Famer's Perception on Desertification Dynamics and Sustainability of Adaptive Strategies in Semiarid Regions: Observations from Karak District, Pakistan

Iffat Tabassum*, Muhammad Aslam Khan, Fazlur-Rahman, Fazlul-Haq

Institute of Geography, Urban & Regional Planning, University of Peshawar, Pakistan
*Corresponding Author, Dr. Iffat Tabassum, Assistant Professor of Geography
Email: hayatkhattak@yahoo.com

Abstract: Desertification has become an important problem for the farmers in the dry lands of Pakistan as it increases the vulnerability of the households whose livelihoods depend predominantly on land resources. Perception based adaptation has been the key strategy that has helped farmers face its consequences in these areas. This study attempts to explore farmer's perception regarding indicators and causes of desertification. It will further try to explore livelihood strategies, adapted by the local communities, and their sustainability. Data was collected through semi-structured questionnaires and focused group discussions. It was found out that declining land productivity and increased water scarcity were the major indicators of desertification during the last thirty years increasing economic and environmental marginality. In response, the local inhabitants have opted for new livelihood strategies, i.e. both off farm and on farm. Some of these have shown good omen.

[Iffat Tabassum, Muhammad Aslam Khan, Fazlur-Rahman, Fazlul-Haq. **Famer's Perception on Desertification Dynamics and Sustainability of Adaptive Strategies in Semiarid Regions: Observations from Karak District, Pakistan.** *Life Sci J* 2014;11(9s):445-452]. (ISSN:1097-8135). http://www.lifesciencesite.com. 91

Key Words: Desertification; Dry lands; Food security; Pakistan; Karak

Introduction

Desertification has re-emerged as a major economic, social and environmental problem in the recent past in most parts of the world (Verstraete et al., 2008; 2011; Anjum et al., 2010; IPCC, 2007; Whitehead et al., 1988; UNCOD, 1977). It has attracted much attention in the global change debate and has earned wider recognition for various reasons (Muller and Hermann, 2012) particularly, its serious implications on human well being, quality of environment and food security (Thomas, 2008; Mannava et al., 2007; MEA, 2005; Eswaran, 2001). Many studies suggest that developing countries of dry region are more likely to face desertification a significant consequence of climate change in these areas (Hoermann et al, 2010, Bierbaum et al., 2007; IPCC, 2007; Stern, 2007; UNDP, 2007). Considerable attention has been given to its mitigation both at government and non-governmental levels, which have successfully converted some of the degraded area into productive land through conservation agriculture and rangeland management (Mekuria et al., 2007).

Desertification is slow onset disaster and hard to identify initially. In this regard the perception of farmers about its indicators, causes and impacts could be used for early diagnosis of the problem, when rehabilitation is relatively easy. In later stage of desertification, rehabilitation of degraded land is not only financially expensive but it is also ecologically difficult. Therefore, earlier diagnosis of the problem and subsequent mitigation strategies can reduce the ecological and financial cost; and at the same time help to safeguard the environment and human well-being. In spite of plethora of research regarding the issue, studies that take account of knowledge about farmers' perceptions of their livelihoods and of land-use management have been rare to date (Tschopp, 2010).

The impacts of desertification are of global concerns, but in areas where large numbers of the people are chronically exposed and vulnerable to climatic variability are particularly critical. In such areas climate variability is contributing to and enhancing desertification through raised temperature; changing rainfall pattern and increased frequency of extreme weather events. Hence increasing the potential vulnerability of these communities to future climate change (Hillel and Rosenzweig, 1989) particularly in areas where crop production and livestock keeping are essential livelihoods strategies.

Impacts of desertification, climatic variability and climate change are highly interlinked and are global phenomenon (Gerten et al., 2011; Müller et al., 2009) while adaptation strategies are mainly local and site-specific; undocumented, developed through local expertise and handed down orally (Mary and Majule, 2009). The local communities of arid and semiarid areas, being the first and most seriously affected (Hoermann et al 2010) adopt themselves to the adverse impacts of consistently changing environmental conditions (Mwang'ombe et al., 2011; Ehlers, 1996, 1997; Reijet et al., 2005; Reed et al., 2007; Winslow, 2004). Adaptation and coping mechanisms of these communities are based mainly on their perceptions and indigenous knowledge which embodies a wide variety

of skills developed outside the formal education system (UNFCCC, 2007). Additionally, consistent challenges to human well-being give people the ability to persist through locally developed coping mechanisms and survival strategies (Noralene et al., 2011). In such cases their level of awareness regarding these shifts and trends has shaped their responses (Hoermann et al 2010). Usually their perceptions about changes were found toning with scientifically observed trends. However, researchers working on this issues are of the opinion that the current rate of change might create a stressed situation by exceeding the limits of local adaptive capacities (Adger and Vincent, 2005; Stringer et al., 2009) particularly in areas of high climatic variability including Pakistan.

