

Environmental Changes in the Hindu Raj Mountains, Pakistan

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ABSTRACT

Global Environmental Change among the world's mountains has become a field of interest for researchers and this issue has been widely studied in many parts of the world. This exploratory research aims to study the changes that have occurred and are still occurring in the Hindu Raj Mountains of northern Pakistan, which is an unexplored region with a wide potential for research. To study the changes in various aspects of physical and social setup, five villages/sub-valleys were selected at varying altitudes above mean sea level. Changes in the bio-physical environment were explored using remote sensing technology. It was found that drastic changes have taken place and are still going on in the natural environment as well as the socio-economic setup of the study area since 1970. The population of the study area has increased by manifold resulting in changes in the household and family structure. Moreover, the land use land cover of the study area has changed considerably. Forest cover has decreased drastically with an increase in both the built up and barren land areas.

1. INTRODUCTION

The northern mountainous belt of Pakistan has witnessed substantial changes in the biophysical and socio-economic setup during the last four to five decades. Changes can be observed in every aspect of the biophysical environment whether it is climatic pattern and behavior of weather elements, productivity and regeneration capacity of natural resources, availability and distribution of irrigation and domestic water, biodiversity, forest cover and the intensity and frequency of flooding events. Natural springs - the main water supplier for both irrigation and domestic use - have been drying out gradually resulting into an alarming situation. In many areas, the centuries' old and productive springs have died out completely. In most parts of this diverse mountainous belt, irrigated agriculture has become a myth and the lands, once producing paddies, are now cultivated with barley and other rain-fed crops. While having a look at the history of these changes, it can be observed that these have occurred in a short period of time and governed by complex natural and human factors (Flint, 1994; Gautam et al., 2003; Ali et al., 2006; Fazlur-

Rahman, 2007a; Fazlur-Rahman, 2007b; Rahman et al., 2014).

However, the above mentioned changes are not occurring independently, and neither their effects remain confined to the same setup. These anomalies are driven by various other factors mostly related to human activities and in turn these changes initiate and drive transformations in the socio-economic setup of the region and the process is going on in a cyclic manner (Jodha et al., 1992). Out-migration both on national and international scale is a recurrent phenomenon amongst several other changes in the socio-economic setup. The out-migration is mainly an indicator of deficient local natural resource base, high dependency on exogenous food supplies, insufficient local food supplies and declining agricultural productivity (Ehlers and Kreutzmann, 2000; Grotzbach, 1984; Kreutzmann, 1992; Ehlers, 1996; Ehlers, 1997). Fazlur-Rahman (2007b) argues that the traditional social setup throughout the mountainous region of Pakistan has been affected by the ongoing process of changes. Accessibility improvement has connected these remote communities to the lowlands and plain areas.

Improved transportation network has become an important factor of changes in the mountainous areas as stated by Ali et al. (2005). This study claims that about half of the natural vegetation cover has been cleared during the last thirty years, mainly as a result of the development of transportation network and improved accessibility to the natural forests.

The coupling effects of the biophysical and socio-economic changes result into the transformation of the traditional and historical natural resource management systems and affected the performance of local social institutions such as reciprocal activities and collective actions (Jodha, 2007). Continuously growing population, changes in household and family systems, economic transformations and changes in livelihood strategies are among the major factors of increase in stress on the fragile environment and diverse mountains' resources (Rahman et al., 2014). As a result, the natural resources are degraded and the sustainability of the fragile mountain environment is threatened. In this situation, the traditional and historical indigenous social institutions and mechanisms for natural resource management are losing their effectiveness and going through the process of transformation (Somanathan, 1991). The key question addressed in this study is: What factors drive the current and unprecedented changes in every aspect of the natural and social environment and effects do these changes have on the natural resource base of the mountainous areas? This research is basically exploratory in nature with the main goal to explore the process of change and the governing factors in the northern mountainous belt of Pakistan. Moreover, the study aims to establish a link between the changes in the biophysical environment and socio-economic setup.

2. METHODOLOGY

2.1 Characteristics of the study area

The present study has been conducted in the Dir Valley (Dir Valley refers to the entire valley formed by River Panjkora covering the Upper and the Lower Dir districts), which is located in the northwestern frontier region of the Khyber Pakhtunkhwa province between Latitude 34°45' N to 35°45' N and Longitude 71°30' E to 72°30' E. Geographically, the study area is an intermountain valley of the Hindu Raj spurs of the great Hindukush Mountain Ranges of Pakistan. The elevation of the

study area ranges from 1,400 m above mean sea level up to around 5,000 m above mean sea level in the northern and northwestern part (Figure 1). The physiographic setup of the area is modified into deeply cut valleys by River Panjkora and its major and minor tributaries originating from mountains all around. These valleys provide flat surface for the construction of dwellings as well as agriculture. The relatively gentler slopes, alluvial fans and terraces near the valley bottom up to an altitude of 3,000 m above mean sea level are used for the construction of permanent human dwellings. On the other hand, temporary seasonal summer houses and animal huts can be found in the mountains above 3,000 m elevation. The summer houses are constructed for pastoralism and seasonal movements in the summer months.

