Rural energy consumption and land degradation in a post-Soviet setting – an example from the west Pamir mountains in Tajikistan

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The sustainable use of energy resources in semi-arid rural mountain areas is a common but still unresolved problem, often resulting in environmental degradation. In a post-Soviet setting the identification of possible solutions poses specific challenges. This study aimed at (1) investigating the current energy supply and consumption patterns at household and village levels in the western Tajik Pamirs, (2) analysing the implications for land degradation and natural resource management, and (3) proposing recommendations for sustainable energy use, taking into consideration the peculiarities of the Soviet heritage. For this, a participatory and multi-level stakeholder approach was applied. Data was collected through comparative in-depth case-studies at household level and through participatory land degradation assessments.

The study revealed that the close interlinkage between local energy resource use and land degradation leads to a paradoxical situation in present energy consumption. The scarcer the local energy resource base, the higher the overall energy consumption at household level appears to be. It can further be concluded that since 1991 energy consumption patterns in the Tajik Pamirs have become comparable to patterns in semi-arid rural mountain regions of developing countries. Like many countries in the South, the Tajik Pamirs suffer from chronic energy scarcity, unsatisfactory supply of modern energy carriers and unsustainable use of local biomass fuels, leading to land degradation. This calls for a reassessment of the energy policy orientation for Tajikistan.

1. Introduction

The sustainable use of energy resources in semi-arid rural mountain areas is a common, yet still unresolved, problem [Jodha, 2001; Messerli and Ives, 1997]. The use of local energy resources in such areas often results in environmental degradation [Kadian and Kaushik, 2003; Rijal, 1998]. In the case of the former Soviet republics these issues must be addressed while taking the peculiarities and the heritage of the earlier communist system into consideration. The collapse of the Soviet Union in 1991 brought more than just independence to the new Central Asian republics.

For Tajikistan the years following independence were characterised by a vacuum of power, the turmoil of a civil war (1992-1997), the breakdown of the state-controlled economic system, and the continuous deterioration of infrastructure [Herbers, 2001]. Especially for remote areas such as the Tajik Pamir mountains, the cessation of subsidised provision of food, energy and other products had far-reaching consequences for people's livelihood as well as the environment. People had no choice other than to rely again on local natural resources to satisfy their daily demand for food and energy, just as they had done before their integration into the Soviet system some 70 years earlier. However, in the meantime conditions had changed: population had increased ninefold since 1908, traditional livelihood strategies for mountain agriculture and resource use were replaced by collective agricultural practices, indigenous knowledge disappeared, and the natural resource base was transformed to fit the Soviet planned economy [Breu and Hurni, 2003].

This sudden and drastic change from an almost complete dependence on subsidised external supplies to a reliance on the local natural resource base had a particularly intense impact on the energy sector. Under Soviet rule people in the Tajik Pamirs received adequate and affordable energy supplies mainly in the form of fossil fuels such as coal, kerosene, and diesel oil [Herbers, 2002]. In addition, decentralised diesel and hydro power stations provided electricity to the remotest corners of this mountain region [Zibung, 2002]. These secured supplies, combined with high population growth and improved living standards, significantly increased the overall demand for energy over the years (Figure 1). Abruptly after 1991, this

