AN ASSOCIATION OF GEOMORPHIC PROCESS AND LAND USE PATTERN IN KHIRTHAR NATIONAL PARK PAKISTAN

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Abstract

Khirthar National Park (KNP) is the largest park of the country, covering over 4600 sq.km. Agriculture is the main occupation of the inhabitants of the park. Due to the mountainous geomorphic features, farming practices are scattered on the different bits of plain areas of the park. Geomorphic processes have close association with vegetation and land use. This paper is an attempt to develop a geomorphic association of land use pattern and to evaluate environmental impact of land use practices in the Khirthar National Park. The plains cover more than 30% area in the park including the pediment at their premises are the fertile land of agricultural activities while the barren mountainous areas including the foot hill, alluvial fans and piedmont are providing the catchments area as source of water. This coordination has developed agriculture in KNP but agriculture also depends on the other factors like climate, people and water.

Key Words: Land use, Geomorphology, Dry land, Irrigated land, Pediments, Plains.

Introduction

Khirthar National Park (KNP) is the 2nd largest park of Pakistan covers an area of about 300,000 hectors of land (Hingol National Park being the biggest now (web: travel-culture.com)). It is situated in Sindh Kohistan region, about 120 km north of Karachi, which is located in the foot hills of the Khirthar range. Khirthar National Park is located between the latitudes 25.090 N and 26.070 N and between longitudes 67.060 E and 67.560 E (Fig.1). The Park was established by the Government of Sindh on 21th January 1974, is governed by the regulation laid out in the

Sindh Wildlife protection ordinance 1972 and is managed by the Sindh Wildlife department (SWD).

Vegetative cover and composition vary among a number of distinctive habitat types including wetland, riparian (river, stream and spring edge vegetation), hill, sandy and rocky plains (Sindhwildlife.com). Key features of the park include flora, fauna, rugged land forms, tribal population and economic activities. Lush vegetation is seen in the park in good years that shows potential to produce the abundance of flora species in the park. The purpose of the national park is to safeguard the natural environment, to regulate ecosystem and to feed, grow and protect the natural biodiversity. As this national park is controlled by the Wildlife department, one of the main objectives of the park is to protect the mammal species such as Sindh Ibex (Capra aegarus), Urial (Ovis vegnei) and Chin Kara (Gazella bennettii). Over all region provides a hilly rugged and barren environment with the pockets of plains and basins where land use is possible.

Objectives

Explaining the land use activities in KNP where the agriculture is the sole profession, we concentrate on the following objectives.

Describe the existing short term geomorphic processes with their impact on land use.

Develop major geomorphic divisions that provide an association with agriculture.

.Explain the pattern of land use activities

Determine the micro-economy of farmers based on the surveyed based data.

Check the climatic conditions feasible of sustainability of agriculture.

As the KNP is declared National Park, we discuss the sustainability of agriculture, biodiversity of the park and management issues.

Methodology

This paper is based on the geomorphology and agriculture existed in the Khirthar National Park Pakistan. Approach to this

area is based on the field survey but the use of satellite images and already published maps help us to discover the whole study by using GIS as a tool.

A random sampling survey of the whole area was conducted to get the detail analysis of the land use pattern. Three general questionnaires were designed. First questionnaire was prepared to get the general know-how of the farming activities. Second questionnaire was specified for rain fed land and last questionnaire was prepared for herders. Total 150 questionnaires were filled covering almost whole of the Khirthar National Park.

During the survey ground realties with the help of GPS was taken. GPS proved to be the main device during the survey. It gives the locations in terms of latitudes and longitudes of all sampling sites, benchmark and relevant geomorphic features.

The study of the geomorphic features was based on the satellite images and already published topographic maps. In this part of study, ground realties with the help of GPS provided added information to confirm the identification of features.

Geomorphic map of the study area was developed with the help of satellite images and topographic maps. Map was prepared to the datum of WGS-1984 and UTM projection of zone 42 North. This cartographic work was completed in Arc GIS (AGIS software from environmental system research Institute). With the help of Arc GIS different geomorphic features were mapped to measure its area. This way the geomorphic division of the whole area was made possible.