The study area is inhabited by the Yousafzai Pathan Tribe with some other small tribes and non-bona-fide migrated people. All the natural resources in the jurisdiction of the valley are owned by the bona-fide inhabitants, managed and utilized under an indigenously devised land tenure system. Up to 1969, the study area was a princely state ruled by various dynasties and feudal rulers. In 1970, it was given the status of settled district and in 1996; it was divided into two districts, i.e., Dir Upper and Dir Lower. The merger of the State in Pakistan and its declaration as a settled district was the arrival of a new era in the dark feudal history of the valley. This administrative shift triggered changes in every aspect of the socio-economic environment of the valley.

2.2 Methods and sources of data collection

2.2.1 Timeframe

This research is mostly based on primary information collected through field survey. To have an insight into the ongoing process of change and transformation, five villages were selected for the study from different sub-valleys with varying elevation above mean sea level. Khall was selected from the lowermost altitudinal zone which is the most easily accessible area. Three villages, namely Balkore, Daskore and Jabar were selected from intermediate altitudinal zones, while Thal was selected from the Kohistan Sub-valley with an altitude above 3,000 m above mean sea level (Figure 1). These villages are characterized by diverse physical socio-economic conditions. To discover temporal variations in environmental and socio-

economic setup, two data points were selected. The first data point was 1970, which can be termed as the beginning of a new era in the history of the study

area, while 2014 was taken as the last data point on the basis of data availability.