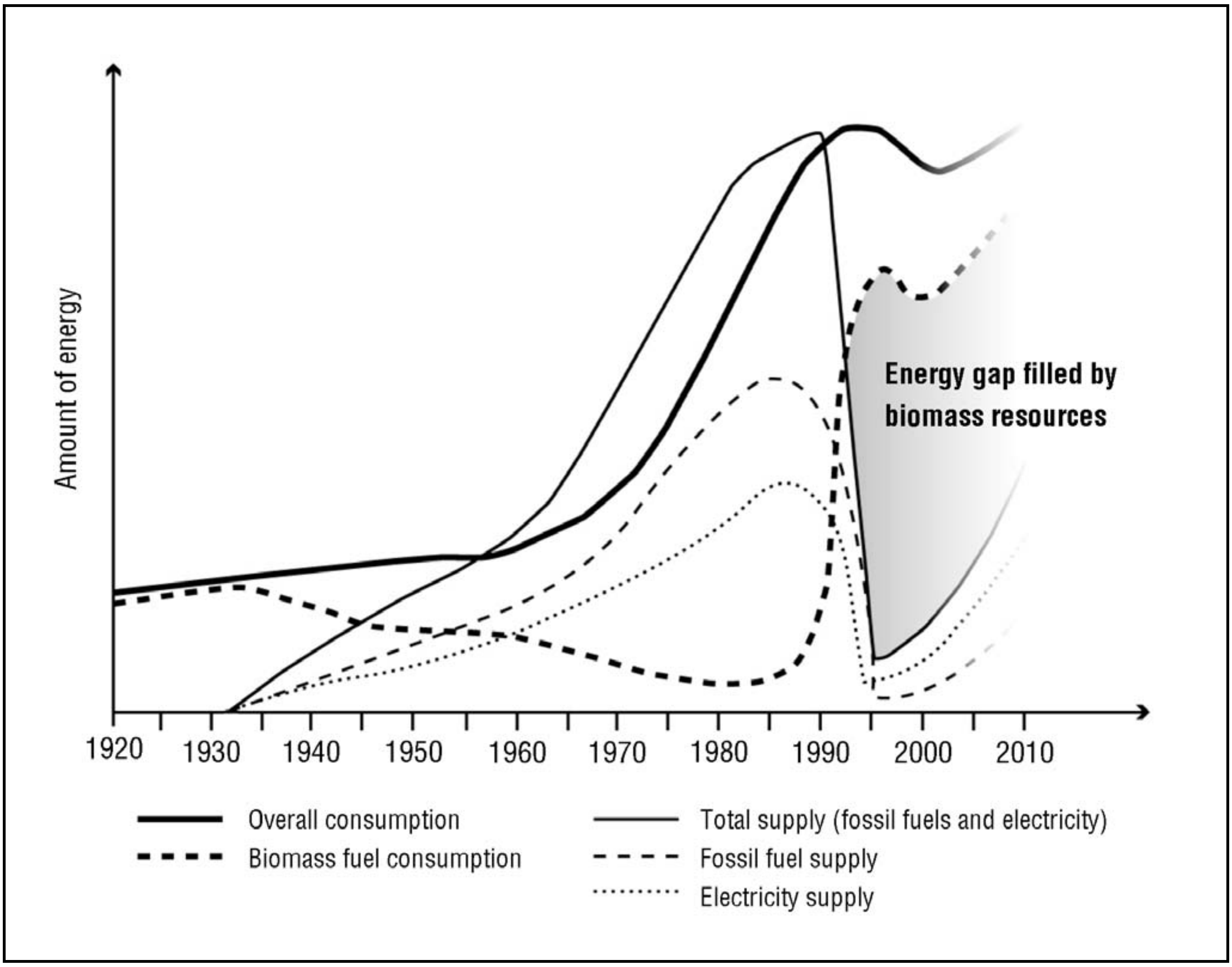

Figure 1. Schematic model of energy consumption and supply in the Tajik Pamirs since 1920.

Note

There are no numerical data on supply and demand for this period. The curves are estimations based on demographic data, data of energy production and imports for single years, as well as historical and anecdotal evidences, such as construction of power stations and grids, amount of coal supplied to households and villages, and the harsh conditions during the years of civil war in the 1990s. In the absence of hard data, this figure is illustrative of how energy consumption developed and how supply sources changed over the years.

high demand for energy had to be covered by local energy resources, which had already been heavily reduced during the Soviet era when Tajikistan lost approximately 90 % of its forests for agricultural land and energy. The consequence was an enormous energy supply gap that exerted pressure on local natural resources and often resulted in rapid environmental degradation. Hence at present, maintaining energy facilities and improving energy supply is considered one of the most urgent development issues in the Tajik Pamirs [Breu and Hurni, 2003].

Despite the high relevance of this issue, so far no in-depth research has been carried out analysing the current energy consumption in the Pamirs. Moreover, the sparse data and analyses available [e.g., Scholz and Krause, 2004] do not take account of the non-commercial fuels which are known to be a major component of rural energy consumption [Chow et al., 2003]. Taking into consideration the peculiarities of the Soviet heritage, this study aims at (1) investigating the current energy supply and consumption patterns at household and village levels in the western Tajik Pamirs, (2) analysing the implications for land degradation and natural resource management, and (3) making recommendations for sustainable energy use.

2. Research area

The Tajik Pamirs consist of the remote and isolated mountainous regions of East Tajikistan with altitudes of up to 7495 m above sea level (Figure 2). By and large they coincide with the political and administrative province of Gorno Badakhshan Autonomous Oblast (GBAO), which encompasses 63,700 km^2 and has only approximately 213,000 inhabitants, of whom 87 % live in rural areas [Breu and Hurni, 2003; MSDSP, 2003]. Land resources – except for water – are very scarce. Most of the territory (65 %) is barren land or rocky terrain, while productive land is very limited: 0.38 % arable land, 0.07 % forest area, and 12.5 % pasture land [Hergarten, 2004]. Harsh temperature and precipitation regimes severely constrain vegetation growth and contribute to higher energy consumption.

The Tajik Pamirs are generally divided into an eastern and a western part. The boundary between these two re-

