

# **Adaptation strategies to increase human resilience against climate variability and change: Lessons from the arid regions of Sudan**

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**Adaptation strategies to increase human resilience against  
climate variability and change: Lessons from the arid regions of Sudan<sup>1</sup>**

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**Abstract.** Certain community-based development activities, in particular, those that are characterized as sustainable livelihoods (SL) activities, serve to build adaptive capacity in the face of climate-related shocks. In countries where drought can be expected to increase in duration and frequency, measures such as these can operate as de facto climate change adaptation options. These measures warrant careful consideration in adaptation policy and planning, alongside larger-scale activities, because they represent options that are clearly effective at the local scale, while rich in co-benefits. To test this hypothesis, case study research was conducted in rural Sudanese communities. This research involved collection and analysis of data on a series of indicators, developed in collaboration with the community, to capture the level of household-level coping capacity achieved by various types of small-scale development interventions aimed at drought disaster management. In each case study, the results point to suites of integrated development measures that significantly increased community coping capacity in the face of drought conditions – conditions that are similar to those predicted under a changed climate regime in Sudan. While such measures tend to be seen as the domain of development agencies, they clearly have a role to play in the adaptation processes of countries like Sudan. This paper explores these measures, discussing their role in community coping and adaptive capacity, their policy and institutional enabling factors, their potential in climate change adaptation, and recommendations for how they can be integrated into adaptation policy and planning.

**Keywords:** adaptation, livelihoods, climate variability, climate change, policy, response measures

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## **1. Introduction:**

Persistent and widespread drought is a recurrent feature of the climate of Sudan that has contributed to severe hardship, poverty, hunger, dislocation and even famine. Yet there are examples of development and environmental management strategies employed by rural populations of Sudan that have increased the resilience of communities for coping with drought and its effects. These examples provide models that could be applied to increase drought resilience more widely in Sudan. They can also provide lessons to guide adaptation to climate change, projections of which indicate the potential for a more arid climate and more frequent drought.

Development and resource management activities are examined in three rural and drought prone areas of Sudan where traditional farming practices are common: Bara Province in North Kordofan State, Arbaat in the Red Sea State, and El Fashir Rural Council in North Darfur State. People in these rural communities face multiple threats, including climate hazards, resource scarcity and degradation, civil strife, market fluctuations, changing resource use rights, and government policy failures. A variety of coping and adaptive strategies have been developed and employed in the communities to address these threats. In addition, each of the communities is the site of a development project that incorporates sustainable livelihood strategies and attempts to build upon local initiatives. These projects have been, in the opinion of community leaders, successful at improving the wellbeing of local people and increasing the resilience of their communities to climatic and other stresses.

In our study of these three cases, we sought to understand how the projects affected community resilience, the factors that enable or inhibit project success, and

factors that can sustain project benefits. We focused in particular on the role of the projects and their component measures in building resilience to drought and examined their potential as approaches to climate change adaptation.

The analysis is conducted within the framework of sustainable livelihoods. Sustainable livelihoods is an approach to poverty reduction that focuses on people's livelihoods, their context of vulnerability to adverse outcomes, and the assets needed to sustain and improve livelihoods, reduce vulnerability and move out of poverty (see, for example, DFID, 1999). Projects that apply a sustainable livelihoods strategy attack poverty and vulnerability holistically by increasing access to the assets needed to achieve positive livelihood outcomes.

In the rural settings of the three case studies, livelihoods are based predominantly on traditional farming and pastoral activities. Exposure to drought, coupled with highly constrained and unequal access to assets, are defining features of the vulnerability of people pursuing rural livelihoods in the study areas. Development projects that have been implemented in the study areas have attempted to increase access to the assets emphasized by the sustainable livelihoods approach: natural, physical, financial, human and social capital. The assets generate multiple benefits for people and their communities, including added resilience to drought.

Using participatory methods with members of the case study communities, aspects of these assets that are important for coping with drought were identified and indicators developed to measure changes in assets that would affect resilience to drought. Structured interviews in the case study communities were then used to gather information about development projects and to collect data on the indicators for before and after their

implementation. The methodological approach, which is adapted from Springate-Baginski and Soussan (no date), is described in greater detail in Osman-Elasha (2006).

## **2. Climatic context**

In order to understand what adaptation options are needed and possible, it is important to identify the climatic variables to which the adaptations relate and to consider the role of non-climatic factors that influence the sensitivity of rural livelihoods to climate change. This addresses the question: what is it that people are adapting to? According to Pittock and Jones (2000) and Smit et al. (2000), the applicability of adaptation options depends on the nature of the stimuli and associated vulnerability.

A previous impact assessment conducted for the purpose of developing the first National Communication of Sudan to the United Nations Framework Convention on Climate Change (UNFCCC) considered vulnerability only to changes in annual average precipitation and temperature (Ministry of Environment and Physical Development, 2003). It gave a long term climate projection for 2030-2060 for the arid region of Western Sudan. The longer-term impacts identified in the national communication include changing rainfall patterns affecting agriculture, food security and economic growth, rising temperatures affecting vector borne diseases (malaria), and decreased water security.

However, it is the variability and extremes in climate, particularly variability of rainfall and periods of persistent and widespread drought, that pose the greatest climatic hazards for farmers and pastoralists in Sudan. Recurring series of dry years have become a normal phenomenon in Sahelian Africa, a region that encompasses Sudan. Since 1961,

several episodes of drought have afflicted Sudan. This period witnessed two widespread droughts during 1967-1973 and 1980-1984. The latter drought was much more acute throughout the Sahel than the preceding drought of 1967-73. Most of the sustainable livelihood measures examined in this study were put in place in response to the 1984 drought. Despite the important influence of climate extremes, development and resource management practices do not respond to these climatic stimuli alone. Non-climatic forces such as institutions, policies and social networks, clearly have significant implications for natural resources decision-making, e.g. the effects of changing farmer's access to the vegetable market in Arbaat area (Abdelatti, 2003). In view of this recent history, our case studies of climate change vulnerability in Sudan, conducted under the international project Assessments of Impacts and Adaptations to Climate Change (AIACC), focus on risks associated with climate variability and drought (Osman-Elasha, 2006).

### **3. Overview of the case studies**

Three case studies were considered in this study, as outlined in the sections below.

#### **3.1 Bara Province, North Kordofan**

The Bara Province lies in the North Kordofan State of Western Sudan. It consists of marginal land, which is becoming increasingly degraded under combined anthropogenic and climatic pressures and is classified as semi-arid and dominated by sandy soils with poor fertility. Most of the province consists of desert scrub vegetation on undulating sand dunes; the average rain fall is quite low at roughly 250-300 mm per year, with frequent seasonal and inter-seasonal rainfall variability.