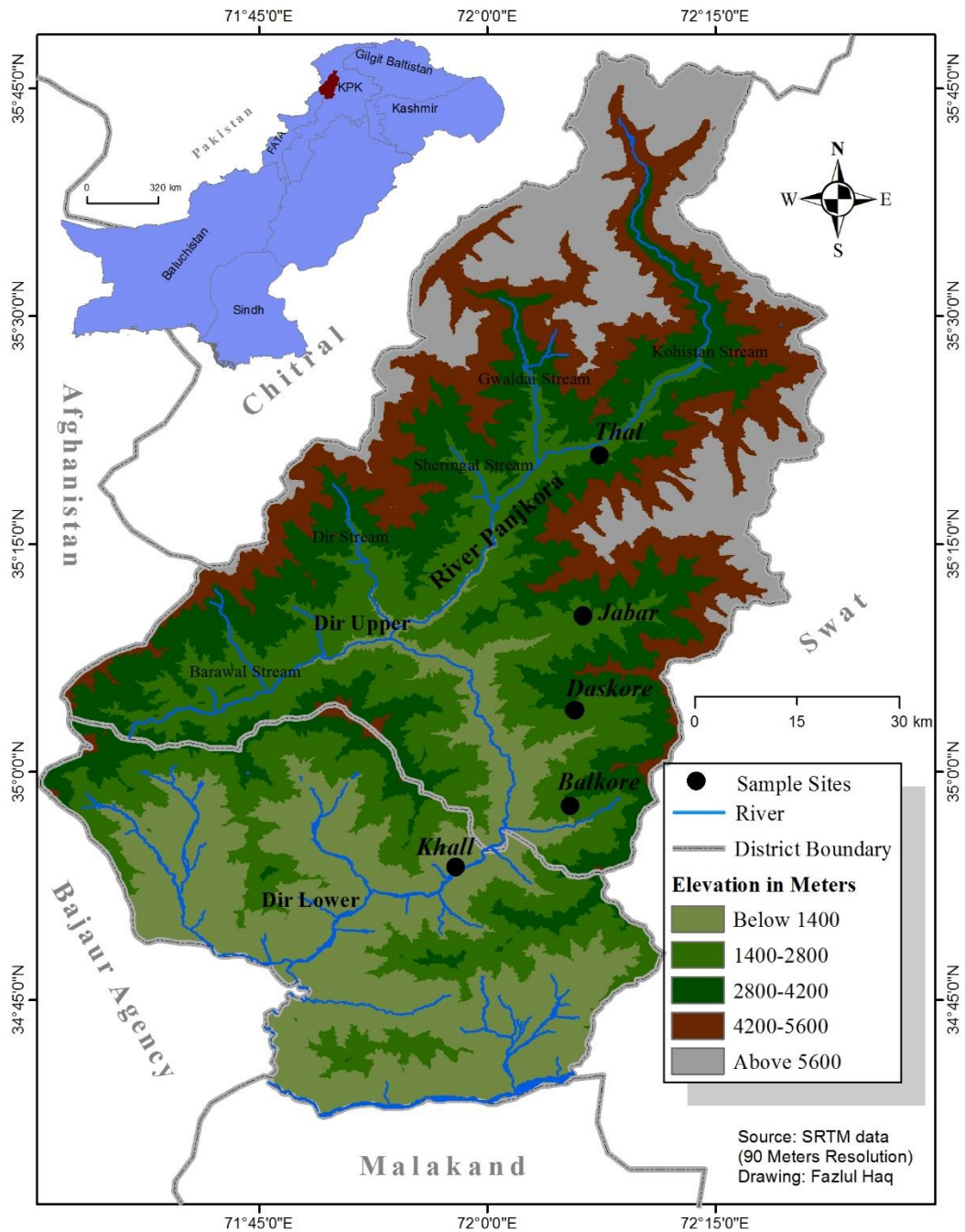


Figure 1. Study area: location, drainage pattern and physiography

2.2.2 Questionnaire survey and sampling

Questionnaire survey and geographical information system (GIS) were used to discover and quantify the changes. The major variables covered through the questionnaire were; economic transformations, modernization of agriculture and irrigation, animal husbandry and migration. A total

of 500 respondents were interviewed from the selected villages. The respondents were selected on the basis of birth year to be earlier than 1960 who could perceive the changes during the last four decades. The purpose of the questionnaire survey was to determine the socio-economic changes occurred during 1970 to 2014. Therefore,

comparative statistical charts were prepared for the two data points using MS Excel

2.2.3 Geo-spatial techniques

GIS was used to determine the spatial and temporal variations in the biophysical environment utilizing the land cover maps of 1970 and 2014 (GoNWFP, 1975; GoKPK, 2014), which were scanned and imported in ArcMap package of ArcGIS 10.3. The rectified raster maps were processed for the preparation of land use land cover maps for 1970 and 2014. The main objective of this step was to quantify the dynamics of forest resources and agricultural land during the study period.

3. RESULTS AND DISCUSSION

3.1 Population and household dynamics

Population growth and the related household dynamics are one of the important elements of socio-economic transformations. While having a look at the figures, it can be observed that the population of the study area has grown from 5,100 in 1972 to 23,110 in 1998 revealing an increase of about five times (Figure 2). Population growth affects almost every sector of life and environment and this issue has been studied extensively worldwide (United Nations, 1973; United Nations, 2001; Repetto, 1986; World Bank, 1992; FAO, 1994; Templeton and Scherr, 1997; Sati, 2009; Gracheva et al., 2012). It has played the pivotal role in the process of environmental changes in the study directly and by triggering household dynamics.

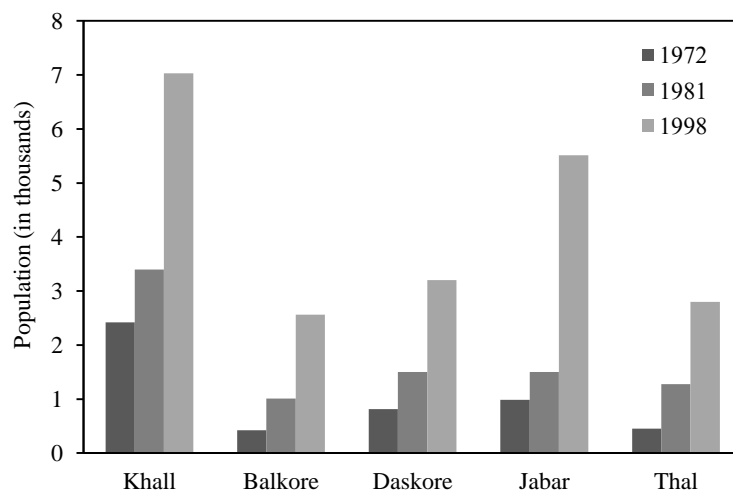


Figure 2. Population growth in the study area (1972-1998) (GoP, 1961; GoP, 1972; GoP, 2000)

Traditionally, the inhabitants of the study area used to live in the form of joint family system as it was an important integrating factor keeping all the relatives together, and also a strategy to cope with issues like conflicts, food insecurity, natural hazards and economic problems. However, during recent decades, the joint family system has decreased significantly and the same trend has been observed in other areas as well (Liu et al., 2003; Knight and Rosa, 2012). Results reveal that during 1970s, 65% families were living in joint and extended family systems and only 35% were nuclear families. During the last four decades, the number of nuclear families has increased to 64% (Figure 3).

As a result of joint family disintegration, the average household size has significantly decreased

during 1970-2014. The proportion of larger families (10 members and above) was 53% in 1970, which decreased to 10% in 2014 replaced by smaller families with 5 or fewer members (Figure 3). Keilman (2003) also concluded the same findings that the household size in most of the developing countries has declined (from 5.1 to 4.4) during 1970-2000, while it fell from 3.2 to 2.5 in the developed countries.

The forces driving household dynamics are numerous. Continuously growing household size makes it hard for the joint family to handle space sharing and the allocation of domestic chores and responsibilities. Therefore, separation becomes necessary resulting in disintegration. Several joint families disintegrated because of the internal

conflicts created as a result of competition for space and allocation of duties as also reported by Goode (1963). Additionally, there are other socio-cultural forces, as identified by the demographic behavior theories (Verdon, 1998), which play a role in the disintegration of joint families. According to

Keilman (2003), these factors include less tolerance to cultural norms; less religion tendency and increased freedom; women education and economic independence; emphasis on gender equity and residential autonomy.