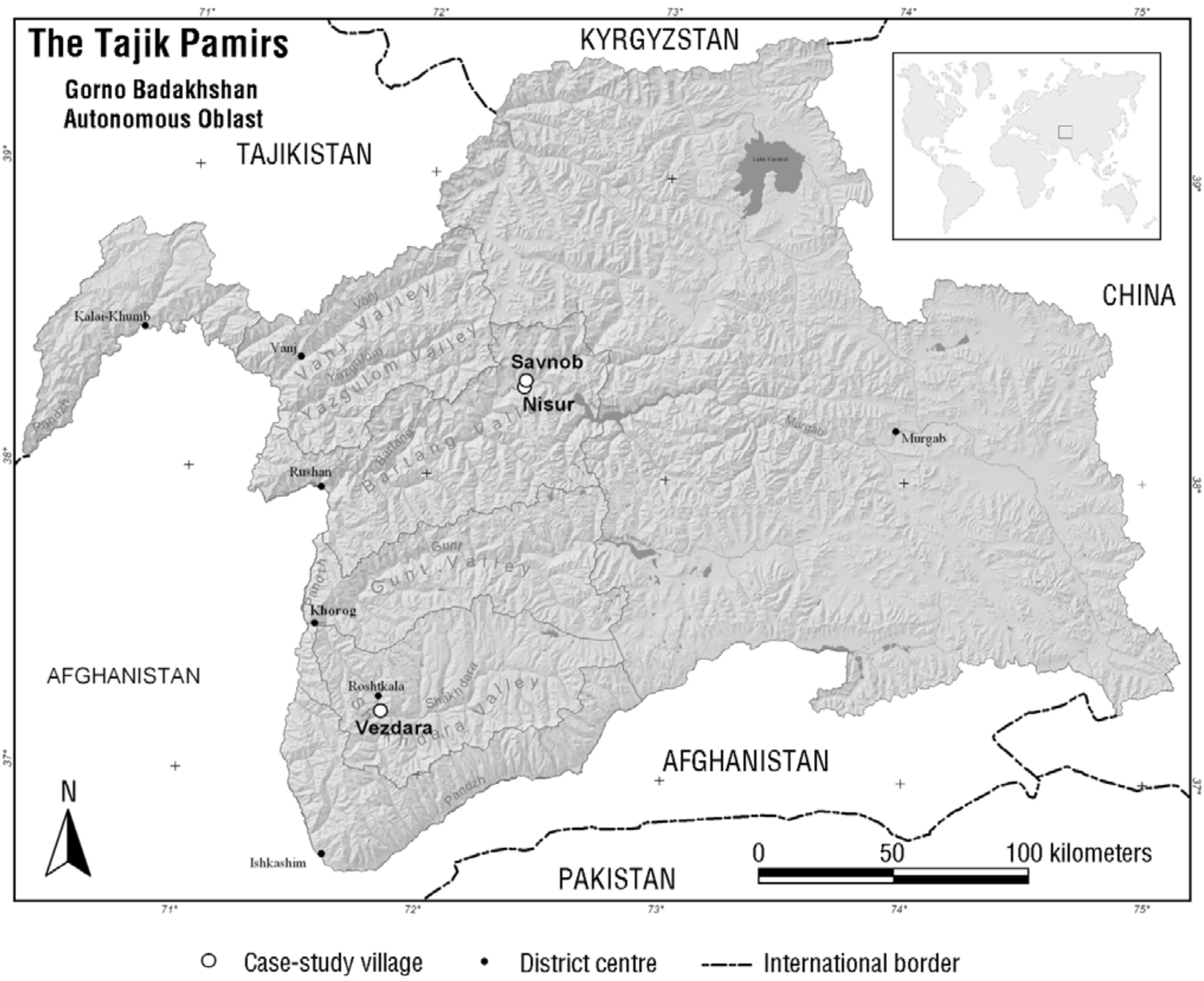

Figure 2. Overview map of the Tajik Pamirs and the three case-study villages

gions is not only manifested in the distinct topography and climate but also in socio-cultural differences. The west – where the study was carried out – is characterised by deeply incised valleys, which receive 100 to 500 mm mean annual precipitation and have a median of 204 vegetation days [Breu et al., 2005]. The land use of the traditional, predominantly Ismaili settlements consists of mixed mountain agriculture with crop cultivation on irrigated land and livestock-breeding based on seasonal exploitation of resources at different altitudes [Herbers, 2001; Haslinger et al., 2006].

3. Approach and methods

The study applied a participatory and multi-level stakeholder approach [Hurni, 1996]. It consisted of (1) comparative in-depth case-studies at household level in three typical villages with different energy resource bases, focusing on energy supply and consumption patterns, and (2) participatory land degradation assessments in 25 selected villages. Households were deliberately chosen as the most meaningful unit for energy consumption rather than a standard per capita analysis [Clemens, 2001]. This allowed clearer understanding of the interlinkage between energy use, natural resources, and land use in different settings. Given the pivotal role of women in energy management, particular attention was paid to gender aspects. For this the Sustainable Development Appraisal [Hurni and Ludi, 2000] was amended. The villages were investigated following an eight-step procedure: (1) participatory transect walk with local informants, (2) interviews with official representatives, i.e., the village organization, (3) structured interviews with members of six households followed by an open discussion, (4) comprehensive investigation of micro-hydro power stations (MHPSs), (5) participatory observations of fuel-wood procurement, (6) group discussions with the women's committee, (7) participatory land degradation assessment with land users, and (8) mapping of relevant features of the land use system. Data was collected during field research from May to July 2003 [Droux and Hoeck, 2004].

3.1. Village and household sampling

The three villages were selected from among the 375 existing villages of the western Pamirs. Factors of similarity were (1) number of households and inhabitants, (2) average number of household members, and (3) altitude. Key factors for distinction of the energy resource base were

Table 1. Characteristics of village types (selected villages): features relevant for energy consumption

Characteristic village features	Type 1 (Vezdara)	Type 2 (Savnob)	Type 3 (Nisur)
1. Altitude	2,800 m	2,700 m	2,600 m
2. Number of hh[1]/inhabitants	28/197	54/341	36/240
3. Average number of hh members	7.0	6.3	6.6
4. Electricity supply	Grid and MHPS	MHPS	None
5. Type of local fuel-wood	Trees and shrubs	Only shrubs	Only shrubs
6. Distance to main market (Khorog)	47 km	175 km	168 km
7. Average arable land per hh	2500 m^2	1660 m^2	3000 m^2
8. Average number of cattle/sheep and goats per hh	5/18	2/12	2/8
9. Number of cowdung units per hh[2]	16.7	9.8	7.2

Notes

1. hh = household(s)
2. The cowdung unit is calculated according to the productivity of large (1) and small livestock (0.065). An adult cow contributes around 10 kg of wet dung per day, while sheep and goats contribute only 0.65 kg per day [Kadian and Kaushik, 2003, p. 64].

(1) availability and type of electricity, (2) availability and type of local fuel-wood, and (3) access to market. These six criteria were applied to a geographic information system (GIS) database provided through the "Pamir Strategy Project" [Breu and Hurni, 2003] and used to define three village types.

Type 1: electricity supply from grid and mini hydro power stations (MHPSs), high biomass index (trees) and relatively short distance to main market *(Khorog).*

Type 2: electricity supply from MHPS, low biomass index (sparse vegetation), and long distance to main market.

Type 3: no electricity supply so far, low biomass index (sparse vegetation), and long distance to main market.

Within each village six households were selected by considering two criteria: (1) wealth ("poor", "average", "rich"), and (2) size, i.e., number of household members ("small", "medium", "large").

