs in 2003) | | | | | | | 7.5 |

3 In summer: USD cents 0.25/kWh, over 50 kWh: USD cents 0.54/kWh, and in winter: USD cents 0.25/kWh, over 200 kWh: USD cents 0.75/kWh.