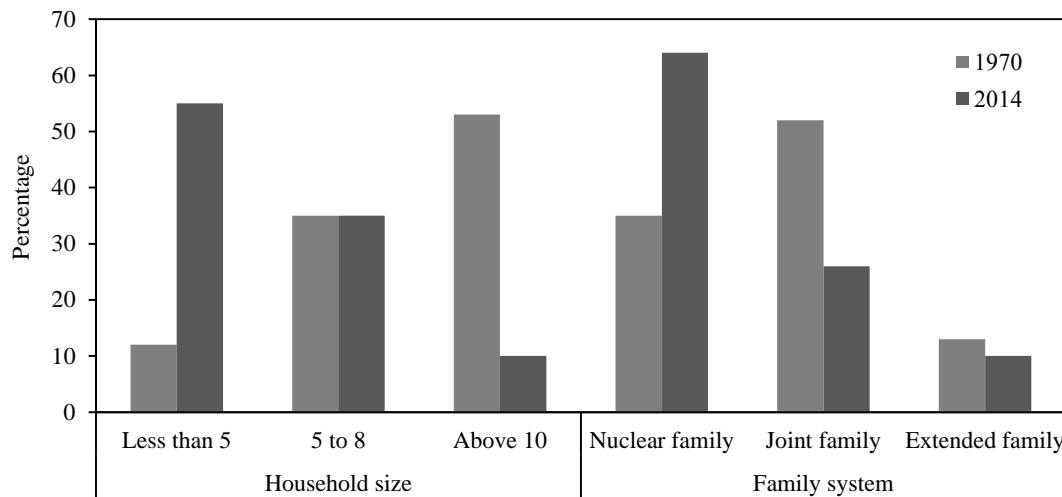


Figure 3. Dynamics of household size and family system (1970-2014)

As families disintegrate, the house design and layout are considerably changed. Most of the structural changes in house construction and designs started after the political change of 1970s'. During the reign of the feudal ruler Shah Jehan, construction of big houses was forbidden in the jurisdiction of the state. However, after the merger of the Dir State in Pakistan, the inhabitants started to modify and construct settlements without such restrictions. Based on building material, the houses are of three types in the study area. 1) Kaccha house which is made up of stones, mud and wood. 2) Pakka houses which are fully concrete structures with doors and windows, usually but not exclusively, metal made. 3) Semi-pakka houses, when cement and corrugated sheets are used along with wood and stones. Results reveal that during 1970-2014, kaccha houses have considerably decreased and pakka houses have increased throughout the study area with slight local variations (Table 1). This shift from traditional and local building material is mainly because of "motorized access to the regional center and availability of money" (Fazlur-Rahman, 2007b), along with the political change and population dynamics.

Another major change is the addition of facilities and rooms to the traditional single room houses. Historically, in the mountainous areas of Pakistan, the houses were in the form of single room, "...without any windows or ventilation, with animal sheds, hay stores, a byre and a storeroom attached to it on one end. All the facilities were under the single roof, ranging from kitchen and sleeping area to wood storage and the storage of agricultural implements" (Fazlur-Rahman, 2007b). The local inhabitants used to build separate rooms with the passage of time in order to accommodate new family members and their spouses, while the rest of the family sharing the main room. More and more innovations were added to the traditional houses from time to time. Separate bedrooms, guestrooms (The guestrooms are not only used for the purpose of serving guests, but also used as bedrooms by the unmarried males of the family who in the past used to sleep on the roofs and open spaces), animal-sheds and kitchens became common after 1970. In addition, the trend of using open-air toilets declined and attach toilets became one of the basic components of the house structure because of several cultural factors. The proportion of households with attached toilets has increased considerably during 1970-2014 (Table 1).

Table 1. Change in house construction, layout, facilities and design in the study area

Study area	Change in house construction, layout and design: % increase or decrease in number from 1970 to 2014									
	Kaccha houses	Semi-pakka houses	Pakka houses	Single room houses	Double room houses	Multiple room houses	Kitchen	Guestroom	Toilet	Animal shed
Khall (N=100)	-48	-17	65	-69	12	57	69	62	80	70
Balkore (N=100)	-39	11	28	-61	23	38	58	84	76	76
Daskore (N=100)	-31	-15	46	-65	39	26	58	86	72	76
Jabbar (N=100)	-45	-13	58	-44	-8	52	69	61	66	56
Thal (N=100)	-27	-17	10	-52	22	30	62	67	60	70