The cumulative impact of recurring droughts, cultivation of marginal lands, fuel wood gathering and overstocking of livestock has drastically depleted the vegetation. As a result, soil erosion, desertification and dust storms have emerged as significant environmental challenges. The local resource base has been degraded, undermining livelihoods and leaving communities more vulnerable to adverse effects of future drought. The province was severely impacted by the 1980-1984 droughts that hit the entire Sahel, affecting family and tribal structures and their autonomous traditional practices of resource management and leading to thousands of people migrating from their villages to refugee camps around the towns and cities.

The target groups considered in this case study were a mix of agro-pastoralists and transhumant, extremely vulnerable to drought in addition to other ongoing pressures and environmental stresses like rangeland degradation, failing livestock and crop production and atmospheric dusting.

In response to these devastating conditions that prevailed in the area, a UNDP/GEF project 'Community-Based Rangeland Rehabilitation (CBRR) for Carbon Sequestration' was initiated in 1992 covering 17 villages within Gireighikh Rural Council in the Central Bara Province. The aim of the project was to implement a simple model of community-based natural resource management to prevent over-exploitation and degradation of marginal lands and rehabilitate rangelands for the purpose of carbon sequestration. It also sought to encourage biodiversity preservation, reduction of dust storms, and reduction of the risks of production failure in this drought-prone area by providing alternatives for sustainable production. To ensure the success and sustainability of this approach, the project provided for increasing numbers of livelihood alternatives to

diversify local production systems and improve the socio-economic conditions, leading to decreased out-migration and population stability. In essence, the project included both mitigation and adaptation outcomes.

Measures implemented by the CBRR project include small scale irrigated vegetable gardens, pest management, improvement of water supply through the construction and management of water wells, forestry/rangelands rehabilitation, wind-break, sand dune stabilization, and tree and shrub planting. The project produced a variety of reported benefits. Human capital for more efficient management of natural resources was increased through training and other capacity building activities. The condition of natural capital was raised by land rehabilitation, better land management, introduction of sheep as replacement for goats, planting of shelterbelts, development of women's gardens, and changing building practices to conserve wood. Physical capital benefits include improved food storage facilities and increased stores of grain for dry periods. Financial capital was increased by improved access to local and national markets, production of marketable sheep, and greater access to credit through revolving credit funds. Social capital benefits include the formation of community development committees and enhanced living conditions of women through participation in community gardens and other activities.

### **3.2 Arbaat, Red Sea State**

The Arbaat study area is the catchment of the Khor Arba'at, a small seasonal stream located in the Red Sea State of northeastern Sudan, about 50 KM north of Port Sudan, the State capital. The region is generally characterized by relative isolation and

harsh terrain, a highly variable rainfall system with recurrent spells of drought, a small area of cultivable land, low population density and sparse distribution. Target groups are rural households practicing agro- pastoral systems in a semi-arid area along the Khor Arba'at. The Khor drains a catchment area of 4750 Km<sup>2</sup> (Bashir, 1991), crossing the area in an east-west direction during the course of its flow from the Red Sea Hills, where it originates, to the Red Sea where it discharges.

The hilly nature of the topography and the Basement Complex formation of the base rock make surface run-off the only source of fresh water in the Red Sea area. The rocky and compact nature of soils, the steep slope, the pattern of rainfall in the area (thunderstorms) and the poor vegetation cover all contribute to the high rates of run-off in the Red Sea area. The Khor Arba't catchment lies on the coastal plain of the Red Sea, between the Red Sea Hills and the saline fringe and coral reefs along the Red Sea. These lands, long known as Arba'at Zira'a, lie on the alluvial deltaic fan of Khor Arba'at and comprise some 54,850 feddans (23,040 ha) formed on a largely silty, sandy and gravelly texture laid down where the Khor Arba'at drainage system debouches to the Red Sea littoral. Out of the total area of the Arba'at deltaic fan, the arable lands of Arba'at have recently been estimated at 23,215 feddans (9,750 ha). Of these, about 9.285 feddans (3.900 ha) can readily sustain flood irrigation agriculture. Though difficult to estimate in the absence of any mapping of spate irrigation, approximately 2,400 feddans (1000 ha) are under cultivation during the rainy seasons. A further 8000 feddans (3,380 ha) have the potential for being brought into the spate irrigation system, if more water was available.

Animals represent the main means of economic and social mobility, recognition and survival of the *Beja* pastoralists of the region.. Aware of their environment's

vulnerability to drought and famine, they developed various mechanisms to sustain their livestock based system and to allow for recovery from shocks (Abdelatti, 2003). Their primarily subsistence agro-pastoral system and dispersed pattern of settlements helped maintain the carrying capacity of the land, reduce competition and conflict, and allow for population increases. The practice of geographical and temporal migration up and down the hills in pursuit of water, pasture and cultivable lands supported sustainable production in a land of highly variable climate. The larger *khors*, or seasonal streams, represented the main winter and summer resorts for livestock, and some *wadi* deltas developed over time into commons that provided refuge to all groups at times of crisis. Although distance, duration and direction of migration might have changed as a form of adaptation in response to changing conditions, the overall pattern remained largely the same in most rural areas.

Adherence to Beja traditions of *salif*, a social code of conduct governing relations and resource use, helped to preserve land, animal and other resources. For example, a strong social sanctioning system on the use of resources imposed by tribal leaders helped constrain overuse of land and wood. The practice of rebuilding of the animal stocks after each drought cycle helped the pastoral system to recover from periods of drought. In recent years, temporary migration for work outside home areas, primarily to Port Sudan, has become an important source of livelihood for rural pastoralists for coping with drought.

Frequent occurrences of the drought and famine conditions in the Red Sea hills have largely been the norm during the 20<sup>th</sup> century. The traditional pattern of natural short-term recovery was shattered after the long drought and famine of the 1980s and the

system failed to re-configure (Abdelatti, 2003). According to DFID (2004), a 'relief culture' in which local and national authorities rely on humanitarian agencies to address humanitarian crises has become established. The reoccurrence of drought and famine conditions have largely made the Red Sea State heavily dependent on central government support and foreign aid organizations and made long term planning, including that of mitigating impacts of drought, of a low priority. In short, the State has almost constantly been in a state of emergency and relief operations that only vary in scale, length and location from one year to the next.

The Khor Arba'at Rehabilitation Project (KARP) project came in response to the Sahelian drought in the 1980s. It was conceived following a regional investigation of potential development projects by SOS Sahel (UK), which was wishing to fund a suitable agricultural development project in the area. The Khor Arba'at delta was chosen as an area where it was felt that rehabilitation of the degraded agricultural farming system could provide considerable benefits to the local community and that the people of Arba'at and their agricultural system had been bypassed and neglected by government services in recent years, yet they were eager to participate in a broad ranging programme designed to improve their livelihoods. The main objectives of the project were to improve livelihoods and food security by rehabilitation of Khor Arba'at delta, sustainable management of natural resources to meet local needs, equitable water harvesting, and enhancement of grassroots participation in the overall development of the community.