3.2. Quantification of energy consumption

The mean annual household energy consumption was determined by measurements and investigations. Local biomass consumption was assessed by identifying the commonly harvested fuel types and their respective units measured in kg with a spring balance (e.g., firewood bundles, *teresken* head- and donkey-loads, dung bags and single dung-cakes). Household members were asked to show the daily amount of a specific fuel type used during summer and/or winter. Subsequently the total annual biomass fuel consumption was calculated. Electricity consumption in kWh was obtained from monthly electricity bills. If these were not available, the consumption was estimated on the basis of either the installed capacity, output, and operation period of the MHPS, or through the required electricity load and duration of use of different appliances. Annual total fossil fuel (diesel oil) consumption in litres (l) was assessed through interviews. In order to summarise and compare, the various fuel types were converted into energy content in joules (J).

3.3. Participatory assessment of land degradation

Following [Stocking and Murnaghan, 2001], a participatory approach was used to assess land degradation processes affecting mainly arable land, orchards, forests and shrub vegetation, pastures, livestock, and water. For this, semi-structured interviews focusing on direct and indirect indicators of land degradation [Herweg and Steiner, 2002] were carried out with land users as local experts. Ultimately this allowed determination of the most common forms of land degradation as well as their intensity and dissemination.

4. Results

4.1. Characteristics of selected villages

The selection process described above led to the identification of three villages with the following characteristics: similar values for altitude, village and household size (Table 1: Nos. 1 to 3), and differences in energy resource base (Table 1: Nos. 4 to 6). Since in the western Pamirs the average village altitude is 2430 m, the median number of households per village is 43, and the average size of a household amounts to 6.9 members, the sample can be considered typical of west Pamir villages.

Vezdara (Type 1) is located in the *Shakhdara* valley, 1.5 hours drive or 47 km from Khorog, the oblast centre and main market place (Figure 2). It was connected to the electricity grid in 1974 and was assured a perennial supply. However, since 1992 the village has been disconnected from the grid during winter. For firewood the inhabitants mainly rely on residual, rather dense, forest areas located in the vicinity as well as on willow trees planted near homesteads. A community-based MHPS constructed in 1999 provides electricity in winter. The two villages representing Type 2 and 3 are neighbouring settlements situated at the far end of the *Bartang* valley, around 9.5 hours drive (or 175 and 168 km respectively) from Khorog. *Savnob* (Type 2) enjoyed electricity supply for the first time in 1988 from diesel generators, which were replaced by a decentralised MHPS in 1989. How-

Table 2. Average annual energy consumption per household in the three case-study villages

Energy consumption features	Vezdara	Savnob	Nisur
1. Electricity (kWh)	3,054	2,356	0
2. Firewood (mainly *Salix)* (kg)	2,327	0	608
3. Teresken shrubs (*Ceratoides spp.)* (kg)	0	7,256	8,124
4. Dung (kg)	1,762	537	400
5. Diesel oil (l)	47	5	114
6. Overall energy consumption[1]	69 GJ	124 GJ	140 GJ
7. Annual heating-degree-days (HDD)[2]	5828	5263	5400
8. Relative heating demand adjusted to the highest HDD (%)	100	90.3	92.6
9. Summer/winter consumption (%)	13/87	34/66	26/74
10. Ratio of per capita consumption small hh/large hh[3]	2.3	2.6	3.3

Notes

1. Overall consumption was calculated on the basis of the following conversion factors: firewood, 1 kg = 15 MJ; *teresken* shrubs, 1 kg = 15 MJ; dung, 1kg = 12 MJ; electricity, 1 kWh = 3.6 MJ; diesel oil, 1 l = 36 MJ.
2. HDD are used as a proxy for space heating demand. HDD = 20º C minus daily mean temperature calculated for each day and added up for the whole year, when > 0. Source: www.hev-statistik.ch
3. Per capita consumption of small households: Vezdara 15.7-18.2 GJ; Savnob 27.4-37.7 GJ; Nisur 25.2-76.8 GJ. Per capita consumption of large households: Vezdara 5.9-8.9 GJ; Savnob 12.2-13.2 GJ; Nisur 14.2-16.8 GJ.

Sources: Rijal, 1999; Clemens, 2001; www.worldenergy.org; www.worldbank.org; www.videncenter.dk

ever, given the general scarcity of water (the village has only one small spring) and the considerable demand for irrigation water, electricity production during summer is limited to the evenings. With regard to domestic fuel, inhabitants started collecting firewood from nearby rather sparse forests right after the collapse of the Soviet Union. Due to almost complete depletion, these areas were officially protected and conserved for rehabilitation in 1996. As a consequence, inhabitants started using shrubs as fuel. In contrast to the first two villages, *Nisur* (Type 3) has never had an electricity supply. Local riparian forests were already cleared during Soviet times and then transformed into grazing land. Since independence, inhabitants have had to rely on shrubs to cover their fuel-wood need.

4.2. Energy consumption, resource use, and patterns

The major fuels used are electricity, firewood (mainly *Salix), teresken* shrubs (*Ceratoides* and *Artemisia),* animal dung, and diesel oil (Table 2). Households commonly follow a multiple fuel use strategy, using more than one fuel type to cover the demand for a specific purpose. Electricity is mainly used for lighting, TV and radio, as well as for heating water, cooking meals, and baking bread, depending on the load supplied. In the case of no or irregular electricity supply, diesel oil is used as a substitute for lighting. Firewood and *teresken* shrubs are burned in order to cover cooking and heating demand, whereas dung is commonly used for heating in winter. The total annual energy consumption per household in the three villages varies considerably (Table 2; Figure 3): while in Vezdara households consume 69 GJ, in Savnob consumption is 80 % higher (124 GJ) and in Nisur more than twice as much (140 GJ). Interestingly, Vezdara, the village with the highest heating demand (Table 2: Nos. 7 to 8), the highest share of winter consumption (Table 2: Nos. 9), and the largest household size (Table 1: No. 3), has by far the lowest annual energy consumption.

These differences in energy consumption at household level can be explained through factors such as local availability (1), accessibility (2), affordability (3), efficiency (4), and competition for resources (5), resulting in a combination of economic and socio-cultural preferences for their application.