3.2 Agricultural transformations

Mixed mountain agriculture, i.e., cultivation of crops and domestication of livestock have played a major role in food security and livelihood sustenance of the inhabitants. Both these pillars of mixed mountain agriculture have gone through several changes and transformations. The major aspects of change are; land use, productivity and per unit yield, agricultural inputs and output, labor engagement and distribution, cropping pattern, irrigation sources and methods, landholding size and farming methods. Population growth and increasing demands for food and fodder have resulted in innovations and the land is now utilized more intensively as compared to the past by introducing modern inputs such as genetic seeds and fertilizers, labor intensification, mechanization and multiple cropping techniques. Innovations in agriculture can also be observed in the surrounding mountainous areas as according to Fazlur-Rahman (2007b) "many modern innovations have been grafted onto the traditional agricultural system, such as new seed varieties and chemical fertilizers". Although due to certain physical constraints, agriculture cannot be mechanized fully; however, mechanization has partially replaced the old sowing and threshing methods. The traditional bull tilling is still important as tractor tilling is not possible everywhere due to inaccessibility, thin soil layer and steep slopes of the terrace fields.

Availability of suitable land for agriculture is

limited due to rough topography. The available agricultural land is extensively fragmented resulting into small landholdings per household. The trend of fragmentation of arable land is not confined to the study area, but common in the neighboring mountainous regions of Pakistan, driven by inheritance and increasing number of households (Fazlur-Rahman, 2007b). Data reveals that 89% of the households own less than 0.5 acres arable land. The percentage of small landholdings was 56% in 1970 and the rest of the households owned more than 0.5 acres land. Presently, bigger landholdings belong only to 11% of the households (Figure 4). As a result agriculture is becoming an activity of secondary importance and off-farm sources of earning are opted.

Changes in cropping pattern and crop rotation are an important strategy to get more yield as the areas where only one crop per annum was grown are now cultivated with multiple crops. The climatic conditions of the lower and middle altitudes favor different crops and enjoy two distinct cropping seasons. Results reveal that the percentage of the respondents growing multiple crops has increased from 13% to 39% during 1970-2014. On the other hand, the percentage of double and single cropping systems decreased from 31% and 56% to 20% and 41% respectively during 1970-2014 (Figure 4). It implies that 80% of the respondents harvest two or more crops per annum while single cropping is practiced only by 20% of the respondents.

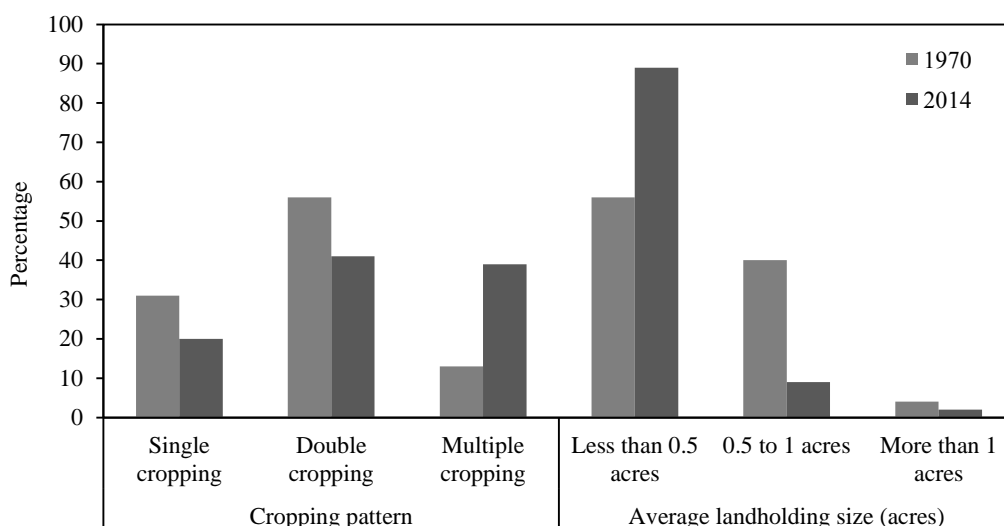


Figure 4. Changes in agricultural landholdings per household and cropping pattern (1970-2014)

In addition to crop intensification, considerable improvements can also be observed in irrigation infrastructure. The canal taken off from Ushiri Stream in the 1970s is a good example, which has brought most of the cultivated land of the Jabar village under irrigation. Moreover, a number of minor water courses have been taken off from the local streams. As a result, the proportion of irrigated and semi-irrigated land has increased considerably, particularly in Jabar where the number of respondents having land under irrigation has increased from 52% in 1970 to 88% in 2014 (Table 2). The overall proportion of

irrigated landowners has increased from 44% to 65%, while the rain-fed landholdings have decreased from 42% to 15%. Irrigation infrastructure has been improved which is another factor of increase in irrigated land. Small water reservoirs are constructed to store the water diverted from seasonal torrents and springs (Figure 5). The stored water is released to the fields through narrow water courses and managed under complex appropriation systems. The decrease in irrigated landholdings in Thal is because of the expansion of un-irrigated land to the pastures and poorly suitable areas (Figure 6).