Associated Geomorphic Features

During the survey in 2000 and again 2004 spectacular and prominent landscape of parallel mountains, ridges, plains and basins were seen which represent the geomorphology of the park. All the major features of the Khirthar region including park is the product of the collision of Indo-Australian plate with Eurasian. Long term geomorphic and geologic structure is because of the tectonic process and short term geomorphic changes occurring over the park could be seen in terms of erosion and deposition. These changes occur frequently with the frequent change in climate. It also provides different structure and features for

describing the patterns and processes. We also found here a close relationship between land use pattern and Geomorphology.

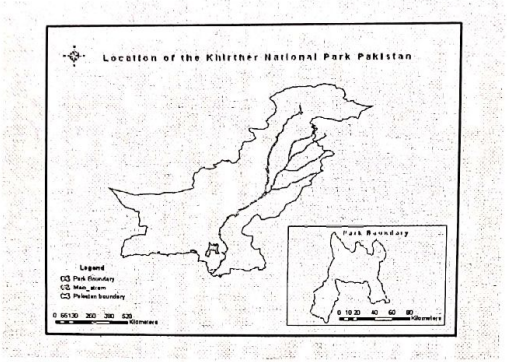


Figure 1: Location of the Khirthar National Park in Pakistan

Other facets of studies like climate, vegetation, hydrology and tectonic process are also associated with one another that make a model to accomplish a natural process.

Khirthar National park is a basin-range desert, dominated by alternating mountains and plains (Fig.3). The mountains and valleys typically run north-south. The mountains ranges have been offset by faults so that the mountain ranges are often offset from one another (I. Rutherford, derrick 2001). Gorges have been developed into the synclinal valleys by the streams. These streams generate piedmonts those are characterized by the pediments and alluvial fans. This process further leads to the development of plains and flood plains.

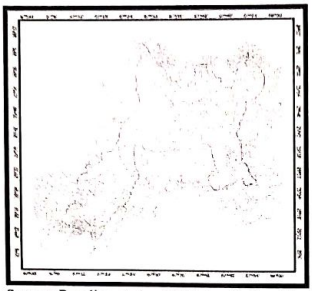
Table-1

Spatial division of major Geomorphic features in terms of km and percentage

Major Features	Area (km)	Area (%)
Plain	1551	31.22
Slope	812	17.45
Upland	2386	50.32

River channel and water bodies are found in the flood plains. They provide the striking feature of the park. Plains cover over 31.22 % of the area of the park (Table1). Most of the plains covered by the larger area are having low relief and approximately no slope angle. Different patches of plains were seen in north-south oriented valleys, where the population was due to availability of water and fertile soil. About whole of the population is located in these patches of plains due to the possibility of agricultural practices. It was calculated by the farming system team in 2000 for the baseline study of KNP that the rangelands covers half of the area of the park. 30% area covered by the plains as discussed, while Parts of the slopes, pediments and alluvial fans cover remaining 17.45 of the Park (Table 1). Vegetation and even cultivation on slopes and peaks of ridges could be seen from the satellite images. Example could be cited from image at Mahar Jabal (mountains) on the east of the Hub River.

Flood plains are the major features defining the association of geomorphology with land use activities. It includes the large river channels. Surrounding body of the Hub Dam and Hub River are the major features of floodplains. Most of the river channels are ephemeral, breaded (Fig. 7) and of variable size. Dendritic pattern of drainage networks are dominant over the region (Fig. 2). Another major feature is plains of KNP. The total area of occupies by the plains in the KNP calculated by D. Fabel in 2000 is 12.5% which about 37500 hectares. Intense agriculture activities, high density, herbs and shrubs in plains area makes it difficult to determine the original morphology and surface features of the areas. But this is the only feature where farming is possible. Drainage pattern, geologic structure and geomorphic setup provide a coordinated association to developed land use activities in the park.