1. *Local availability.* Households in Vezdara enjoy more favourable electricity supply conditions compared to Savnob since grid supply proves to be more appropriate with regard to load compared to the MHPS. This may explain the difference in electric power consumption between households in Vezdara and Savnob (Table 2: No. 1). Further, Vezdara also shows the highest consumption for firewood (Table 2: No. 2), which is both freely accessible within walking distance (Figure 3) and privately grown, while Savnob and Nisur lack any accessible local source of firewood. Dung is generally available from private livestock, but its use as fuel is often constrained by the competing need for fertiliser, whereas *teresken* shrubs are widely available but less efficient.
2. *Accessibility.* In Vezdara the collection of dead wood is allowed, while in Savnob recovering forest land is protected and its use restricted. *Teresken* shrubs are freely accessible but their harvest represents particular drudgery given the deep, ramified root system hampering manual extraction (Figure 4). However, households in Savnob and Nisur annually collect 7,256 kg and 8,124 kg respectively of *teresken* to cover their demand for cooking and heating. Since fuel-wood

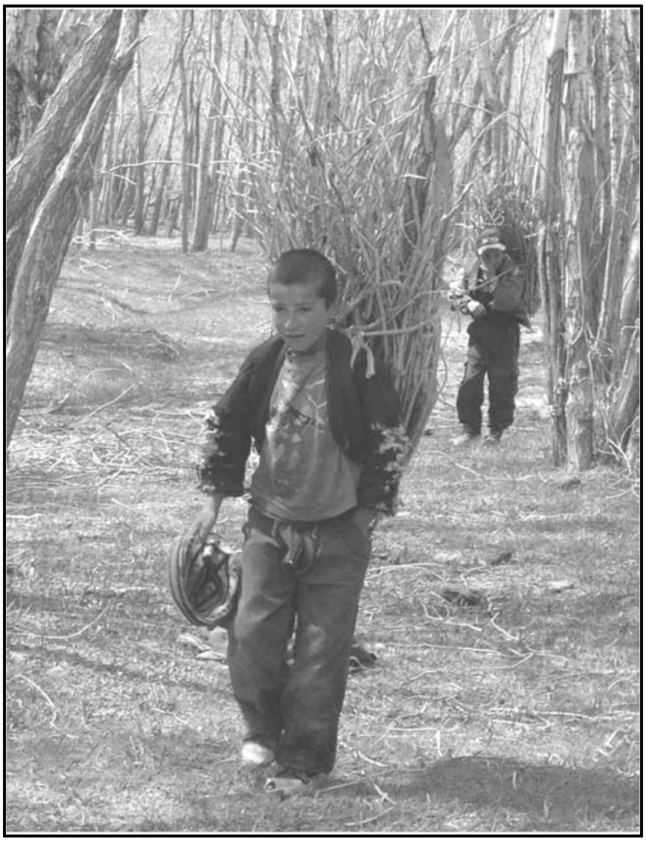

Figure 3. Children from the village of Vezdara with firewood collected from a nearby remnant forest

Figure 4. Woman from the village of Savnob gathering *teresken* shrubs to be used as a fuel

must be harvested at an increasing distance from settlements year after year, procurement becomes more and more time-consuming: at present up to eight hours daily from spring until autumn are required. This arduous work is mostly performed by women and children, who carry head loads of up to 30 kg to the village.

3. *Affordability.* Electric power and fossil fuels must be bought, in contrast to local firewood, dung and shrubs, which are generally non-commercial energy carriers. Fossil fuels are very expensive and thus commonly only used for lighting. In contrast, electricity is relatively cheap and affordable to almost every household, but often limited in supply. Since Nisur lacks any electric power supply, households consume 114 l of diesel oil per year solely to cover their lighting demand, whereas in Vezdara and Savnob only small quantities are used to overcome rare electricity supply gaps (Table 2: No. 5). Firewood purchased from distant forests – as practised in Nisur – is very expensive and only affordable to wealthy households. Therefore, firewood consumption in Nisur is considerably lower than in Vezdara.
4. *Efficiency.* Electricity is efficient for cooking and lighting, and fossil fuels are fairly efficient for cooking when considering the available appliances. Firewood is also relatively efficient, followed by dung, which is preferably used for heating. In comparison *teresken* shrubs are very inefficient, despite a high heating value, because they burn like paper. This characteristic may explain to a great extent the large difference in overall household energy consumption between the two villages relying on shrubs and Vezdara, where no *teresken* is burned. In addition, the appliances available in most households are inherited from Soviet times and were originally designed to run on fossil fuels. Nowadays, the heavy coal stoves are operated with firewood, dung and fast-burning shrubs, resulting in high resource consumption. Furthermore, Soviet electric appliances (kettles, ovens, and stoves) often demand loads too high to work effectively under present supply conditions.
5. *Competition.* The competitive use of scarce resources such as water, wood and dung, which fulfil more than one purpose in the livelihood system, presents people with a dilemma. They are forced to decide for which of the competing purposes water (irrigation vs. hydro power), wood (construction vs. fuel), and dung (fertiliser vs. fuel) should be used. Under subsistence economy conditions, however, preference is generally given to basic food production and income generation over energy production.

Investigations have further shown that the amount of dung made available as fuel is largely determined by the ratio of arable land to be fertilised to the dung produced (Table 1: Nos. 7 to 9). This is a qualitative indicator influencing the decision-making at household level. The ratio is expressed in total m^2 per so-called “cowdung unit” (CDU = 10 kg of wet dung produced per cow per day). The label proposed for this ratio is “arable land per cowdung unit” (ALCDU). The lower the ALCDU, the more dung that is available for burning. The purchase of artificial fertiliser allows an increase in the proportion of fuel dung. Vezdara, with an ALCDU of 150 m^2/CDU and intensive application of artificial fertiliser, uses by far the greatest amount of dung as fuel (Table 2: No. 4), whereas Savnob and Nisur with a higher ALCDU of 169 m^2/CDU and 417 m^2/CDU respectively and only occasional use of chemical fertiliser, burn much less.