More than two third of the total geographical area of Pakistan is arid and semiarid. Due to vulnerable terrain and aridity considerable area is highly susceptible to desertification (Zia et al., 2004). Social issues like rapid population growth and socio-economic changes synergized with climatic variability further intensify the risks and uncertainty of livelihoods of farm households. This situation necessitates the adaptation of appropriate strategies manifolds. Therefore, it is needed to explore and evaluate the indigenous adaptation strategies through applied research for long-term environmental rehabilitation and sustainable land management. Hence, the present research is undertaken in an area that is highly prone and affected by desertification to explore indigenous knowledge and perceptions regarding indicators, causes and coping strategies, along with scientific analysis of the prevailing issue. This study attempts to find answer to the question – what strategies are adopted by the agrarian communities in the dry areas and how far are they successful to cope with the impacts of desertification.

Material and methods

Study Area

The study area, district Karak, a representative of dry hilly region of Pakistan, is located in southern part of Khyber Pakhtunkhwa Province (Figure 1). Generally the area has moderate relief ranging from 300 to 1400 meters above sea level (with an average altitude of 600 meters). Climatically, the district is semiarid with an annual average rainfall of 330 mm. Climatic elements show considerable variation within the district and rainfall decreases from northwest (700 mm) to south east (250 mm). Only 18.8% of the total area of the district is cultivated, most of which is rain fed. About 2.1% area of the district is under forest cover (GoP, 2001).

Data collection

The study is based on primary data for which extensive field work was carried out from January through March 2010. Three basic primary tools i.e. questionnaire, interviews and focused group discussions (FGDs) were used for the collection of required information. The questionnaire was focusing on the socio-economic and demographic characteristics, agricultural practices and livestock characteristics of sample households. Questions regarding major issues related to land degradation and adaptive mechanisms for mitigation were also included.

Multi stage stratified random sampling method was adopted for primary data collection. For this purpose the district was divided into three major zones i.e. Dry farming/Rangeland, Rain-fed, and Irrigated Land (Figure 1). One *Patwar* circle (revenue area comprising a few revenue estates/ *mauzas*), was selected on the basis of purposive sampling from each zone. In the second stage, two *mauzas* were selected from each *Patwar* circle for detailed data collection (Figure 1). Finally a total of 465 households were selected randomly, through proportional sampling, from Shnawa Gudi Khel (255), Mitha Khel (115) and Issak Khumari (95) making an overall sample size of 17%.

Focused group discussion and group interviews were conducted with the key persons such as the elders, leaders of the community and office bearers of the local level community organization of the respective *mauzas*. Information regarding rangeland, their utilization and management, and general perceptions on desertification, its causes, indicators and coping mechanisms were discussed. Qualitative research methodology was adopted, which is ideal to look into the perceptions of respondents (Dahlgren et al. 2004) and provides a greater depth of information on the relevance of the subject (Tschopp et al., 2010).

Results and discussions

Land in study area is kept either private property primarily used for crop cultivation or communal land/ *shamilat* that is predominantly used as rangeland. Problems, prospects and potentialities of these land use categories are different but highly interlinked. Both types of lands are highly prone to desertification.

Important issues related to desertification of cropland include declining crop yields and frequent crop failures. Yield of major traditional crops like gram, millet and barley has decreased significantly in recent years (Table 1). This declining productivity was identified by majority of the farmers as an indicator of desertification in the entire district but more noticeable in Shnawa Gudi Khel located in dry farming and rangeland region. This region was a major producer of millet and gram which have reduced drastically. The other two regions have effected to lesser extent, where these crops were secondary to wheat and groundnuts.

In wheat growing areas it was noticed that the yield of wheat has increased slightly but net benefits have reduced due to increasing dependence of farmers on farm inputs making agriculture practices considerably expensive. Crop failure in the area is also a major dilemma faced by the local people that result in food insecurity.