Source: Baseline study of Khirthar National Park
Figure 2: Drainage view in Dendritic pattern

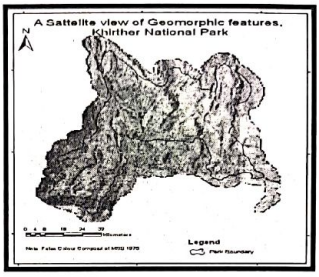


Figure 3: Geomorphic view of the Park Boundary

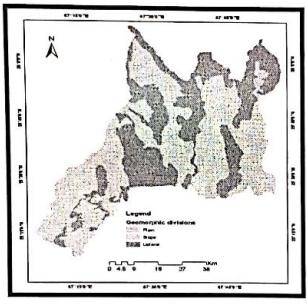


Fig.4: Major Geomorphic divisions of KNP, a) Plains include plains, floodplains, fill Valley, b) Slopes include fan, piedmonts, terrace and slopes and c) Uplands include hilly and plateaus area.

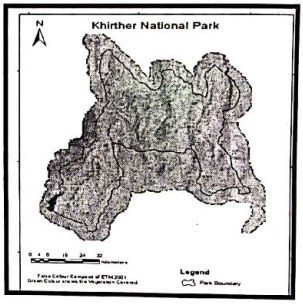


Fig. 5: Vegetation within the Park Boundary

Erosional and Sepositional Impact

Natural erosion then deposition of soil by wind and water in the park takes a heavy toll on farming productivity and farming viability. Plateau and hilly areas of the park covers 50% of the park, while 50% covers the rest of the part containing plains, piedmont terraces and alluvial (table 2). This part of the area

which has not been modified by the human activities consists of the fine gravel lags, sand and silts.

Pediments are gently sloping surface developed across bedrock. Sometime back the pediments in the park were being actively dissected by streams with their headwater at a time when fan deposition was in active (Fig. 6). Although, they covers the 2% of the park, but this prominent feature shows higher rate of erosion in park's area in the past (Rutherford, I. Fabel, D. 2001).Erosion by streams in the plains and flood plains was also striking feature in the park. Heavy rainfall sometime not only destroys the standing agricultural fields but removal of silt from the cultivated land has also bit stronger impact Strong winds were also observed during the survey. Dust and sand storms occur frequently, but there was no station where the wind speed and direction could be recorded. High wind speed not only shares the high evaporation rate in summer but it exceeds the erosion of fine sand and silt, which is striking process shaping the land. It sometime physically damages the crops.

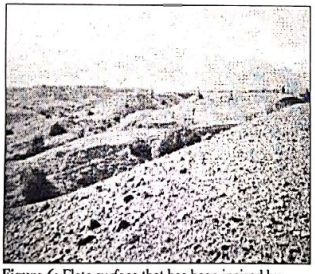


Figure 6: Flate surface that has been incised by stream
Stream that have all of their catchments on the Piedmont surface

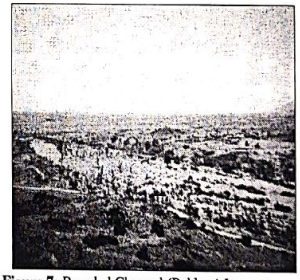


Figure 7: Breaded Chennel (Pokhan) Largest

Rate of erosion was accelerated by the action of the herded livestock, especially during the drought season. Livestock are the vital bail for the people during drought. Rangeland covers margin of the total area of the park. When a larger vegetative area is cleared by the herded animals, highway for the sediments is prepared. This phenomenon accelerates the rate of erosion.

Sometime grazing animals are blamed for the main cause of erosion by the scientists.

Grazing of grasses and cutting of trees have dual impact that, not only the plain surface is denudated and eroded but trapped sediments are also scattered. In some of the places sediments deposited on the beds of streams and channels are closed by trees and other vegetations. In the flow season, eroded and transported sediments are trapped on the either sides and build up the channel banks. In absence of vegetation, this process could not sustain that provide a hurdle to irrigated, as well as rain fed land.

Land use pattern

Food scarcity and continuous loss of agriculture lands are issues of global concern (A. Shalaby, R. Tateishi 2007, aboel Ghar, A. Shalaby, R. Tateishi 2004). The problem has now affected the country wide and at micro-scale level. Agriculture is the sole and dominant occupation in KNP region. Farming society in the (KNP) has developed the land use pattern under the present environmental conditions. They utilize the traditional ways to cultivate their lands. Generally cultivation takes place either on rain fed land or on irrigated land. Use of rangelands for grazing and browsing of reared animals is common practice in the park. Many studies have discussed land cover and land use activities in the arid, semi arid and agricultural productive land (A. Shalaby, R. Tateishi 2007). Environmental degradation from human pressure and land use has become a major problem worldwide (Erlich, 1988; Wilson, 1992), Environmental degradation due to marginal management practices and their multiple, global consequences have been a serious impediment to agricultural and economic development in the tropics (Lal, 1989, Budry Bayard, Curtis Jolly, 2006).