Each of the villages shows a specific household energy consumption pattern (Figure 5). However, the consump-

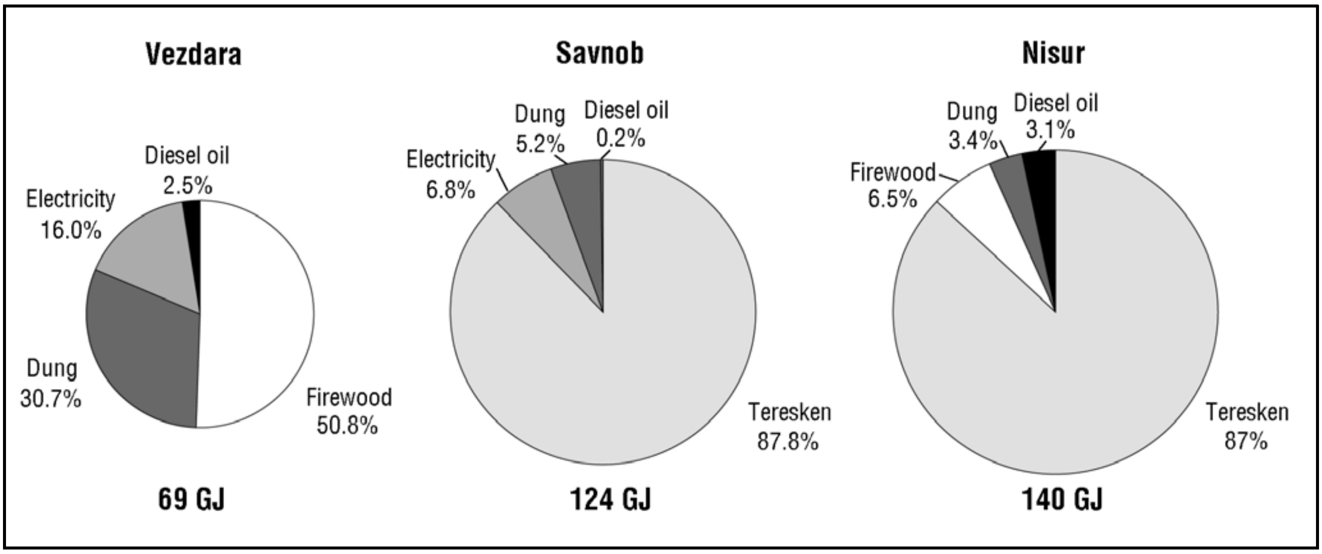

Figure 5. Household energy consumption patterns of the three case-study villages

tion patterns share common characteristics.

- *A high percentage of biomass fuels.* Firewood, shrubs and/or dung range from 81.5 % (Vezdara) to 93.1 % (Savnob), and 96.9 % (Nisur) respectively.
- *A high proportion of local energy resources.* For Vezdara and Savnob local energy accounts for 97.5 % and 99.8 % respectively when taking into account the contribution of hydro power (MHPS and grid).
- *A high proportion of winter consumption (Table 2: No. 9).* In Savnob winter consumption amounts to 66 %, in Nisur to 74 % and in Vezdara to 87 % of the overall annual energy consumption.
- An economy of scale in household energy consumption: per capita consumption shows significant differences between small and large households; households with few members consume between 2.3 and 3.3 times more per capita than large households (Table 2: No. 10). This phenomenon is also known from other rural areas such as in Pakistan [Clemens, 2001], Ethiopia [Bewket, 2003], and India [Mahapatra and Mitchell, 1999].

4.3. Implications for land degradation and resource use

Energy supply and consumption patterns completely changed with the collapse of the Soviet system. Under Soviet rule 96 % of the energy was imported to the Tajik Pamirs in the form of mainly fossil fuels [Kleandrov, 1974; Zibung, 2002], whereas currently around 98 % of the energy is derived from local, mainly less efficient biomass sources (Figure 6). The Soviet regime provided efficient resources and adequate appliances to cover all specific domestic energy needs at affordable prices: coal for metal stoves to heat, kerosene for kerosene cookers to prepare meals, and electricity for lighting and other purposes. This explains why the traditional Pamiri houses built during Soviet times are considerably larger compared to pre-Soviet architecture, where the main room had a volume of about 20 m^3 [Schultz, 1914]. At present its size averages 100-160 m^3 which is generally too large to be properly heated. While the appliances are still available, adequate energy supply and resources are lacking: The heavy coal stoves, e.g., heated with the fast-burning *teresken* shrubs, consume enormous quantities of biomass.

Given the households' high dependence on local energy resources, the availability and accessibility of biomass fuels play a pivotal role in household energy consumption. Their excessive use has serious effects on land degradation and people's livelihood, and vice versa. The most common forms of land degradation related to energy use are thus observed on forest land (1), arable land (2), orchards (3), and shrubs (4).