Vegetation, particularly tree cover on the rough terrain of the rangeland has been reduced significantly leading to declined biomass production and deteriorated quality. Consequently some vegetation species are now extinct and others are under threat. Reduced productivity of livestock, increased diseases and loss of their weight particularly during droughts period have attributed to deterioration of rangeland too. Moreover, gully erosion along the hill slopes is quite common while in many parts, flat land and fields have severely eroded and presenting typically badland topography (plate 1).

Causes of desertification

In focused group discussions, one of the most common perceptions of the farmers was that the weather conditions in the area have substantially changed. The most important change reported by the local people was the shifting of rainfall regimes as well as increasing extreme events. Many of them were of the opinion that frequency of flash floods, dust storms, forest fires and long dry spells have also increased considerably. Torrential rainfall and flash floods are also enhancing the development of bad land topography. In addition, the participants perceived that the winter temperature has increased over the years (table 2).

Rainfall variability has been considered as one of the main causes of desertification in the area. Almost all the respondents were of the view that rainfall pattern has considerably changed particularly in winter season rainfall decreased noticeably increasing the water stress for *Rabi* crops like wheat and gram. Late winter and spring rains/hail usually destroys standing crops of wheat and gram; and also delays harvest of Rabi crops.

Inter-annual and intra-seasonal rainfall variability is one of the major factors influencing biophysical systems and eventually the rural livelihoods in the drought-prone areas. As precipitation and temperature variability directly affects agricultural systems and subsequent yield reduction, local farmers understood that rainfall distribution is more important than seasonal rainfall totals. Another important problem is the strong dry winds blowing in late spring which causes severe damages to standing winter crops and decreases the already low atmospheric humidity and soil moisture. More often these winds are also considered responsible for crop diseases of gram.

Agriculture has become expensive due to both increased demand of farm inputs and inflation of inputs like improved seeds, chemical fertilizers, irrigation and other inputs. Desertification was also considered an important factor in bringing social changes as reduced productivity has led to extensive labour migration both inside and outside the country. This large-scale out-migration of young people has significantly transformed the population structure, traditional social setup and led to over exploitation of natural resources. Increasing access to education and off-farm employment particularly in the urban centers and abroad, raised social status of the local inhabitants and increased inflow of remittance have contributed towards shift of livelihood strategies.

Adaptive Strategies

Longer term strategies (beyond a single season) are needed for people to respond to a new set of evolving conditions (biophysical, social and economic) that they have not previously experienced (CGIAR, 2009). Creative adjustment mechanisms or strategies adopted by the local inhabitants in study area include diversification of economic activities, changes in traditional agriculture practices (farm and livestock) and revival of local level resource management systems. Besides, tube wells installation, rainwater harvesting and management have also been important strategies adopted by local farmers. These adapted strategies can be grouped into two broad categories i.e. Enhancement of off- farm activities and adaptive strategies on farmlands.

Diversification of economy is one of the most important strategies adopted by majority of the respondents like other climatically stressed parts of the region (Hoermann et al 2010). Because of declining cereal production, food demand of the households cannot be met for the whole year. The annual harvest does not last for more than six months and in many cases domestic production is enough for three to four months (Table 3). In such a situation dependence on the market has substantially increased hence the need for cash income becomes essential. As a result large number of households depends on off-farm activities to supplement the subsistence agriculture.

However, opportunities for non-agriculture economic activities are limited in the district. Therefore, majority of young male population has migrated to other parts of the country as well as abroad. Those working in different parts of the country are mostly employed in government jobs or recruited in armed forces. Income of a single out-migrant is comparatively small and the amount sent is usually not enough to cover the household expenditures; therefore, more than one person from many households, are working in off-farm sector outside the district.

For the last three decades international migration from the study area has also increased. According to the collected data, 34% households have at least one member while 19% of them have more than one person working abroad (Table 4). Issak Khumari had the highest share in international migration, where significant development in agriculture has been made through the investment of remittances. Beside land and agriculture some households have invested remittances in transportation sector and other small-scale businesses in local market. Thus remittances have opened new avenues for off farm employment to the local inhabitants.

Beside these positive changes brought by migration, some negative implications have also been attributed to it. The most important negative change brought by emigration mentioned by respondents was the erosion of social fabric and traditional norms/rules for the use of natural resources. Previously, the communities followed these norms/rules very strictly for the management of natural resources, which although unwritten had very clear distribution of responsibilities among locals for various tasks. Most important among these were diversion of floodwater, harvesting and management of rainwater, regulating the utilization and management of grazing lands, resolving conflicts among different tribes and safety/security issues in the area (Table 5). People did not implement these rules strictly over times due to decreased dependence on natural resources as a result of off-farm employment, increased income, and reduced manpower. As a result, adverse impacts on natural resources and environment became apparent.