Three distinct types of land-use could be identified.

1. Irrigated Land use cropping
2. Dry land use cropping
3. Rangelands

Irrigated land use cropping

Irrigated fields are the smallest but most productive area used for crop farming. Villages tend to be located within the highly irrigated areas of KNP, which supply the bulk of grain

and cash crops, vegetables, plus crop residues eaten by farm livestock. Most irrigation water is pumped from dug wells and drilled bores—powered by diesel engines—but camel-powered water wheels and natural springs remain important sources. Larger area for irrigated cropping is watered with the help of network of irrigated channels spread across the fields (Fig.11). Tillage is an important feature of irrigated as well as dry land cropping (Fig.13). Winter is the main season for irrigated crops: wheat is grown mainly for consumption purpose (Fig. 12) and onions (mainly for sale) occupy the greatest proportion. Cotton is the main irrigated summer crop but planted on a much smaller area. Many vegetable crops are grown throughout the year on small plots, for both consumption and sale.

Dry land cropping

The largest part of the land use area was seen under the dry land farming. The dry land cropping systems are believed to have a history dating back more than 5000 years (Harvey and Flam, 1993). The dry land areas are located mostly near by hilly area in plains and basins (Fig 14). Hilly area provides them catchments. The run-off water is trapped and regulated from the catchments, by constructing supply channels and banks following the monsoonal rainfall (Fig. 15). The trapped water percolates to the sub-soil; once the surface has dried, it is tilled and seeded. Short-term summer crops—millet, sorghum, cluster bean and mung bean are most commonly planted, often as mixtures. Use of the dry land fields is entirely dependent upon rainfall in the catchments. Many areas of the Park had not been planted dry land crops since 1994-2001, because of the prolonged drought.

Rangeland

Livestock grazing is a centuries-old traditional land use (K. Chandrasekhar et at;, 2006, Goldstein and Beall, 1990; Handa, 1994; Nusser and Clemens, 1996; Chakravarty-Kaul, 1998) it has been viewed as the underlying driving force of habitat degradation, imbalance in wild prey–predator population densities and loss of biodiversity realized in the recent past (K. Chandrasekhar et at;, 2006, McArthur et al., 1979; Casimir et al., 1980; Kreutzmann, 1993; Katoh et al., 1998; Mishra et al., 2001, 2004; Zhang et al.,

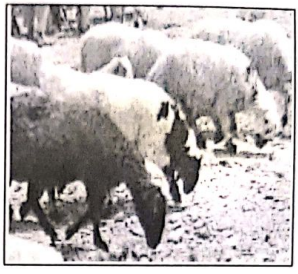
2002; Ikeda, 2004). In KNP, use of range land for herded livestock is widespread. It covers more area than irrigated and dry land cropping combined. It is also most dominant economic activity in park even in drought seasons. Livestock are a vital component of most farms. Goats are the major livestock (Fig.8). At least one or two goats are reared by most of the farmer's families. Flocks of sheep's were also seen herded in the rangelands (Fig 9 & 10). On dry land-dependent farms, livestock may be the only source of income for many years. Multi-purpose, animals are a source of food (usually milk), income, power and a store of wealth. Goats and sheep are the most numerous species, probably followed by cattle, donkeys and camels. Livestock feeds include crop residues and browsing, plus lopped branches and shrubs. Many are herded on a nomadic basis, covering large areas of the Park in the search for feed.

Economic Environment

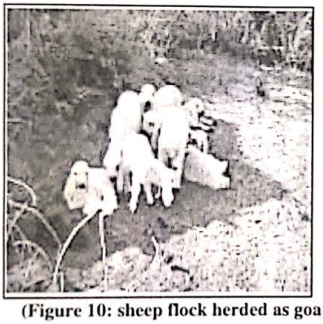
Most of the people involved in the cash cropping agriculture while animals are reared parallel with farming activities. Livestock not only support the farmer's household economy, but in drought years, existence of livestock remains the only way of survival, therefore their importance can not be neglected. Production from the dry land fields varies every year, its up to the amount of precipitation. Investment into dry land fields is approximately none. Just land is tilled no pesticide and fertilizer are used. Enough amount of precipitation in monsoon seasons produced substantial quantity of crops. Most of the rain fed lands could be cultivated by irrigation method, if water is utilized in systematic way People are not that much richer that they can create small canals for irrigating lands.