1. According to local informants 70 to 80 % of the *forest* cover has been lost during the last 20 years mainly due to the high demand for energy[1]. Forests are affected by various forms of degradation: decrease in covered area, reduction of vegetation density, decline in number of species (biodiversity), and deterioration of single plants. The depletion of forest land commonly follows a sequence of degradation processes. First dead wood is collected; with increasing scarcity branches are chopped from living trees and bushes, and brushwood is continuously cleared, thus creating a park-like landscape with short grass and single larger trees. With increased pressure, wood is commercialised and legally or illegally chopped. The remaining stumps are cut, the area entirely cleared and eventually used for grazing. Land thus becomes prone to erosion and salinisation, which hinders the natural rehabilitation of the former forest.
   The depletion of local forests has the following implications: either firewood from other, more distant forests has to be purchased or other freely accessible but less efficient resources are tapped as an alternative and thus put under pressure.
2. Local land users often reported decreasing crop yields and an increase in fertilizer demand to maintain yields on their *arable land.* Loss of soil fertility and leaching of nutrients can largely be attributed to unfavourable crop rotation and irrigation practices as well as to lack

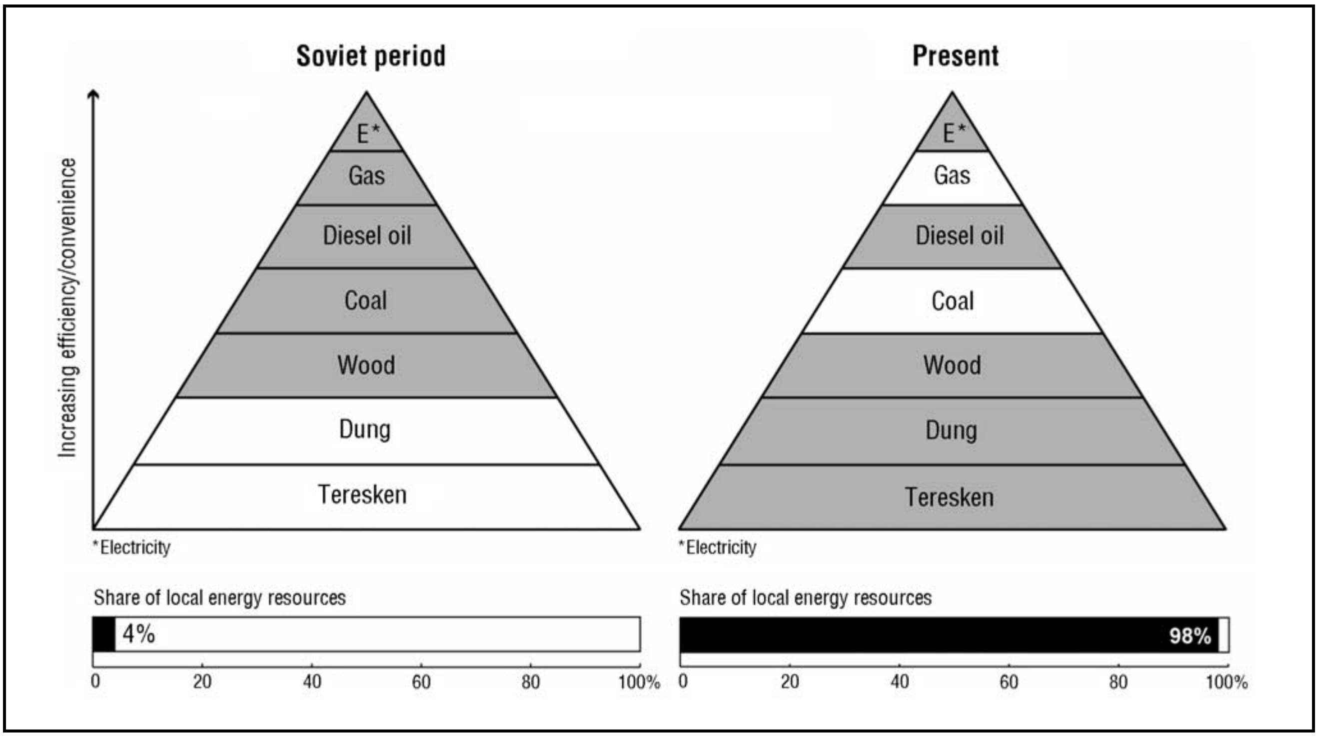

Figure 6. Comparison of the energy resource portfolios during Soviet period and at present. Shaded bands denote energy resources in use.

of nutrient return. Although the application of dung as fertiliser takes priority over its use as fuel, some dung is still burned, thus further depriving the soil of nutrients.

The use of dung as fuel has the following implications: either additional artificial fertiliser is purchased as a substitute or yields will further decrease.

3. Branches of *fruit trees* are often cut as firewood to help local people survive exceptionally cold or prolonged winters, sometimes leaving behind nothing more than bare trunks. Fruit yields are thus considerably reduced if not completely lost. In particular, single-parent and poor households are often forced to rely on orchards as a fuel source.

   The use of firewood from fruit trees has the following implications: people are deprived of an important vitamin-rich supplement as well as of a potential source of income.
4. The harvest of *teresken shrubs* as a substitute for depleted firewood sources often results in the complete removal of the vegetation cover on affected mountain slopes. Vast areas thus become liable to wind and water erosion, leading to the risk of desertification. In Savnob and Nisur 10.4 ha and 11.6 ha respectively are annually cleared to meet the energy demand of one single household. When added up for the two settlements, the annually cleared area amounts to 561.6 ha and 417.6 ha respectively.

   The intensive collection of shrubs has the following implications: people have to cope with increasing distances and workload as well as with expenditures of time and money for fuel procurement. Moreover, the clearing of shrub vegetation deprives both wildlife and domestic animals of important nutrient-rich forage.