The age and sex selective, migration has resulted in labor shortage, as those who have migrated are young males leaving women and elders of the families behind. As a result a lot of land is now being left fallow due to labor shortage. It also had a profound impact on the livestock sector where shortage of appropriate labor has resulted in the reduction of herd size as well as change in its composition, with goats becoming more dominant. Herd size has also been decreased in most of the households to reduce pressure on rangeland resources.

To control the problem of rapid deforestation, since 1994, the local community has revived the system of closing the rangeland and forests area (*nagha*) for grazing and cutting of firewood for two days in a week (Friday and Wednesday). In addition, driving of camels to the rangeland for bringing firewood and grasses has also been banned in the area as a safeguard to mass removal of grass and wood. Invoking temporary confiscation is also discouraging free grazing of livestock in the rangeland as well as in the surroundings of the villages. The inhabitants are also reviving other traditional values and norms governing the management of resources along with collective action for the overall benefit of the society (Table 5).

In response to decreasing vegetation cover on hill slopes the inhabitants have carried out extensive plantation on their farms and fields. Besides economic benefits, these plantations are playing significant role in controlling desertification by protecting soil erosion in the area. Increased vegetation cover has also promoted bee culture for collecting honey, which has become an additional source of farm income.

Another important adaptive measure against desertification includes changes in agriculture practices. There is an increased investment now in agricultural development, new crops have been introduced and herd size has been reduced. Technological and mechanical agricultural practices are being introduced to increase agricultural production through increased use of chemical fertilizers and improved seeds. In this regard the perception of the farmers was that the high-yielding new crop varieties are more water demanding as well as much susceptible to pests and diseases than traditional varieties which were more resistant.

Due to expansion of agriculture and modern high-water demanding varieties irrigation has become more important. As a result, irrigated land in district Karak has increased from 2% to more than 11% of the total cultivated land in last ten years (GoP, 1998, 2007). In irrigated areas, groundwater is exploited to meet dry season water requirements. However, groundwater levels also are associated with the rainfall. Thus, overexploitation of groundwater and highly variable rainfall patterns have led to problems of water scarcity and saline water intrusion and that has enhanced the environmental risks in many parts of the district. In addition to underground water extraction, construction of small dams and rainwater harvesting has also increased with the help of public and non-governmental organizations. Storage of surface water has also helped in combating desertification and reduced the adverse effects of torrential rains. The inhabitants of the study area have constructed diversions and embankments in many parts of the district to store the water and reduce water speed. Reduced water speed has minimized its erosive capacity. Moreover, these small water reservoirs are also used for irrigation on limited scale, water ponds for local livestock and wildlife/migratory birds.

New crop varieties like groundnuts [1], and of vegetables have enhanced household income. Groundnut is a cover crop, which provides agronomical measure against soil erosion –desertification. Currently

[1] Karak is among major groundnut growing district of Pakistan.

cotton and rice are also experimentally grown on saline soil to reduce salinity on the advice of agriculture extension department. People have also started growing cotton, sugarcane and rice (subject to the availability of water) on a very small scale. These are profitable in the short run, but on a large scale their long-term sustainability is questionable in the wake of limited water supply.

