Impact of Drought and Desertification on Sustainable Livelihoods in Wadi Al Muggadam Khartoum State, Sudan

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A thesis submitted to the University of Khartoum in partial fulfillment of the require for The Degree of M. Sc. in Desertification

Desertification and Desert Cultivation Studies Institute
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Dedication

To

My mother
And
My sister

With much love and respect
Acknowledgements

I would like to thank Allah the Al Mighty who is the ultimate guide of this work and life in general.

I wish to express my special thanks to my supervisor Dr. Mohamed Ahmad Elfeel for his valuable advices and encouragement, without his help and guidance this thesis would not have come out as it is.

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Impact of Drought and Desertification on Sustainable Livelihoods in Wadi Al Muggadam Khartoum State, Sudan Desertification and Desert Cultivation Studies, Institute University of Khartoum, Shambat

Abstract. The study aimed to evaluate rural livelihood assets for the households and their ability for sustainability under prevailing climate variability and land degradation conditions in Wadi Al Muggadam area. A comparison was held between the households in rehabilitated and non rehabilitated areas in crops yield, income, animal's numbers and migration. The study used primary data obtained from a field survey collected by a random sample of 100 respondents by means of a structured questionnaire. This sample covered four villages: Wad Omer and Um Harout representing the rehabilitated areas and Ageeb and Bohat Alguhwai representing non-rehabilitated areas. The primary data supplemented with secondary data we obtained from relevant sources. The descriptive and the statistical analysis were conducted with the sustainable livelihood framework approach. The results pointed higher illiteracy rate in non-rehabilitated areas compared with rehabilitated areas, this is attributable to unawareness of the importance of the education and the unavailability of schools and teachers. Increase in youth and male percentages in rehabilitated areas indicated reduced migration and improved livelihood situation. The Special Programme for Food Security (SPFS), implemented by the State government, had significantly increased crop productivities and
agricultural income in the rehabilitated villages. There was no significant
difference in terms of ownership and the number of animals between
households in rehabilitated and non-rehabilitated areas. The percentage of
crop sale was higher than percentage of crop consumption in the
rehabilitated villages compared to non-rehabilitated villages. Several
factors, including use are of users sand creep, the instability of income,
lack of employment opportunities, had become a complex problem facing
the sustainability of livelihoods in the study area. The proposals of
respondents for area development were making finance available and
establishment of tree belts to help the community combat desertification,
conserve agricultural lands and natural pastures which will contribute to
sustainable rural livelihood. The project of SPFS helped mitigating the
effects of drought and land degradation, improved the situations and
facilitated access to assets of livelihoods in rehabilitated villages compared
to non-rehabilitated ones. The study recommended that more efforts should
be taken to improve management of natural resources to prevent land
degradation and soil erosion, expansion of SPFS activities to increase
farmers' income and repeat SPFS experience in other sites to reduce
poverty and promote sustainable rural livelihood.
تأثير الجفاف والتصحر على استدامة سبل كسب العيش

في منطقة وادي المقدم - ولاية الخرطوم - السودان

معهد دراسات التصحر واستزراع الصحراويات

جامعة الخرطوم - شميات
لا يوجد نص قابل للقراءة بشكل طبيعي من الصورة المقدمة.
Desertification is a major environmental problem with adverse socio-economic impacts on the livelihood of the population in the arid, semiarid and dry sub-humid lands of the world, in general, and in developing countries, in particular. In Sudan, the relatively poor population in the rural areas seeks sustenance from the natural resources of their fragile ecosystem; people cultivate marginal lands for growing their stable crops, cut wood for fuel and for building their homes and making enclosures for their animals. Their herds graze in the villages around the water points. These human activities cause land degradation which is steadily accelerated due to increasing human and livestock pressures (Mustafa, 2007).