5. Discussion

5.1. Energy consumption patterns – a paradox

Energy use in rural areas of the western Pamirs is not homogeneous. Major differences seem to exist in the amount and consumption patterns of villages with distinctive energy resource bases. The results from the three case-studies suggest – at first sight – a paradoxical situation: households with very difficult energy supply situations apparently consume almost twice as much energy as households which enjoy more favourable supply conditions. Surprisingly, the scarcer the energy resource base, the higher the overall energy consumption at household level appears to be. This has severe implications for land degradation. At the same time, the negative effects detectable can help in explaining the startling paradox: the energy shortage results in high pressure on the local commercially freely available fuel resource (i.e., wood). The high demand for energy combined with virtually no management and control mechanisms leads to a continuous degradation of this resource (i.e., forest) within walking distance until it is completely depleted. The further exploitation of this resource then requires mechanised transport to reach farther places. As a consequence the formerly freely available resource becomes commercialised. However, those households which cannot afford such transport are consequently forced to switch to other non-commercial and usually less efficient sources of energy (i.e., dung or *teresken).* The processes observed seem to lead to a vicious circle: shortage – pressure – degradation – reinforced shortage – reinforced pressure – depletion – commercialisation – resource switch. This ultimately causes a downward spiral both transferring and increasing pressure from a relatively efficient to a normally less efficient local energy source. Consequently larger quantities of fuel have to be exploited to obtain the same energy production. Since the newly tapped resource is often already used for other livelihood purposes such as dung applied as fertiliser, additional pressure is exerted. Moreover, the ever-increasing workload for fuel procurement in terms of time spent, physical effort, and quantity to be collected, as well as the related process of resource commercialisation, often have additional negative impacts on people's health and wealth. As in other similar situations, this particularly affects women [see e.g., Kadian and Kaushik, 2003; Rijal, 1998; Shailaja, 2000]. Eventually, these processes lead to increased poverty, which again reinforces dependence on freely available fuel resources. It can thus be concluded that the degradation of local land resources commonly results in an increase in overall energy consumption at the household level, explaining the paradox mentioned above.

5.2. Implications of the Soviet heritage

Since independence in 1991 energy consumption patterns in the Tajik Pamirs have become comparable to patterns in semi-arid rural mountain regions of developing countries such as Nepal, Pakistan, or Ethiopia. They are characterised by a high proportion of solid cooking fuels – mainly provided by local biomass – and only a low proportion of modern energy carriers [Clemens, 2001; Rijal, 1999; UNDP and ESMAP, 2003; Wolde-Ghiorgis, 2001]. However, with regard to the energy supply infrastructure, major differences still exist. While in the Tajik Pamirs about 94 % of the rural population have access to electricity, the percentage of rural areas with electrification in Nepal and Ethiopia only amounts to 3 % and 10 % respectively [Mahat, 2004; Wolde-Ghiorgis, 2001]. Such a high percentage is typical for the former Soviet republics in general: Tajikistan 98 %, Armenia 98.9 %, Uzbekistan 99 %, Turkmenistan 99.6 %, Kyrgyzstan 99.8 %, and Kazakhstan 99.9 % [UNDP and ESMAP, 2003; UNDP, 2004]. Unfortunately the ongoing deterioration of the Soviet infrastructure and services in the Tajik Pamirs mean satisfactory electricity provision is no longer guaranteed. Moreover, the demand side is still considerably determined by the Soviet-era heritage and proves to be unfavourable to the new supply situation.

5.3. Challenges, opportunities and recommendations

Sustainable and satisfactory energy supply in semi-arid rural mountain areas seems to be a promising entry point for mitigating land degradation. However, restoring Soviet supply conditions in the Tajik Pamirs based on subsidised external fossil fuel provision is neither feasible nor desirable. Nevertheless, due to the scarce local resource base, a sustainable use of local biomass fuels – in particular *teresken* – appears simply impossible at present. Innovative ways therefore have to be found to sustainably manage local energy resources in a mid- and long-term perspective. This will require an adaptation of the demand side to better fit the energy supply situation. Considering the triple challenge of sustainable rural energy supply, improving livelihoods, mitigating land degradation, and assuming global responsibility for biodiversity preservation and global climate change, a cross-sector approach (energy, agriculture, and forestry) has to be applied with profound consideration of women's pivotal role in energy procurement and consumption. Moreover, energy issues must be addressed in a wider context than just through national large-scale supply-side initiatives [see Chow et al., 2003]. Due to the close interrelations between energy and major livelihood and degradation issues, particular focus on demand-side measures at community and household levels in order to achieve a reduction in resource consumption, particularly during winter, is recommended. The post-Soviet setting and the high-mountain conditions pose some specific challenges as well as opportunities for improving the energy situation in the western Pamirs. Despite the dilapidation of the extensive electricity infrastructure, it represents a major potential in providing an efficient, modern and multi-purpose energy carrier to a large portion of the population. In view of this, focus on the following measures is recommended.

- Priority should be given to address the *demand side* by adapting the appliances (stoves, ovens, electric appliances, lighting systems, etc.) to the specific characteristics of the available local energy resources and supply conditions and by promoting better insulation of buildings.
- On the *supply side* the focus should be on developing and fostering adequate, affordable, renewable and decentralised energy options, preferably managed at community level. This may be achieved through the promotion of external investments and credits for the rehabilitation of the existing and the construction of additional decentralised (micro-) hydro power facilities, as well as by fostering private and community-based firewood plantations and the production of efficient heating resources such as fuel briquettes [see Bewket, 2003; Mahapatra and Mitchell, 1999].

This set of recommendations takes into account the increasingly ambivalent situation of the Tajik Pamirs, where the inherited demand side and extensive electricity infrastructure is confronted with consumption patterns comparable to classic Third World countries. This intermediary position between a transitional and developing country calls for a reassessment of the energy policy orientation for Tajikistan. Contrary to recommendations in [Scholz and Krause, 2004], more attention has to be paid to the fact that the Tajik Pamirs suffer from chronic energy scarcity, unsatisfactory modern energy services, and unsustainable use of biomass, which lead to land degradation as in many countries in the South. ■

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Note

1. There are no numerical data available confirming this. However, our observations during field research combined with those from local informants allow us to conclude that the majority of the forest land has been lost in recent years. Local informants especially pointed out the severe impact of the civil war (1992-1997) on local resources and

economy, when more than 55,000 refugees from the lowlands had to be accommodated in the mountain villages.

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