Productions from the irrigated crops are not highly fluctuating, but their rates do not remain same each year. Irrigated land needs heavy amount of investment, if the profit margin does not remain higher and constant then, next year it could have an impact on its production. Following example can give you the further understanding of the economics of the crops.

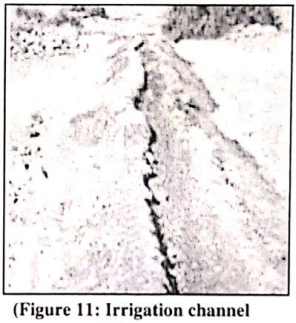
(Figure 8: goat flock herded)



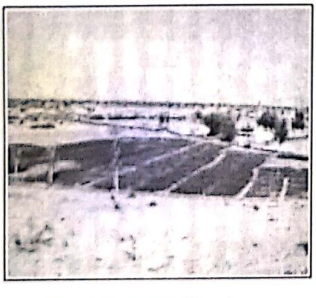
(Figure 9: sheep flock herded as goat)



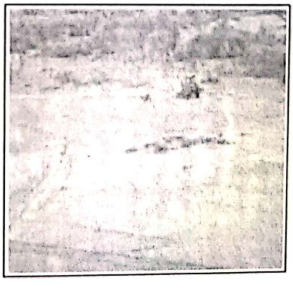
(Figure 10: sheep flock herded as goat)



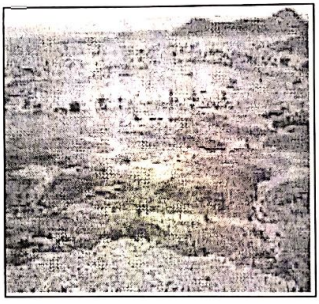
(Figure 11: Irrigation channel across sandy)



(Figure 12: Grown Wheat)



(Figure 13: Irrigated field being harrowed)



(Figure14: Catchment area for Drylands)

(Figure 15: Long dryland retaining Wall)

Example of Cost and return of selected cash crops

Economics of Onions (per acre)

Costs

Transportation	Rs.6000
Fertilizers (three bags)	Rs.2000
Pesticides	Rs.1000
Seed cost	Rs. 10000
Total costs	***Rs. 19000***

Current rate of onion is maximum 150 rupees per *maund*. They can get a maximum of two hundred *maunds* from one acre.

Returns

(Yield 200 *maund* per acre and price Rs 150 per *maund*)

Gross Income Rs 30000

Net income (returns-costs)Rs 11000 per acre

Economics of cotton (per acre)

Costs

Transportation	Rs 5000
Fertilizers (three bags)	Rs 2000
Pesticides	Rs 1000
Seed cost	Rs 1000
Total costs	***Rs 9000***

Returns

(Yield 200 *maund* per acre and price Rs 750 per *maund*)

Gross Income Rs.43000
Net income (returns-costs) Rs.32000 **per** acre

With the help of the above example net amount of onion is 11,000 rupees. It could be 5000 in one year and 15000 in other year. Sometime the transportation cost exceeds the total cost of the crops, in this condition crops seem to be spread on the field as rubbish and farmers are not able to transport and sell them in the market. This happens when market rates are lower. Variation in profit does impact the production of crop in next coming year, means more profit more production.

Climate as an indicator

Study area is located in the region of high erratic rainfall with high summer temperature (Perkins, Petheram, and Mahar 2001). This way sometime the regular cropping to irrigate the fields are restricted in the winter months, except after enough rainfall. Good monsoon years allow extensive cropping of non-irrigated fields (Parkins, Petheram, and Mahar 2001). Rainfall in the park is not only erratic but is much localized that could be recorded temporally as well as spatially. If there is rainfall in one corner of the park like hub dam surrounding or Mol area (South west of Park) then we will not be sure about the same quantity of shower in Tiko baren area (North west of the Park). Similarly between the 1995 to1999 there was no drop of water by rain in monsoon period that had very strong impact on the farming activities and the lives of the people. Sometime huge rainfall generates violent floods, those causes to brakes banks of dry land fields. So the rainfall in the Khirthar region is inconsistence, unpredictable, sometime brief and sometime huge not only affects the dry land fields but irrigated fields are also affected by this natural phenomena.