Table 2. Proportion of agricultural landholdings under irrigation

Study area	Proportion of landowners by irrigation (%age)					
	Irrigated		Semi-irrigated		Rain-fed	
	1970	2014	1970	2014	1970	2014
Khall	42	64	2	30	56	6
Balkore	54	42	22	35	24	23
Daskore	62	50	18	14	20	36
Jabar	52	88	20	7	20	5
Thal	92	81	4	13	4	6
%age	44	65	13	20	42	15

3.3 Dynamics of land use land cover

Land use land cover of the study area has considerably changed during the study period, driven mainly by the socio-economic transformations. Land cover of the study area is dominated by natural

vegetation including alpine forests dominated by deodar; coniferous forests; rangelands in the proximal hills of the residential areas and high altitude pastures.



Figure 5. Reservoir for the storage of surplus water discharge from springs



Figure 6. Poorly structured high altitude cultivated fields in the village Thal

Results reveal that in 1970 natural vegetation cover constituted 73% of the land cover - 57% forests and 16% rangelands and pastures - distributed throughout the valley (Table 3 and Figure 7). Agricultural area covered 17% of the land of the

study area. Barren rock outcrops and permanent snow cover was 9% of the total land area and only 1% was covered by built up area. Considerable change can be observed in the land use land cover pattern of the study area during 1970-2014. Natural

vegetation has decreased to 54% of the total land area where forests have recorded a decrease of 17%, while rangelands and pastures have decreased by 2%. Agricultural land has increased to 22% and built

up area has recorded 5 times increase from 1% to 5%, while the barren land has increased from 9% to 19% during 1970-2014 (Table 3).

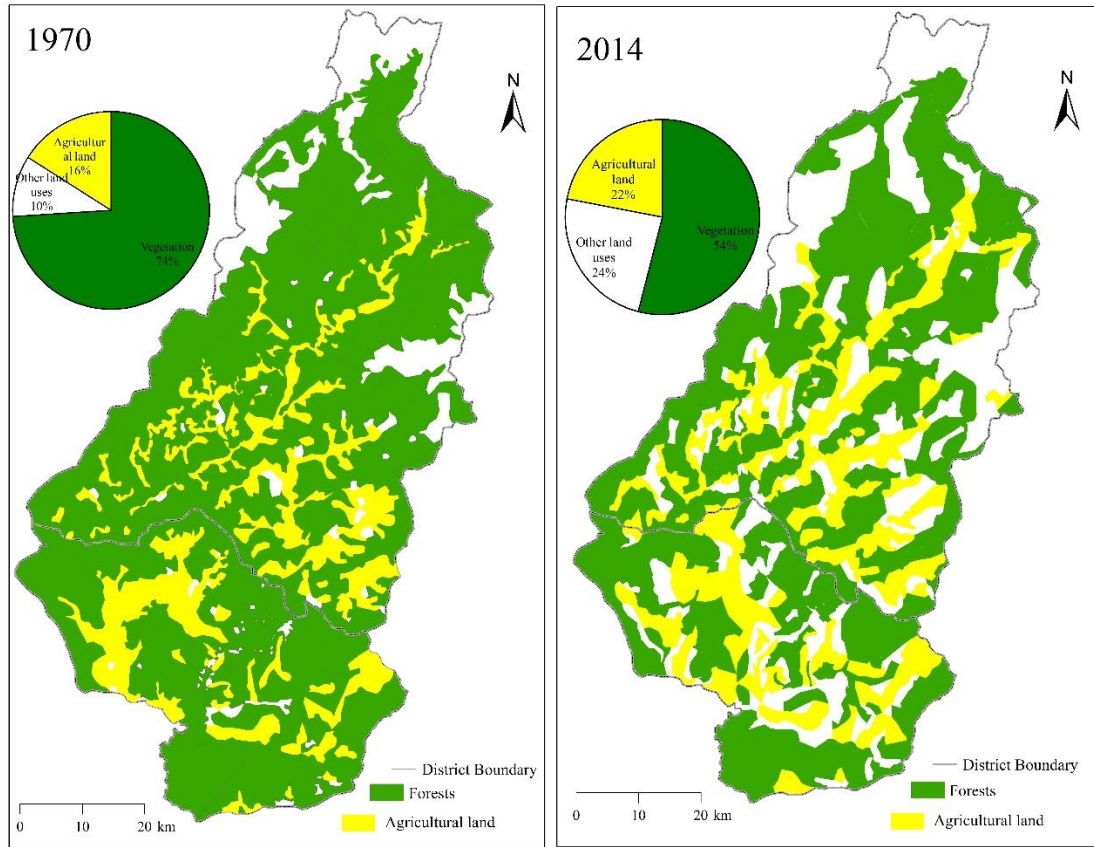


Figure 7. Dynamics of agricultural land and forest cover (GoNWFP, 1975; GoKPK, 2014)

Table 3. Land use land cover dynamics in the study area (1970 to 2014)

Land cover	Area/percentage (1970)		Area/percentage (2014)	
	Area (000 Hectare)	Percentage	Area (000 Hectare)	Percentage
Forests	305.8	57	210.5	40
Rangelands/pastures	84.3	16	74.8	14
Agricultural land	89.3	17	115.4	22
Built up area	6.4	1	28.6	5
Barren land	45.5	9	103	19
Total	532	100	532	100

Agricultural land has expanded in all directions but mainly onto the grazing lands and lower altitude forests. The rangelands and forests are cleared and the slopes are modified into terrace fields known as Karin (Figure 8). The less favorable hill slopes around the villages at high altitude, are brought under cultivation through introducing fast ripening seed varieties of barley, maize and potato.