The project introduced use of micro-catchment water harvesting techniques or contour bunds for planting trees (see Figure 1), agricultural extension and training for improved agricultural practice, adult literacy education for women, credit program and

training, and formation and training of a community development committee. The project also supported local experiments and initiatives such as spreading home gardens, digging wells for irrigation, and establishment of local shops that spared people the trip to Port Sudan. Benefits from these measures include improved agricultural production, enhanced livelihood opportunities, increased access to credit, reduced out-migration and stabilization of local population, and greater recognition by men of women's role and rights.

### **3.3 El Fashir, North Darfur**

North Darfur is situated on the northern transitional margin of the Inter Tropical Convergence Zone. Consequently, most of the area is deficient in water even in the wettest months of July to September, which account for 80% of annual rainfall. During June, the hottest month, temperatures regularly reach over 45°C and in January, the coldest month, temperatures reach 18°C. North Darfur is one of the most drought-affected regions of the Sudan. The drought years of 1983-85 greatly affected the demographic and socio-economic conditions of the area. Large numbers of people left their homes due to famine and the environmental impacts of desertification and drought. This was accompanied by tribal conflicts, the growth of shanty towns and changes in the pattern of livestock raising and agricultural production. During this time, most people lost over half of their cattle, as well as large numbers of sheep, goats and camels.

While the two previous case studies presented a reactive type of adaptation that had been introduced into the area by means of an externally promoted project in response to specific climate stimuli, this case study represents autonomously developed adaptation

measures that were initially evolved by the local community and only later supported and expanded by an externally funded project. Examples of these measures include *trus* cultivation and traditional water harvesting, *magun* cultivation, use of home gardens, and shifting cultivation.

*Trus* cultivation is a traditional water conserving method of cultivation used on clay soils that harvests water run-off by constructing low earth bunds called *trus*. In recent years, as rain-fed farming on sandy soils became increasingly risky and unable to produce enough food for the family, indigenous *trus* cultivation became increasingly important. In 1964 the first local attempt to construct a large *trus* embankment across the Wadi El Ku succeeded. The farmers harvested a good crop of sorghum. This confirmed to villagers living in such an arid area, that harvested surface run-off could be used with some degree of certainty. Consequently, more farmers started to shift to clay soils and practice *trus* cultivation.

*Magun* cultivation was adopted in response to sand encroachment on top of fertile soil. It involves digging holes 10-30cm in diameter and 5-15cm deep, spaced at distances of 40-70cm, to plant seedlings. The soil inside is loosened by hoe, and part is pulled forward onto the down-slope edge of the hole. Seedlings of tobacco and water melon are sown in the centre. Home gardens, or *jubraka*, are operated mostly by women and used for growing of fast maturing crops and some vegetables like *okra*, *pumpkins* and *cucumbers*. Shifting cultivation is employed to minimize the risk of crop failure by farming both sandy soils and clay alluvial deposits. The main cropping site for a family that provides the greatest portion of its subsistence needs is usually on sandy soils and is used to grow millet, sesame and groundnut. The family may also cultivate plots on clay

soils using water harvesting techniques to grow sorghum, vegetables and tobacco, the latter being a cash crop.

In 1998 a nonprofit organization, Intermediate Technology Development Group (ITDG), began to implement a program to support livelihoods and food security in the El Fashir Rural Council of North Darfur. The ITDG food security programme sought to build upon indigenous knowledge regarding water-harvesting techniques with the involvement of local communities. The aim is to harvest as much of the rain that does fall in parched North Darfur and store it for as long as possible in order to provide enough water for irrigation and domestic use. ITDG Sudan is helping communities tackle this situation through various methods including earth dams to capture increased amounts of rainy season floodwater from streams.

#### **4. Analytical Approach to Adaptation**

As mentioned earlier, the study evaluated vulnerability and adaptation to climate hazards within the context of the sustainable livelihoods framework. Farming and pastoral households' perceptions of risk, their vulnerability to the impacts of past droughts, and their current practices and capacity for coping with and adapting to drought were assessed. The capacity to cope and adapt, as well as the effects of observed interventions, were evaluated in terms of changes the five livelihood capitals measured along three dimensions: productivity, sustainability, and equity (see Table 1). Indicators that are relevant to each local context were developed with the participation of local stakeholders to measure changes in the five capitals (see Table 2).

#### **4.1 Livelihood Systems, Vulnerability and Adaptation**

The study covered human livelihood systems in three rural areas in Sudan, focusing mainly on farming and livestock raising and their experiences with sustainable livelihood and environmental management interventions in their agricultural production systems. Our approach emphasizes the interconnections among the various levels within the livelihood system (i.e. household, community, state and national), in addition to a general analysis of external forces, policies and institutional frameworks operating at scales from local to national scales that affect their livelihood systems,

From the three case study studies, several insights about adaptation are apparent. Most important is that autonomously developed adaptation measures in the Darfur and Arbaat case studies were not made as responses to climatic conditions or risks alone. Instead they were made as part of a continuous community-level risk management process that encompassed non-climate as well as climate related risks. Yet these responses have helped to build general capacity and resilience in the communities that has increased their resilience to climate related risks.

The challenge is that future risks under climate change may exceed the tolerance level of many human systems. While rural communities may have adapted their livelihoods over centuries and developed sophisticated coping strategies to deal with local risks, events that are unusually severe, persistent or frequent can invalidate those strategies and increase risk (UNDP, 2004). Consequently, these adaptation responses may no longer be considered as effective options for mitigating the adverse future climatic impacts. Combined with the additional uncertainty caused by economic globalization, which may invalidate the economic viability of local production, climate change makes

local risk coping strategies increasingly difficult and the option of successful risk management more challenging.

In the Arbaat area before the KARP activities were introduced, a set of community driven adaptation measures were in use. However in the face of very severe drought, as in 1984, these measures became inadequate in reducing human vulnerability, highlighting the need for external intervention and support. Human capacities were developed in response to the need and vulnerability under which the community was living when KARP came into the area. Moreover, the flexibility maintained by the project in response to these needs (supporting education, literacy classes and the women programme), has combined to generate a strong and positive impact.

#### **4.2 Characteristics of Adaptations**

The Sustainable Livelihood Assessment Approach was used to measure the impact of a package of measures (interventions) on a community's coping/adaptive capacity. The approach aimed at examining the condition of available livelihood assets (natural, physical, financial, human and social) before and after the intervention in order to assess the capacity of communities to adapt to future climate variability and change. Different types of adaptation were covered by the case studies, some are considered as being developed spontaneously, or autonomously, as a regular part of on-going resource and risk management, and others that are consciously and specifically planned in light of specific climate-related risks.