Data from the temperature record shows that by contrast with the rainfall annual and diurnal range of temperature in the park is stable. Summers are very hot usually having 40 + degree while sometime it crossed 50 degrees (Fig. 14). The hottest months use to cause very high evaporation rate. Evapo transpiration rates in the region are estimated by Flam (1998) at 2240 mm/annum. Its rates could be higher in the prolong drought period like 1995-2001. 114 years rainfall data of Hyderabad station shows that July and

August are the months of maximum rainfall while June and September are the months of moderate rainfall (Fig.13)

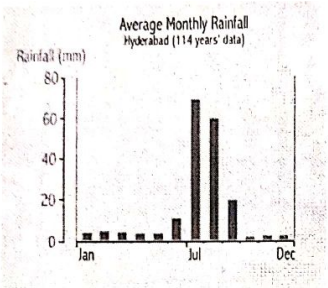


Figure16.average monthly rainfall (114 years data) Hyderabad Sindh

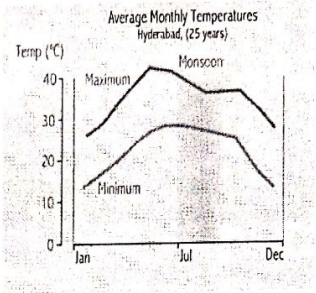


Figure 17. Average min. and max temperature 25 years data) Hyderabad, Sindh

Environmental impact on land use

The strength of relationship between man and his environment has long been the matter of debate among the geographers *(Charles Whynne~Hammond 1985).* Traditionally there has been two view points: **Determinism** and **Possiblism**. Determinism is basically the idea that the environment is largely responsible for man's behavior. Possiblism takes the alternative view and hold that although the environment offers possible courses of action, man himself determines his own way of life *(Charles Whynne~Hammond 1985).* Historically it has been proved that man is the product of environment and environment diverts his way and directions. Darwin said that life developed under the selective action of natural forces. Life developed and evolutionarised in Khirthar region, since 5000 years, remained under the possible conditions and obstacle. Its degree of progress is determined by use of indigenous resources and Natural relief in this environment.

Land use pattern of the park, mainly the farming system, developed by inhabitants in response to the natural environment in which they are located, the resources and technologies available for them to use in that environment, the social, cultural and religious norms to which they subscribes and the economic environment in which they participate (Parkins, Petheram, Mahar

2001). Society developed in the park is also a response of the above given environmental facts. As the agriculture is the sole occupation of the people of the park. Their social life also depends on the agricultural practices. The natural environment in which practices take place provides an unsustainable type of agriculture. Fluctuation in the productivity of the commodity is the reflectance of natural-environmental calamities and man made activities. Many factors have been discovered those explain the impact on land use over this agrarian society.

Management issues

After the establishment of the park issues between the management and inhabitant of the park were raised. Conservation, preservation and protection of the biodiversity of the park are the main concern of the management of the park. After the promulgation of the ordinance in 1974, hunting of animal and cutting of trees have been highly restricted especially in the Game reserve and Game century area. These are the specific reserved area for the conservation of flora and fauna. In game century hunting is never allowed while in Game reserve area special time and quota are permitted for some period in a year. Park community has been aware about the promulgation of the laws, but they still claim their right on land and land use. Grazing, browsing and cutting of trees are still a common practice. After the establishment of the park, development seems to be prevented. Basic facilities like electricity, Gas supply and communication have not been provided to this area. Even no single road was found within the boundary of the park. Easy approach and accessibility to the market not only increase the profit but it also increases the production. In response of this agricultural activities could increase. The management of the park would not allow encouraging this trend because this will go against the theme of the KNP that is conservation of flora and fauna.