Built up area has also expanded substantially mainly because of population growth and the associated household dynamics. The existing residential areas are not capable to accommodate more settlements. To acquire space, the nearby forests and rangelands are cleared and in certain areas, the built up areas expand onto the agricultural lands.



Figure 8. Rain-fed cultivated terraces on hill slopes

Rapid expansion of residential areas has recently become one of the important aspects of change threatening the sustainability of natural resource base. The major impact of this expansion is deforestation and destruction of natural ecosystems. The increasing number of households has affected the forest cover in two ways: first by the expansion of built up areas and secondly, the pressure on forests for the collection of timber as well as non-timber forest products (NTFPs) has increased. In the villages where the surrounding vegetation cover areas are too steep to be used for settlements, the built up areas have expanded to the cultivated land and isolated dwellings can be seen in the fields (Figure 9). However, if suitable land is available and accessibility does not obstruct, settlements are constructed in the nearby forest areas and rangelands (Figure 10). Clearing of forest areas for the construction of dwellings has become a common practice. A study conducted in the village Ambodiaviavy in Madagascar (Harrison, 1992) explains the relationship of household dynamics and deforestation as, in 1947; a total of 32 people in eight families came and settled over in this forest

cover area. Until 1990s, the valley bottom lands filled up completely and the new couples started to clear forest on the valley slopes. As a result of this expansion, in a period of about four decades, two third of the forests of the valley were cleared.

Due to a smaller number of households in the past, the use of timber and fuel wood was negligible compared to the regeneration capacity of the natural vegetation cover. At maximum, a few standing trees were cut once in several years for the construction and repair of houses and livestock shelters, if the dry fallen wood didn't meet the needs. The situation changed after the drastic socio-economic changes, and raised living standards of people during 1970s and 1980s. During the 1980s and 1990s, the increasing trend of constructing big houses with multiple rooms multiplied the consumption of timber. Presently, even the smallest house consists of at least four rooms: a living room, a guestroom, a kitchen and an animal shed. The abandonment of single room houses and the transformation of joint families increased the consumption of firewood and timber causing high rate of deforestation.



Figure 9. Expansion of settlements to the agricultural land



Figure 10. Construction of settlements in rangelands and forest cover areas

3.4 Development of accessibility/road networks

The construction of roads in the mountainous areas in general and the study area in particular is one of the important elements of change. In the past, the area was isolated and away from the development activities and socio-economic changes occurring in the adjacent plain areas. However, the past few decades have witnessed considerable development in infrastructure and transportation networks which have linked these communities to the rest of the world. These developments have

opened the way for several changes and transformations in every sector of life (also see Cook and Butz, 2011).

Before the political change of 1970, the Nawab of Dir deliberately kept the then State isolated through restricting the means of transport inside and outside the State jurisdiction. It was a strategy to keep people dispersed not to unite against his ruthless rule and also to restrict the movement of British Officials. The highway running from Chakdara (the southernmost part of the valley) to the

present day Dir city (the capital of the then state) was the only transportation route. This route was strictly monitored by the Nawab's authorities and was mainly used by the state's vehicles. This route was also used by the British Officials once or twice a year moving to Chitral under an agreement between the state ruler and the British.

Presently every village is connected to the markets and the low lying plain areas (Figure 11). The important positive effect of the improved accessibility is the betterment in material circumstances of the inhabitants by increasing monetary wealth particularly in the far-off villages of the study area. The construction of roads brought the markets closer resulting into the modernization of agriculture and exogenous food to supplement the

local production. However, unfortunately, the improved access to the remote mountains played a key role in deforestation in the study area as in other mountainous regions (Allen and Barnes, 1985; Kreutzmann, 1991; Kreutzmann, 1993; Uhlig and Kreutzmann, 1995; Allan, 1985; Allan, 1986; Allan, 1989). In the past, the forests of the upper parts of the study area were protected as it was very difficult to transport wood in bulk. Presently the high altitude forests and pastures are linked to the lowlands. The route constructed to the Kumrat forests of the Thal village has exposed the forests to commercial harvesting. Even heavy vehicles can reach the high altitude forests of Kumrat (above 3,000 m) and the bulk of timber and fuel wood is transported down (Figure 12).