An example of the first type is the development of *trus* cultivation in Darfur, a water harvesting technique which was a community driven adaptation measure taken in

response to loss and scarcity of irrigation water. For the second, an example is the planting of shelterbelts in arid lands of Bara Province, which was introduced by the UNDP/GEF funded project in response to the soil erosion and land degradation resulting from frequent drought.

Another characterization could be the duration of adaptation, which distinguishes responses according to the time frame over which they apply, such as the tactical (shorter-term) versus strategic (longer-term) (Stakhiv 1993; Smit et al. 1996). In our case studies, some tactical adaptations were identified in response to an extreme climatic condition (drought), such as the selling of livestock, expanding agriculture lands in response to declining productivity per unit area (at the expense of forest and range lands), and most widely the use of relief foods (introduced by relief organizations).

However, over time local people and national governments, as well as international organizations, discovered that this type of adaptation is unsustainable, since it does not address the root causes of the problem but only the symptoms. As a result, the communities would face a similar or worse situation in the future with less and less coping capacity. This led some organizations and governments to start adopting strategic approaches to adaptation, as in the development projects implemented in the Gregikh Rural Council of Bara and in Arbaat and the locally initiated measures implemented the El Fashir Rural Council of North Darfur. This included measures such as the structural changes in the farm operation and management applied as long term strategies.

For example, in Bara, changes in land management were made such as limiting crop areas, range rehabilitation, livestock improvement, agroforestry, sand dune fixation, and replacing goats with sheep that have less impact on the environment. In the case of

Darfur, measures included the diversification of income sources by practicing different economic activities. In Arbaat, measures included improved management of water and land through water harvesting techniques, earth bunds and a terracing system, increasing recharge of the surface and ground water reservoirs, and enhanced equity in access to water.

According to Smit et al. (2000), adaptations could also be distinguished according to the form in which they occur and the agent responsible. Responsibility can be differentiated among the various actors that undertake or facilitate it. This proved true in our case studies, although the assessment indicated that the adaptation measures had been implemented as one package with the involvement of multiple stakeholders, including local communities, project staff and government officials. Still, the roles of different actors could be distinguished. For example, in Bara, key actors involved in the implementation of different measures could be identified as follows: UNDP project staff for the provision of water pumps, seeds, seedlings and technical acumen; government agencies for training, supervision and guidance; subsistence farmers for implementing improved management practices on their farms; and women groups for facilitating women's participation in production activities and decision-making.

Differentiation could further consider capacity of different actors to play their roles and ensure the sustainability of important activities regarding rangeland rehabilitation, water harvesting and resource management. Moreover, distinctions among adaptations based on form have been suggested by, among others, Burton *et al.* (1993), Carter *et al.* (1994) and Smithers and Smit (1997). These studies consider adaptations according to their administrative, financial, institutional, legal, managerial,

organizational, political, practical, structural, and technological characteristics. For example, Bryant *et al.* (2000) identifies forms of adaptation at the farm-level, including modification of resource management, purchasing crop insurance, and diversification. They also identify different forms of policy level adaptations including aid for research and development, incentive strategies and infrastructure measures.

In assessing different forms of responses to drought in our case studies, we came to the conclusion that in order to ensure effectiveness and sustainability of responses, different forms need to address the different livelihood capitals and be applied simultaneously at different levels, e.g. the introduction of sheep fattening at the farm level in the Bara case study for income generation (financial capital) succeeded because it was simultaneously accompanied by the provision of adequate veterinary services (physical capital), employed under the supervision of the Community Development Committee (community level), as well as supportive marketing (policy-making level).

Another example from the Arbaat case study is the implementation of measures aiming at improving access to credit (financial capital) for increasing farm production, which was supported by the launching of a farmers training program and a farm level extension (human capital). This was in addition to the formation of village committees (community level organizations) for the supervision, as well as the issuance by the state government (policy-making level) of permits to farmers to grant their accessibility to nearby markets (legislative measure).

In the Darfur case study, the adoption and expansion of water harvesting techniques, initially developed by the communities (community level), then supported by the Intermediate Technology Development Group project , contributed significantly to a

dramatic increase in the production and diversification of agricultural crops, (diversification/Income ) e.g. introduction of the tobacco, tomatoes, okra, chilies, onions, garlic, potatoes, sweet melon, and citrus fruits beside the traditional farming of millet (the main subsistent crop), *dura (sorghum)*, pearl, and groundnut. This was accompanied by the formation of unions (social capital), to organize the production, harvesting, and accessibility to markets (Traditional Farmers and Fruits and Vegetable Unions). Good capacity grain stores were established to accommodate the increased grain production (physical capital).

### **4.3 Adaptation Options**

In this paper adaptation refers to adjustments in natural, social, financial physical and human capitals in response to actual or expected climatic event and their effects or impacts. This section identifies types of adaptation to climate variability and change, giving examples drawn from the three case studies. The types of adaptations highlighted here are activities that represent changes in some attributes of one or more livelihood capitals, directly related to reducing vulnerability to climatic variability and change.

In each of the case studies, community members participated in consultations and focus group meetings to screen environmental management measures in use in their communities and identify those that act as an adaptation to climate hazards, particularly drought. Community members also participated in categorizing measures according to the primary type of livelihood capital targeted, evaluating benefits generated, identifying implementing actors, assessing the resources and capacities needed to implement, and identifying important uncertainties that might affect their performance. Some of the

measures that emerged from the participatory assessments as effective for improving livelihoods and as viable options upon which to build adaptation to future climate change are presented in Table 3.

Implementation of most measures involved multiple actors. Actors most commonly identified as responsible for implementation include community based organizations, traditional leaders, women's groups and rural extension officers. These same actors are likely to play important roles in building future adaptation. Capacities identified as needed range from basic extension and training knowledge to good managerial skills, specialized technical capacities and leadership qualities. In the Bara case study, the role of policies and institutions in relation to adaptation was found to play a major contributing role to the sustainability of most of the coping strategies practised by local communities in the study area. This was mainly due to the availability of local institutions, including community development committees and local NGOs, and their ability to continue carrying out the development activities after the termination of the externally funded project.

Essential resources repeatedly identified throughout the case studies include finance, credit for purchase of seed, service infrastructures for education, health, food storage, marketing and agricultural extension, and machinery and spare parts. Shortage in financial resources is identified in three case studies as a threatening factor to the sustainability of the adaptation measures. Another important threat and uncertainty highlighted in the two of the three case studies is the out migration of skilled worker and technicians measures.