Discussion & Conclusion

The farming system within the KNP survived, developed and continuously adapted for an extremely long period of time due to the resilience and flexibility of the village communities, who must continuously cope with extremely demanding physical

environment (J. Perkin et al 2000). Factors discussed above are responsible for the either boosting or declining the agricultural activities in the boundary of the KNP. Impact of prolong and continuous drought has key contribution in modifying physical, cultural and economic environment of the park. This feature seems to be more enhanced when affecting the agriculture of the park. Our findings suggest that more than 30% of the park consist of smaller and larger patches of plain. Plains area with fertile alluvial soil in the park provides lush vegetation in good years. Efficient water resource management in the park could improve time span of existence of lush vegetation in dry period also. This way the conservation strategy and livelihood resources in the park will improve.

People of the KNP are leading very hard and desperate lives. Especially people living in the remote areas like northern and western part of the park are either herders or depending on rain fed land. Over all herding community with no access to irrigation water is affected with this harsh environment but people living near the plains or natural springs where irrigation is possible for cultivation, economic activities seem and poverty level is comparatively low. This is unstable and fragile society which is surviving under the threat of natural and man made phenomena. Farming community of the park is tribal in origin controlled by the local chief (Sardar). Sardar resolves all the disputes and conflicts of the people with the little or sometime without intervention of the police in his local court. He has authority to impose fines on local crimes convicted and make judgment on property and family issues and problems about which those who are involved are beholden to obey.

Human impact in the park boundary could be realized by the unstable population and variations in the climate. After the prolong drought in 2000, mobility of the inhabitant to the plain area were seen and most of the whole villages seems to be completely evacuated, so that, the people can earn and feed their families. Demography of the parks works like a balloon which is swollen when air is injected and reduced when air is leaked out. From the data of 1998 population of the park is approximately 100,000 which was reduced to 75,000 after the prolong drought and it could accede to 125000 in good years.

The most popular issue and world wide debate about the conservation in National parks is that the farming system and conservation could be managed parallel in the national parks, because the land use activities in the national parks divert the purpose of conservation at some extent. Extension of farming activities in the national park has dual impact on flora as well as fauna. Most of the species of animals migrate from the places where human activities are increased. Farming activities use to replace the naturally growing species of the plants. This way we find a clash between farming activities and conservation.

As far as conservation activities in the Khirthar National Park is concerned, the issue does not seem to be with high degree, but in future this issue could be a problem. Population in the parks area is about 100,000+ that will increase specially in good years. As the population will increase the pressure on land and water will increase. Similarly fauna and flora species will be under pressure. In the Park where human activities are extensive, natural species are diverted. As the population is sporadic in the park, farmers about the crops remains threatened of some mammal species like Chin Kara (*Gazella bennettii*), Urial (*Ovis vegnei*) and Sindh Ibex (*Capra aegarus*). There are many complaints about the destruction of crops by Chin Kara and Urial. Ignorance of wildlife department on this issue is the serious matter. SWD should make their policy to balance the conservation and farming activities. The question in future will be same that "Can farming system and conservation co-exist in National Parks!"

Recommendation

This study set out to enhance the phenomenon of agriculture system and its relation with the geomorphology of the park. Geomorphic landscapes provide the main habitat to biodiversity of the park. Management of the KNP should need to address the sound strategy to improve the livelihood system and conservation of the biodiversity of the park. Following recommendations are being proposed, keeping in the mind both the issues in KNP.

i. Policy should be made to balance and sustain conservation and farming system in the park.
ii. Catchment area of the steam must be well identifying for better water resource management on the park.

iii. Small dams for water reservoir should be constructed. This will improve the irrigation system and natural habitat could also be flourished around the reservoirs.

iv. Semi-aridity of the area requires conducting a comprehensive hydrological survey of the entire plain area of the park.

v. Metalled roads must be constructed to improve the economic activities and to provide the opportunity to establish the tourism in the park.

vi. Anthropogenic actions are very important in terms of the sustainability of the assets of the park, so inhabitant of the park must be properly educated.

vii. Trainings and skills should be provided to people of the park to utilize efficiently their indigenous resources to improve their economic activities.

viii. Government should provide subsidiary to the people of the park from their indigenous resources (e.g., installation of wind mills and technology of solar energy) to utilize the energy, sustaining natural environment.

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