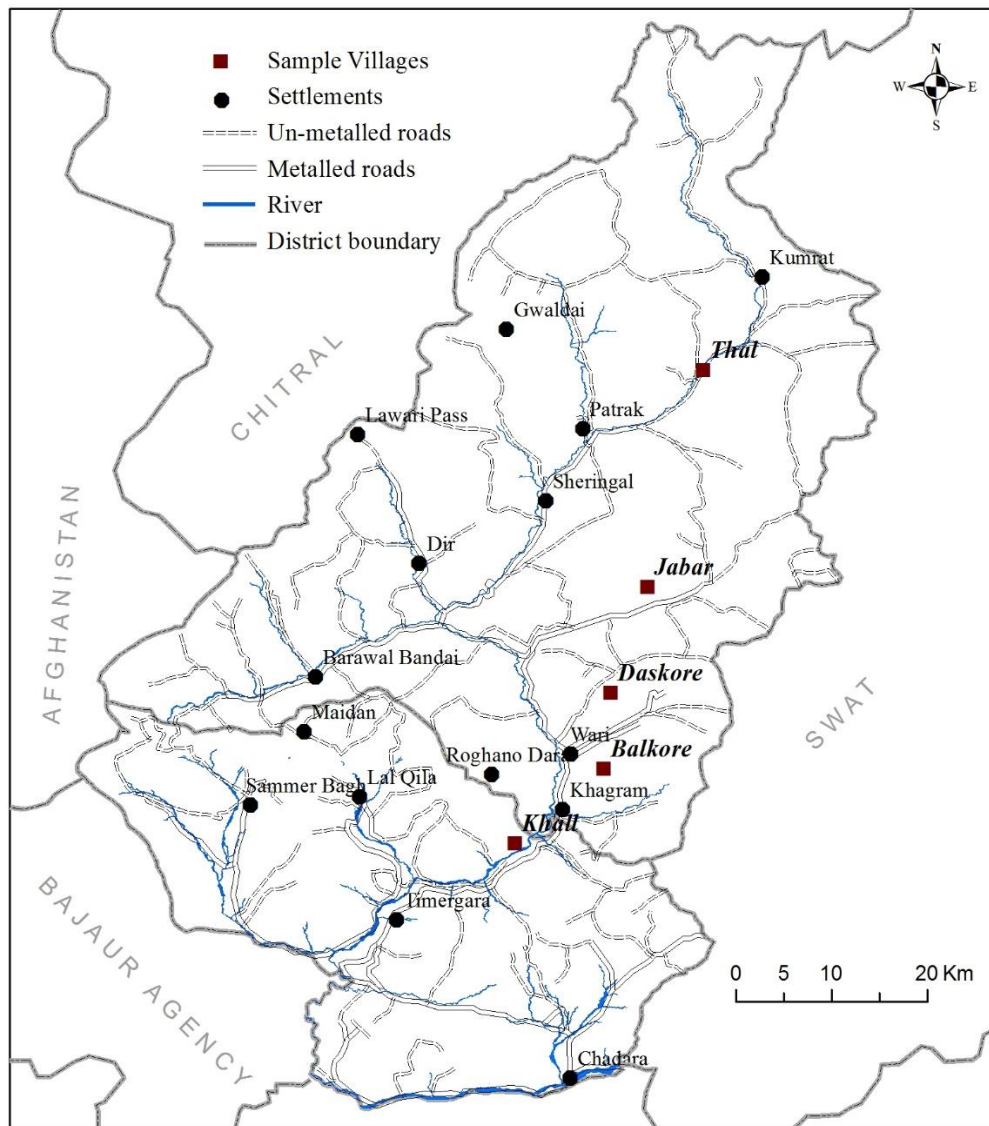


Figure 11. Study area: road network



Figure 12. Truck route in the high mountains forests of Thal

4. CONCLUSIONS

The past few decades have witnessed considerable changes in the socio-economic conditions of the communities inhabiting the Hindu Raj Mountains. The major changes in the socio-economic environment include population growth, increase in the number of household and decrease in the average household size, agricultural transformations, economic changes and improvements in accessibility. The socio-economic transformations triggered a number of changes in various aspects of the biophysical environment particularly land use land cover pattern and natural resource base. Researchers have identified a number of causes and driving forces behind land use changes. Population and household dynamics along with other factors are the main driving forces resulting into substantial changes in the land use pattern and leading towards environmental degradation. Growing population and increasing number of households need more space and thus resulting into the expansion of built up areas, which engulf other land use categories.

The built up areas have expanded towards both the agricultural land and vegetation cover. In

the villages with limited suitable residential land, built up areas have expanded towards the agricultural land. The expansion of built up areas towards the vegetation cover has affected the forests and rangelands both directly and indirectly. In the former case, vegetation cover areas are cleared for acquiring space for the construction of new houses. In the latter case, people who inhabit those areas harvest the forests for fuel wood and timber resulting in the conversion of vegetation cover into barren land. A total of 17% decrease has been observed in forest cover areas during the study period. Hence, barren lands have expanded considerably along with the settlements expansion.

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