Common threats to the sustainability of coping capacity are changing top down government decisions and policies, as exemplified in the planned heightening of the Khor Arba'at Dam. Heightening of the dam would divert more water for urban use in the capital city of Port Sudan to alleviate severe water shortage during summer time. But at the same time it is expected to negatively impact the Arbaat area because increasing water storage in the dam would reduce the volume of water spillover that used to pass downstream and supply the Arbaat community. Potential adverse effects of reduced water supply to Arbaat include reduced cultivated area, displacement of families, spread and invasion of aggressive mesquite trees on their fertile agricultural land, and reduced production of food for subsistence and marketing to urban dwellers in Port Sudan.

The issue of the Khor Arbaat dam highlights the problem of conflicts in the interests at the local or micro level and interests at a more macro level. The State government is under pressure from the Port Sudan urban population to secure drinking water for an ever-growing population and the options are limited to one source, the Khor Arba'at. Thus, without a major change in State government policy of total dependence on the Arba'at, the Arba'at farmers are going to end up being the losers, at least in the short term. However, local farmers have proposed measures to mitigate adverse impacts of raising the dam that include (1) assigning a fixed share of the Khor water to the Arba'at population by the government, (2) providing for exploitation of ground water by digging wells to irrigate the home gardens and installing pumps in areas where ground water is available and sufficient for agricultural purposes, and (3) providing social and economic services to the area in compensation for their diverted water.

Alternative water sources such as bringing water from the Main River Nile or desalinization of the seawater are found to be expensive large projects that could only be addressed through central government funding. Moreover, the Arba'at committee held several meetings with the concerned parties, but according to them, they failed to get any real support. By the time the survey was done, people took their case to some of the prominent religious leaders who have access to decision-makers and could better communicate the community's interest to them. It is well established over the years that those religious leaders along with other traditional community leaders are the source of wisdom, possessing good negotiating abilities and having gained the trust of their people, so they represent good entry points to new ideas or development approaches.

#### **4.4 Productivity, Equity and Sustainability Dimensions**

These measures have also been assessed across the dimensions of productivity, equity and sustainability. By looking at these dimensions, the assessment is aimed at identifying whether these adaptations have effectively reduced vulnerability to current climatic variability and whether it is going to effectively reduce potential future impacts of climate change.

##### *The Productivity Dimension*

Different indicators have been developed for each case study to assess the productivity effects of adaptation measures across the livelihood capitals. In the Bara case study, indicators used for assessing productivity in the natural capital considered issues related to total rehabilitated land area and carrying capacity and forage production.

In Arbaat and Darfur, it considered issues like improvement of land productivity for supporting diversified crops, increased crop productivity and the amount of water conserved.

In the case of Bara, results indicate an overall improvement in the three indicators of land rehabilitation, carrying capacity and forage production by 58%, 46% and 48% respectively, when compared to their situation before the intervention. The improvement of rangeland had also led to a significant increase in animal numbers, particularly sheep. The rehabilitation of the rangeland increased the forage production, which increased the carrying capacity. However, the improvement of the latter was relatively less than the others (46%), presumably because of the negative relationship between carrying capacity and animal numbers.

In the case of Arbaat, project measures improved land productivity by 12% and crop productivity by about 19 %. The improvements in both water quality and quantity could be attributed to the intervention in the form of the introduction of new ideas regarding water harvesting and management by community members.

The Darfur case study showed that the productivity per unit land increased by more than 50% from the introduction of water harvesting. Moreover, the diversification of agricultural crops contributed to an increase of household income through marketing of different types of fruits and vegetables.

Productivity in the financial capital addressed similar issues across the three case studies, which are mainly the number of income generating activities, created employment opportunities and the efficiency of the credit systems introduced. All showed positive results with regard to the three indicators. However, in the Darfur case

study, the amount and stability of credit depend to a large extent on the sufficiency of agricultural production, which means that if production is poor, then less credit will be granted. In Bara more credits will be granted to men and rich women, assuming that they will be able to repay. While in Arbaat, the Agricultural Bank provided seeds on credit and small loans for interested farmers, benefiting 36% of the people. In spite of this, the study revealed that only about 12% of the sample think that credit availability has directly contributed to the success of the project. A larger proportion (40.4%) attributed the success of the project to the provision of basic community needs for education, health and training.

### *The Equity Dimension*

The assessment of equity, focused on the situation of minority groups and women, their access to resources, and their contribution to the decision making process before and after the project interventions. Analysis showed that generally the equity situation was much improved compared to the pre-intervention period in all the areas studied, although there are differences on the level of improvement. For example, Bara witnessed a positive improvement in the access of women and minorities to the different social services because the project administration was keen on involving them in the various project activities. Consequently they created the enabling condition for their involvement through training and extension services for minorities and women development programs.

The results showed that women's participation in productive activities like the Women Irrigated Gardens (WIG) was excellent (88% of total respondents). It also

showed that the training and extension opportunities opened to marginalized groups have significantly improved (97 % of total respondents). Equity issues were a real challenge in the Arbaat area, where people traditionally oppose and restrict women's participation in many out-door activities. However, the area witnessed a giant jump under the project; with regard to women's participation in community development activities, participation in public life, accessibility to resources, and involvement in the production process. They currently constitute 63% of the total number of farmers. Another indicator is their participation in meetings, regarded by over 76% of respondents as reasonably high after the project, compared to fewer than 7% prior to the project. Moreover, according to the respondents, women's involvement in community committees has doubled to more than four times its level prior to the project.

On benefiting from services such as education, results reflected that adult literacy attendance was particularly high among women: 70% of female respondents indicated that they attended regular classes compared to only 2.4% attendants before the project. The greater participation of women in the income generating activities gave them a sense of independence and more freedom to highlight their problems and express their needs publicly. This led the project management to give more consideration to activities specifically targeting women such as motherhood care, women empowerment, and elder education. This has led to better outcomes and more equal diffusion of the benefits through the community. Moreover, women and men equally enjoy good access to credit, child schooling opportunities and to a slightly lesser degree in activities that require moderate cash payment, such as possessing sprayers, improved seeds and pesticides.

However, inequality in access is clearer in relation to the vegetable market, which is governed primarily by size and quality of produce, which in turn depends on the land size and type of inputs applied. This situation provided a relative advantage for rich farmers with large land areas compared to the less privileged ones.

The Darfur case study provides a different example on equity issues, where few variations were observed before and after project implementation with regard to the role of women in the agricultural operation, water harvesting and cultivation *on sandy soil (qoz)*. The majority of respondents indicated that the level of women's participation in these activities can be considered generally as good. However, a clear division of work is in place that is not as pronounced in the other case studies. Some tasks could be only assigned to women while others assigned only to men. This is particularly true among members of Fruit and Vegetable Farmers Union. While fruit gardens are grown and managed only by men, vegetable plots are the responsibility of women, who are also responsible for crop farming and harvest. In spite of this disproportionate workload assigned to women, men are still the ones who make all decisions regarding land ownership and farm planning. Despite of the fact that women in Darfur constitute more than 85% of the total labour force of the forest sector, mainly as workers in forest roads, opening fire lines and looking after seedlings in the forest nurseries, but less than 1% hold key positions in this sector (Osman-Elasha, 1996). Women in Sudan have been called "invisible laborers," as their work is often not counted in formal labor statistics.