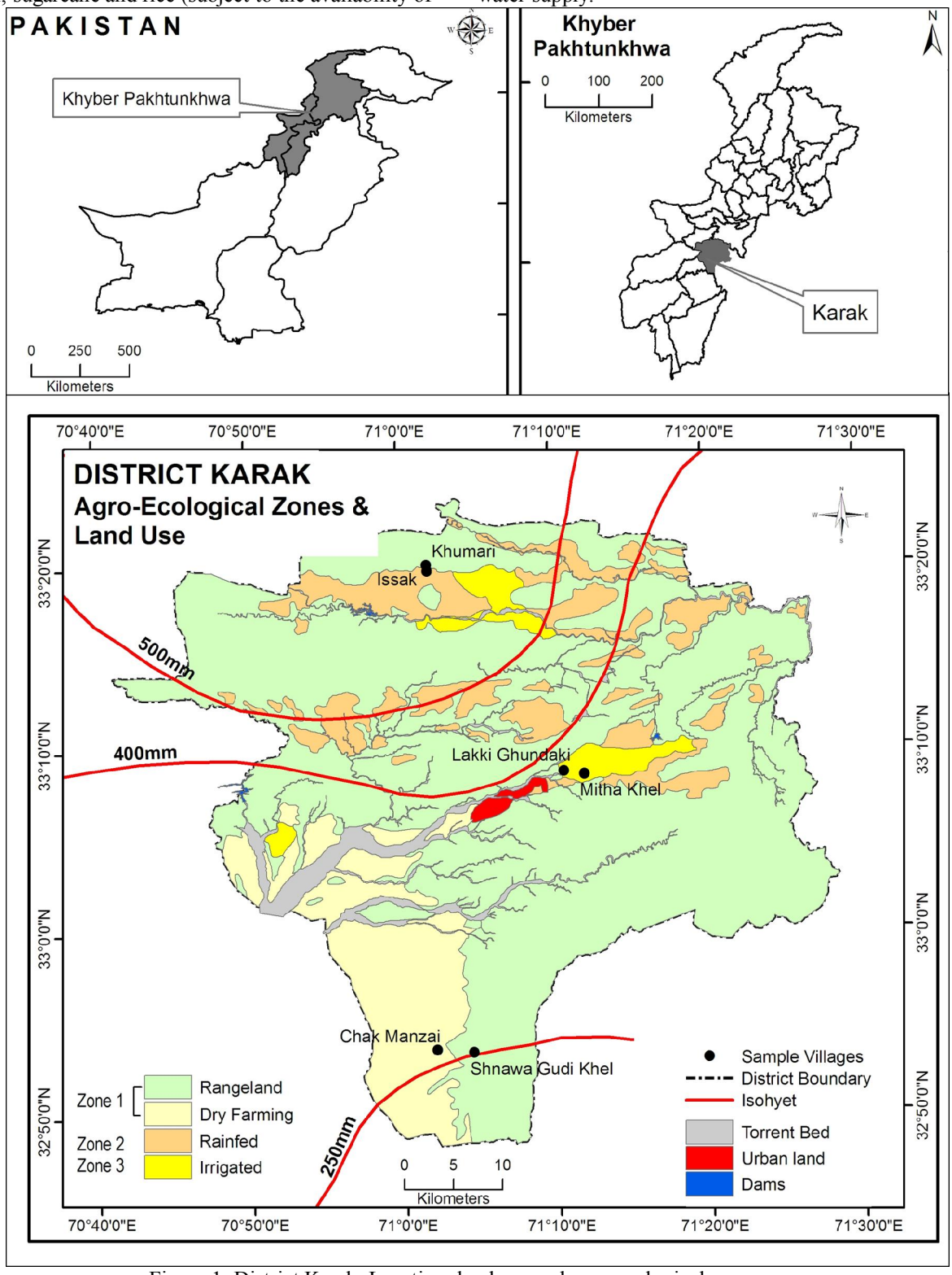

Figure 1: District Karak: Location, land use and agro-ecological zones

Plate 1 Gully Erosion

Table 1: Karak District: Change in Mean Yield (Kg/ha) of Major Crops (30 Years Back and Current)

Village	Wheat		Groundnut		Millet		Gram	
	Current	Back	Current	Back	Current	Back	Current	Back
Karak	1054.97	980.65	425.05	179.03	432.52	749.42	382.28	507.53
Issak Khumari	1699.37	1258.95	1212.63	797.89	522.11	642.53	.00	.00
Mitha Khel	1093.57	1257.04	697.39	64.78	435.48	640.00	72.35	84.87
Shnawa Gudi Khel	797.49	752.31	8.82	.00	397.80	838.59	664.47	887.22

Table 2: Perception of respondents regarding unusual climatic events (N=465)

Event	Percentage of respondents
Changed rainfall pattern	95
Increased droughts	65
Increased temperature	58
Strong winds	58
Increased flash floods	86
Dust storms	72
Forest fires	37

Table 3: Karak District: Food Security

Time Duration	Number of respondents	%age
<4 months	91	20
4- 6 months	193	41
6-8 months	76	16
8-10 months	63	14
Year around	42	09
Total	465	100

Table 4: Karak District: Sector-wise Working Population in Sample Households

Activity	Issak Khumari	Mitha Khel	Shnawa Gudikhel	Karak
Agricultural	57	56	426	539
Non agricultural	169	226	680	1075
Total	226	282	1106	1614