### *The Sustainability Dimension*

Taking into consideration that climate change could modify the historical patterns of both climate variability and extreme events in an unpredictable manner, communities may need to not only sustain their current flexibility and resilience, but increase their abilities to absorb and respond to different types and a wider range of impacts if they are to maintain their coping capacities and ability to adapt to potential changes. In this context, resilience is not just returning to a fixed level of vulnerability, but reducing vulnerability and enhancing the capacity to minimize risks so that vulnerability to future climatic events is reduced. To be sustainable, adaptation efforts must anticipate potential socioeconomic and environmental changes and pursue options that build resilience to the stresses resulting from these changes.

In the three case studies, a different set of indicators was considered for each of the livelihood capitals. All the indicators used for assessing sustainability in the Bara case study showed poor conditions before the project intervention. The situation changed after the intervention, and the information became more readily available (80%). One important factor that contributed to the sustainability of most of the coping strategies in Bara is the continuity of the local institutional setup created by the project, evaluated by 78%, as being very effective. The continuity of the institutional setup is attributed to the efficiency community development committees as well as the effort of a branch of the NGO Sudanese Environmental Conservation Society (SECS). SECS took over the tasks of the project and continue to build on it.

Key to the sustainability of coping capacity is the availability and timely dissemination of information on rainfall, new production inputs, and prices. This is in addition to the effectiveness of credit repayment, which was found to be excellent (88%),

under the revolving fund which continued to work very well as a system. This was in addition to supportive government policy with regard to developing and encouraging the adoption of income-generating activities.

A list of sustainability elements presented by the Arbaat case study emphasized that the acquired skills and knowledge represent the main sustainable benefits to the community. Elements for sustainability that have been introduced right from the start of the project include:

- Government involvement and commitment to the provision of financial and technical contribution;
- Establishment of community development organizations and building their capacities;
- Continuous awareness campaigns and training programs for different community groups, particularly women;
- Community participation in planning and contribution to the cost of inputs (the cost sharing of inputs: KARP 40%, Government 40% and beneficiaries 20%);
- Positive reaction of the project to basic community needs (initiating and/or strengthening of the community services (e.g. health and education));
- Use of appropriate techniques and technology in different farm level practices;

- Serious consideration and positive responses by the project to recommendations and experts' advice put forward upon the evaluations of different project activities. For example the women's component was not part of the original planned activities; but following the first evaluation it was proposed, and now women farmers constitute 63% of total project components.

In the case of Darfur, a key sustainability element is the fact that the basic environmental management measure around which all the other measures have been built is the autonomously developed water harvesting technique. This is very important as it is a clear indication that this is an adapted, tested and viable measure, which evolved with time and has so far provided a safeguard to local communities against harsh climatic conditions. In addition, the case study of Darfur highlights the prominent role played by community leaders in ensuring sustainability of important indigenous knowledge, cultural values and wisdom and their transfer between generations. Moreover, under the traditional system of local administration the responsibilities of the traditional leaders used to include land allocation, protection of common natural resources, organization of management of natural resources, security and organization of foreign tribes passing or residing in the area, defining and delineating nomadic routes, and settlement of tribal disputes.

The changing in government policies and institutions led to the replacement of traditional administration with different government structures, which is among the major factors contributing to the current conflicts in Darfur Region.

## 5. Perceived risks

The main risk perceived in Arbaat is the heightening of the Khor Arba'at dam to divert water to Port Sudan that would also reduce water supply to farmers in Arba'at al Zira'a. The loss of water would jeopardize the effectiveness of water harvesting and other measures used to cope with variable rainfall and drought, undermine efforts to improve access to the five livelihood capitals, and reduce resilience to both climate and non-climate stresses. The solution proposed by the local committee to the State authorities, as alternatives, includes (1) digging wells to irrigate the home gardens, (2) guaranteeing an agreed amount of water from the Khor to Arba'at and (3) providing compensation to the area in the form of social and economic services. Digging of wells will also contribute to reducing the risk of frequent low seasonal rainfall. Given the present level of technology, knowledge and economic conditions in the area, the predictability of a good runoff of the Khor or abundant water volume coming from the highland is extremely difficult, and hence, there is always a risk of the occurrence of water shortages or floods. Another risk is the increase in the population and water demand for Port Sudan, which is very likely to occur given the current trends of migration from rural areas to big cities and towns. This requires developing a rational and economically effective water management system within the urban areas, in order to guarantee sustainable water supply, without causing greater deficiency problems elsewhere.

In Bara, the improved rangeland condition and the available water within the area have attracted more people with their livestock. Migration into the region might be the main external risk, which could trigger problems in the future. Moreover, there are some worries with regards to brain drain as the analysis showed that 20-30% of trained people

used to migrate during the dry season to work in towns or in irrigated schemes. This migration was found to be temporary as the workers return to their home areas during the rainy season. Nevertheless, if the percent of the migrating people increased significantly, that might constitute a risk, particularly if it is combined with a shortage in training opportunities.

Our case study of El Fashir Rural Council began prior to the current conflict and violence in Darfur, which present a substantial risk to the sustainability of adaptation efforts. This is a clear example of the effect of war on the human livelihood and sustainable development interventions. The hard work of many people could easily be lost and resources that could have generated income for years could be destroyed. Historically, conflicts in Darfur are over scarcity of natural resources. During the terrible droughts of the 1980s, nomads faced with dried-out natural pastures started to take their herds into the farms of the resident agriculturalists. They allowed their herds to graze the farmers' crops and the farmers, suffering just as much from the drought, defended their land and their crops. Animal herders and farmers clashed, sometimes different groups of herders also fought each other for water or pastureland. Fighting between different groups has led to tribal quarrels and local skirmishes have escalated in to larger tribal conflicts.

The result we see now is a violent conflict that holds the concern and attention of the world. The context of vulnerability of the people of Darfur has deteriorated severely. But despite the violence and displacement of large numbers of people in Darfur, within the case study villages of El Fashir Rural Council water harvesting and associated agricultural activities continue without external support, cultivated area has increased,

crop productivity is up from 2005, and livestock production has increased such that the villages are the main meat suppliers to the town of El Fashir.<sup>2</sup> Whether these activities and benefits can be sustained in El Fashir is highly doubtful as the crisis in Darfur continues; extension of them to wider areas is impossible without cessation of hostilities and establishment of security in the region. The current conflict in Darfur deserves detailed assessment and in-depth analysis that go beyond the scope of this paper.

## **6. Lessons Learned for Adaptation Processes**

In the three Sudanese case studies, community development projects contributed to reductions in the vulnerability of the people to climate hazards as well as other stresses. These projects each implemented a suite of measures aimed at improving living conditions and increasing food security by strengthening livelihoods while taking into account frequent drought as one of the major threats to people in the region. The projects sought to engage those at risk in making decisions and implementing the measures and to build upon indigenous knowledge and practice. The projects emphasized a holistic approach to increasing the natural, physical, financial, human and social capacities necessary for adaptive responses that are effective in reducing vulnerability. Some measures were motivated explicitly by the desire to reduce climate risks (e.g. water harvesting), some to expand livelihood options (e.g. introduction of new crops and types of livestock), some to improve and sustain the productivity of land (e.g. rehabilitating rangelands, controlling access and use of rangelands), some to increase individuals' skills (training and extension services), some to expand participation in decision making

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<sup>2</sup> Personal communication to N. Goutbi from Practical Action staff member responsible for El Fashi region, 06 September 2006.

(formation and engagement of village committees and women's groups), some to empower marginalized persons (e.g. literacy programs and irrigated gardens for women), and some to improve financial conditions (e.g. revolving credit fund and marketing assistance). But taken together, they had the effect of increasing resilience of the communities to recurrent drought.

The benefits from the capacity building emphasis appear to be long lasting as the measures continue to be in use in the study areas and have been replicated in other communities, despite discontinuation of external funding of the development projects. This is true, thus far, even of the sites in El Fashir Rural Council in North Darfur. The experiences of the case studies is a demonstration that management of climate risks can be integrated into development projects and that this can provide lasting benefits for reducing vulnerability to climate risks. The assessment of the three case studies illustrate the viability of a number of adaptation options available to governments, communities and development agencies for reducing vulnerability to climate related risks. It also shows that there are many kinds of policies and measures with the potential to ameliorate problematic climate change impacts. Moreover, research is needed to explore the potential sustainability of these adaptation measures to future climatic changes. There is also a need to evaluate the relative merit of different adaptation options so as to prioritize according to appropriate criteria. The evaluation criteria may differ greatly depending upon whether the evaluation is taken from the point of view of a government or other stakeholders and can differ from one locality to another.

Using a bottom-up approach enables a better understanding of a community's vulnerability and adaptation needs, because those affected by climate hazards are in the

best position to define their problems, formulate priorities, and anticipated risks. For example, in the Arba'at case study, local communities highlighted the potential threats to their lands that could result from the building of a proposed dam in the khor, such as the reduction of the irrigated areas and consequently reduction in productivity. They suggested certain mitigating measures that the government should consider putting in place, if it decided to carry on with the plan of establishment.

The experiences presented in this paper could provide a sample of possible adaptation measures that could be considered by policy makers when they formulate sectoral plans aiming at sustainable development. Furthermore, by relating specific types of adaptation to rural communities and stakeholders, it is hoped that this work will contribute to the development of practical and useful adaptation programs for future climate change.

Although what was presented here could be used by communities living in similar conditions and livelihood settings, specific adaptation measures would need to be tailored to local conditions and decision-making processes.

Future adaptation should focus on the enhancement of current resilience and continue developing the flexible management approaches that facilitated adjustments in response to the past and current climatic variability. Consistent with the findings of Smit et.al. (2001), we find that a useful alternative to focusing on particular adaptation measures is to work to enhance adaptive capacity, or the broader ability of a system to cope with climate-related risks and opportunities. In the context of sustainable livelihoods, this takes the form of increasing access to natural, physical, financial, human and social assets that can be used to respond to climatic and other stresses. A focus on

enhancing capacity allows for local and individual assessments of options, and the incorporation of adaptation into existing risk management processes.

Important to the development of adaptive capacity is the timely dissemination of information on climate related hazards and vulnerabilities, and on the different practical types of adaptation measures and coping mechanisms that different stakeholders could implement in order to reduce the potential adverse impacts.

Special consideration should be given to the integration of indigenous knowledge with regard to historical experience with climate variability and the traditional responses evolved over time. This could provide a strong basis for promoting future adaptation to future change. For example, the water harvesting techniques adopted in the Darfur area that have proved to contribute greatly to increasing community resilience to harsh drought conditions could be diffused more widely to adapt to future climate change. However, there is a need to recognize that long-term climate change could cause patterns of climate variability to change in unpredictable ways from those experienced in the past. This may decrease the reliability of historical traditional knowledge and its effectiveness in providing a safeguard against future impacts.

The Bara case study provides an opportunity for integrating mitigation and adaptation concerns, particularly in addressing the natural capital through rangeland rehabilitation, re-vegetation and biodiversity conservation. For example, the application of a sustainable grazing system represented by grazing allotments was found to improve the quality and diversity of grazing lands, and availability of desirable species, so it provided for mitigation through carbon sequestration as well as fostering resilience to potential fodder gaps in the future. Similarly, planting of shelterbelts can both maintain

an important carbon sink and provide protection against the impacts of sand storms and encroachment.

Many adaptation activities would be carried out at the local level. Effective execution will require that local institutions and local community leaders be involved in the decision-making process. As shown by the Bara case study, the major role of traditional administration in natural resources conservation and management has contributed to the effectiveness of adaptation measures at improving the productivity, sustainability and equitable access of livelihood assets. Traditional leaders respect and consider each other, and their communities respect them as well. This is indicated by their ability to solve frequent problems between herders and farmers, putting both of them under control by addressing the root causes for conflicts such as demarcating routes for migrating tribes and herders.

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**Table 1: Locally-derived criteria for assessing changes in livelihood capitals**

Dimensions of the five livelihood capitals	The five livelihood capitals				
	Natural	Physical	Financial	Human	Social
<b>Productivity</b>	Soil fertility	Irrigation infrastructure	Income	Employment	Education and extension
<b>Equity</b>	Access to land	Access to irrigation system	Access to credit	Individual/household rights	Access to decision-making
<b>Sustainability</b>	Land management	Water management	Savings and investment	Health	Local institutions