Table 5: Determinant of desertification and sustainability of local adopted strategy

Indicators	Causes	Adoption	Role		Sustainability
			Positive	Negative	
Decreased crop yield of major crops	Water scarcity	Rain water harvesting	More land is brought under irrigation	No negative impacts	Sustainable
				Agriculture become expensive	
		Tube wells		Overexploitation of ground water	Unsustainable
Decreased grassland area and its productivity	Climatic variability Overexploitation Declined interest of the locals in land	Revival of traditional *nagha* system	Rangeland rehabilitation and conservation	Short term fodder and fuel wood shortage	Sustainable
Increased cost of agriculture	Soil erosion Out-migration Water scarcity High price of agriculture inputs	Depend more on non-agriculture sources	Dependency on land has decreased	Increased abandoned lands	Unsustainable
Badland topography	Soil erosion	*Bands* and leveling of fields	Cultivated lands are protected	Increased maintenance work	Sustainable
Crop failure	Climatic variability	Change in agriculture inputs and crops	Increased crops yield	Agriculture became capital intensive	Sustainable

Conclusion

This study on farmer's perception regarding the indicators and causes of desertification and their adaptation to cope with it reveals that farmers are well aware of the process and its increasing impacts. To cope with desertification and decreasing land productivity in the Karak district, the inhabitants of the area have adopted a shift to off-farm employment both inside and outside the district. The large-scale migration for off-farm employment has somewhat reduced the dependence on natural resources. However, income from off-farm sources led to the negligence towards management of natural resources, whereby implementation of traditional rules and norms set for sustainable utilization of such resources as water, land, and natural vegetation were somewhat ignored. Nevertheless, the ensuing reduction in productivity and adverse consequences such as enhanced frequency and intensity of flash floods and soil erosion made the inhabitants realize the importance of management of natural resources through traditional norms and values. Their revival is a good omen and hopefully would lead to safeguard against desertification in future.

In terms of adaptive strategies on farmlands, the efforts have been concentrated on growing new crop varieties such as groundnut, harvesting of rainwater, extension of irrigation, reduction in herd size and changing its composition. These efforts need to be supported as much as possible because some of them such as installation of tube-wells has resulted into extraction of ground water below fresh water zone (abstraction of salt water) leading to increased soil salinity. Technology transfer and extension on conservation practices and selection of suitable and better-adopted plant varieties and livestock breeds could be of substantial help. Further, financial assistance through farm credits could also help poor farmers to invest in their lands for improving its productivity.

References

1. Verstraete MM. Climate Change and Desertification: Where Do We Stand, Where Do We Go? *Global and Planetary Change,* 2008; 64:105–110.
2. Verstraete MM. Towards a Global Dry-lands Observing System: Observational Requirements and Institutional Solutions. *Land Degradation and Development*, 2011; 22:198-213.
3. Anjum SA. Desertification in Pakistan: Causes, impacts and management. *Journal of Food, Agriculture & Environment,* 2010; 8(2):1203-1208.
4. IPCC. 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.
5. Whitehead EE, CF Hutchinson, BN Timmermann, RG Varady. Arid Lands Today and Tomorrow. Westview Press: Boulder, CO, 1988.
6. UNCOD. (United Nations Conference on Desertification), Desertification: Its Causes and