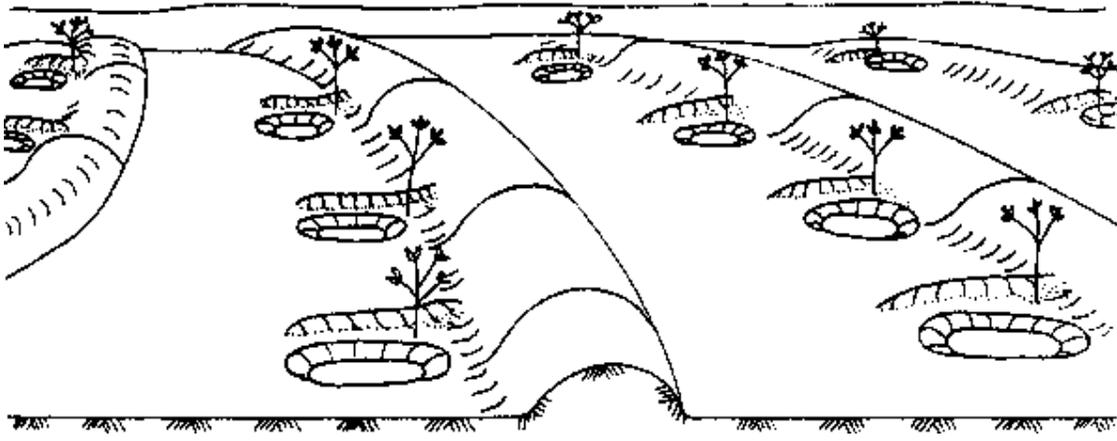
**Table 2: Sample indicators of different SL capitals**

Natural capital	Social capital	Financial	Physical capital	Human capital
Land ownership/access (# ha)	Organizational set-up (local village committees)	Type of income generating activities	Management of water wells	Ownership of assets
Livestock holdings (# heads)	Role of village committees in the decision making process.	Income levels and stability	Maintenance of water pumps	Skilled labors
Fertility of land (soil quality)	Membership to organizations	Revolving funds /amount of credit granted to individuals	Grain stores (capacity and accessibility)	Housing type
Fodder production (amount)	Sharing of responsibility	Savings	Grain mills (capacity and accessibility)	Access of marginal groups to education, training and extension services

Table 3: Summary table of characteristics of adaptation measures

Capital	Measure	Benefits	Actors	Resources	Capacities	Uncertainties
<b>Natural</b>	<ul style="list-style-type: none"> <li>❖ Water harvesting and management</li> <li>❖ Introduction of new crops or species</li> <li>❖ Increased vegetation cover</li> <li>❖ Home gardens )</li> </ul>	<ul style="list-style-type: none"> <li>❖ Improved environmental conditions</li> <li>❖ Household food security</li> <li>❖ Improved water supply (quantity and quality)</li> </ul>	<ul style="list-style-type: none"> <li>❖ Subsistence farmers</li> <li>❖ Women</li> <li>❖ Government and project officials (guidance&amp; supervision)</li> <li>❖ CBOs</li> </ul>	<ul style="list-style-type: none"> <li>❖ Resource base</li> <li>❖ Source for funding</li> <li>❖ Capital money</li> </ul>	<ul style="list-style-type: none"> <li>Basic farming skills</li> <li>-Basic management skills</li> <li>-Training &amp; Extension knowledge</li> </ul>	<ul style="list-style-type: none"> <li>- Shortage of financial resources</li> <li>-Changing government policies</li> </ul>
<b>Physical</b>	<ul style="list-style-type: none"> <li>❖ Installation &amp; maintainace of irrigation system</li> <li>❖ Grain stores</li> <li>❖ Fertilizers</li> </ul>	<ul style="list-style-type: none"> <li>❖ Provision of physical assets necessary for sustaining their livelihoods</li> </ul>	<ul style="list-style-type: none"> <li>❖ Development Committees (supervision)</li> <li>❖ Community workers</li> <li>❖ CBOs</li> </ul>	<ul style="list-style-type: none"> <li>❖ Financial resources</li> <li>❖ Local building material</li> <li>❖ Spare parts</li> <li>❖ Machineries for digging</li> </ul>	<ul style="list-style-type: none"> <li>❖ Training skills</li> <li>❖ Technical know how related to operation &amp; maintainace</li> </ul>	<ul style="list-style-type: none"> <li>❖ Shortage in financial resources</li> <li>❖ Changing Government Policies</li> </ul>
<b>Financial</b>	<ul style="list-style-type: none"> <li>❖ Income generation activities</li> <li>❖ Diversification of livelihood systems</li> <li>❖ Access to credit and increased production</li> </ul>	<ul style="list-style-type: none"> <li>❖ Income generation, poverty alleviation and improved livelihood conditions</li> </ul>	<ul style="list-style-type: none"> <li>❖ Community-based organizations Rural extension officers</li> <li>❖ CBOs</li> </ul>	<ul style="list-style-type: none"> <li>❖ Creditable seed money</li> <li>❖ Extension facility</li> </ul>	<ul style="list-style-type: none"> <li>❖ Organizational skills (committees , unions, women etc)</li> <li>❖ Rural extension skills</li> </ul>	<ul style="list-style-type: none"> <li>❖ Government policies</li> <li>❖ Limited finance</li> </ul>
<b>Human</b>	<ul style="list-style-type: none"> <li>❖ Build on traditional knowledge</li> <li>❖ Capacity building ( training, extension, education, health )</li> <li>❖ Empowering women</li> </ul>	<ul style="list-style-type: none"> <li>❖ Improved human capacities and management skills</li> <li>❖ Improved health conditions</li> </ul>	<ul style="list-style-type: none"> <li>❖ Community-based organizations (CBOs)</li> <li>❖ Rural extension officers and school teachers</li> </ul>	<ul style="list-style-type: none"> <li>❖ Training and extension material</li> <li>❖ Clinics and health services</li> <li>❖ Schools and literacy classes</li> </ul>	<ul style="list-style-type: none"> <li>❖ Teaching and training skills</li> <li>❖ Rural Extension capacity</li> </ul>	<ul style="list-style-type: none"> <li>• Migration of skilled people</li> <li>❖ Conflicts and civil war</li> </ul>
<b>Social</b>	<ul style="list-style-type: none"> <li>❖ Organisational setup</li> <li>❖ Increased participation of communities in the decision making process</li> <li>❖ Further women participation in public life</li> <li>❖ Information exchange &amp;networking</li> </ul>	<ul style="list-style-type: none"> <li>❖ Community organization</li> <li>❖ Enhanced Community participation In the decision making process</li> <li>❖ Improved ability of women to participate in public life.</li> </ul>	<ul style="list-style-type: none"> <li>❖ Community based organizations (farmers, women, leaders)</li> <li>❖ Teachers and Extension officers</li> </ul>	<ul style="list-style-type: none"> <li>❖ Communication means (networking)</li> <li>❖ A source for providing and updating the climate information</li> <li>❖ Extension material</li> </ul>	<ul style="list-style-type: none"> <li>❖ Community leadership capacity</li> <li>❖ Extension and teaching skills</li> </ul>	<ul style="list-style-type: none"> <li>❖ Social &amp; tribal conflicts</li> <li>❖ Migration of skilled workers</li> </ul>

Figure 1. Contour bunds for tree planting in Arbaat



## Endnotes