Consequences. Pergamon Press, Oxford Nairobi, Kenya, 1977.
7. Müller C, A Bondeau, A Popp, K Waha, M Fader. Climate change impacts on agricultural yields. The World Bank, Washington, DC, 2009.
8. Thomas RJ. Addressing Land Degradation and Climate Change in Dry-land Agro-ecosystems Through Sustainable Land Management. *Journal of Environmental Monitoring*, 2008; 10:595–603.
9. Mannava VK, Sivakumar N, Ndegwa. (ed.) Climate and Land Degradation. Environmental Science and Engineering. Spingers, New York 2007.
10. MEA. 2005. Millennium Ecosystem Assessment: Ecosystem and Human Well-being: Desertification Synthesis Home Page (http://www.eco-web.com/editorial/060715.html) Accessed 23 October 2008.
11. Eswaran H, R Lal, PF Reich. Land Degradation: An overview. In E.M. Bridges et al. (ed.) Responses to Land Degradation. Oxford Press, New Delhi, India, 2001.
12. Hoermann B, Banerjee S, Kollmair M. Labour migration for development in the western hindukush Himalayas Kathmando, *ICMOD*, 2010.
13. Bierbaum RJ, M Holdren, RH, MacCracken PH, Raven. Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable. *United Nations Foundation and Sigma Xi, the United States,* 2007.
14. Stern N. Stern Review on the Economics of Climate Change. Cambridge University Press, Cambridge,UK, 2007.
15. UNDP. Human Development Report 2007/2008. UNDP, New York, USA, 2007.
16. Mekuria WE, M Veldkamp, J Haile, B Nyssen, Muysd, K Gebrehiwot. Effectiveness of exclosures to restore degraded soils as a result of overgrazing in Tigray, Ethiopia. *Journal of Arid Environments,* 2007; 69:270–284.
17. Tschopp RA, A Aseffa, Schelling, J Zinsstag. Farmers' Perceptions of Livestock, Agriculture, and Natural Resources in the Rural Ethiopian Highlands. *Mountain Research and Development,* 2010; 30(4):381-390.
18. Hillel D, and C Rosenzweig. The Greenhouse Effect and its Implications Regarding Global Agric. In: B. Res. (ed.) Agric Prepared for the Climate Change. The World Bank, Washington, D.C. 1989.
19. Gerten D, J Heinke, H Hoff, H Biemans, M Fader, K Waha. Global water availability and requirements for future food production. *Journal of Hydro- meteorology,* 2011; 12:885–899.
20. Mary AL, and AE Majule. Impacts of climate change, variability and adaptation strategies on agriculture in semi arid areas of Tanzania: The case of Manyoni District in Singida Region, Tanzania. *African Journal of Environmental Science and Technology*, 2009; 3(8):206-218.
21. Mwang'ombe. Livelihoods under Climate Variability and Change: An Analysis of the Adaptive Capacity of Rural Poor to Water Scarcity in Kenya's Drylands. Journal of Environmental Science and Technology, 2011; 4(4):403-410.
22. Ehlers E, Population Growth, Resource Management and Well Adapted Land Use in the Bagrot/Karakoram. *Applied Geography & Development*, 1996; 48:7-28.
23. Ehlers E. Traditional Environmental Knowledge and Consciousness and the Problem of Sustained Agricultural Development. *Applied Geography & Development*, 1997; 49:79-95.
24. Reij C, G Tappan, A Belemvire. Changing Land Management Practices and Vegetation on the Central Plateau of Burkina Faso (1968–2002). *Journal of Arid Environments*, 2005; 63(3):642-659.
25. Reed MS, AJ Dougill, MJ Taylor. Integrating Local and Scientific Knowledge for Adaptation to Land Degradation: Kalal Rangeland Management Options. *Land degradation and Development,* 2007; 18:249-268.
26. Winslow M, BI Shapiro, R Thomas, SV Shetty. Desertification, Drought, Poverty and Agriculture: Research Lessons and Opportunities. Aleppo, Syria, Patancheru, India; and Rome, Italy, 2004.
27. UNFCCC. Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries. UNFCCC, Germany, 2007.
28. Noralene U, Y Takeuchi, R Shaw. Local adaptation for livelihood resilience in Albay, Philippines. *Environmental Hazards,* 2011; 10(2):139-153.
29. Adger WN. and Vincent. Successful adaptation to climate change across scales. *Global Environmental Change*, 2005; 15:77–86.
30. Stringer LC. Adaptations to climate change, drought and desertification: local insights to enhance policy in southern Africa. Environ. Sci. Policy. doi:10.1016/j.envsci.2009.04.002
31. Zia MS, T Mahmood, BM Bai, M Aslam. Land and Environmental Degradation and its Amelioration for Sustainable Agriculture in Pakistan. *Science Vision*, 2004; 9(1-2):1-5.
32. GoP. 2001. District Census Report of Karak 1998. Population Census Organization Islamabad, Pakistan.
33. Dahlgren L, M Emmelin, A Winkvist. Qualitative Methodology for International Public Health. Umea University, Sweden, 2004.
34. CGIAR. Climate, agriculture and food security: A strategy for change. 2009.
35. GoP. 1998. NWFP Livestock Census 1996 Vol. II. Peshawar, Pakistan.
36. GoP. 2007. Soil Survey Pakistan. Agricultural Census Organization Statistics Division, Government of Pakistan, Lahore.