Since the devastating drought of 1980-1984 that hit the Sahelian countries, Wadi Almuggadam area became more susceptible to future drought and climate change. The cumulative impacts of recurrent droughts lead to serious diminishing surface water, depletion of vegetation cover, destruction of top soil fertility, low productivity of primal and cultivatable crops, due to land degradation. Farmers and pastoralists who lost their animal herds became disabled to grow vegetables or crops for food. Before fifty years ago, the family animal ownership accounted on overage 100 sheep, 110 goats, 110 camels and 10 donkeys (Ministry of Agriculture. 1997). Also, people cultivated in rainy season some vegetables and crops for subsistence in
wadi beds and banks, and obtained yields ranging between 6 -11 sack/feddan.

In the recent years, the ownership of animals decreased to 6 sheep, 5 goats, one camel, one donkey and the cattle were completely lost the suitable conditions for their livings as disappeared. The agricultural activity has become very limited depending on weather conditions (Ali.et.al, 1995).

All these degradation of resources and assets, led to the socio-economic situations deterioration, rural livelihoods undermining and consequent decrease in households' income, increase in poverty and forced people to leave their villages and migrate to the neighboring towns and cities, working in marginal jobs.

As a response to these worrying conditions that prevailed in study area, the Government identified western Omdurman (Wadi Al Muggadam area) beside two other sites (Lower Atbara and Abu Habil) for implantation of special programme for food security (SPFS) with agreement with the General People’s Committee for the Great Socialist People’s Libyan Arab Jamahiriya (the Donor), the Government of the Republic of Sudan and the Food and Agriculture Organization of the United Nations (FAO) to provide assistance for the execution of the project.

The implemented programme aimed to enhance and improve food security situation through: water control, encourage biodiversity conservation, reduce dust storms, and reduce the risks of production failure. This is to ensure the success and sustainability of production, increase numbers of livelihood alternatives, diversify local production and
improve the socio-economic conditions, which lead to decrease out-migration and more population stability.

1.1 Problem statement:
The research problems are stated as follow:
Wadi Almuggadam area, which lies in semi-desert zone of west Omdurman district, is classified as vulnerable lands to recurring drought and desertification as it suffers from direct desertification processes, annual rainfall variability and high pressures of livestock and population, soil deterioration associated with desert encroachment and loss of land especially land buried by sand.
The study area is extremely vulnerable to drought and people continuing pressures on land in addition to environmental stresses, which led to extension of land degradation. All these are interpreted as the inability of resources to sustain production, leading to undermining livelihoods leaving communities more vulnerable to more adverse effects of future droughts
As result, thousands of people migrated from their villages to the towns and cities.

1.2 Objective of research:
The study aims:
- to evaluate rural livelihoods households assets and their potential to sustainability under prevailing climate variability and lands degradation conditions: a comparison between rehabilitated and non rehabilitated areas
- to evaluate the effects of land degradation on:
* crop productivity.
* pastoralists and farmers income.
* livestock numbers..
* migration by number of immigrants, type of migration and reasons for migration.
- to explore how local communities adopt strategy to enable them adapt to current situation.

1.3 Hypotheses:
- the major degradation of lands is due to sand dunes encroachment covering and burying large areas that has influenced:
  * limited water resources.
  * the productivity of crops.
  * the quantity and quality of livestock.
  * farmers income.
  * food security situation.
  * migration of people.
- local communities adopted strategies for coping with the climate change seeking a better livelihood.

1.4 Organization of the study:

This study consists of four chapters as follow:
Chapter one: includes introduction, problem statement research objectives, hypotheses, and organization of the study.
Chapter two: reviews the literature. It covers history of desertification, definitions of desertification and droughts. Land degradation definition, desertification causes in Sudan, impact of drought and desertification at
local and national level, climate variability and climate change, desertification and desert cultivation, concept of rural development, concept of participation development, sustainable development, definition of sustainable livelihood, sustainable rural livelihood framework, sustainability.

Chapter three: provides the materials and methods, it covers data collection and analysis. Also, includes general information about the study area includes: location, topography, climate, water resources, geology, vegetation cover, population, family characteristics, economic activities, the special programme for food security and their objective, project components, the impact of the programme, constraints the implementation and why is the expansion of SPFS.

Chapter four: shows results and discussion: includes the general characteristics of population, situation of human capital indictors, situation of physical capital indictors, situation of natural capital indictors, situation of financial capital indictors, situation of social capital indictors, summary, conclusions and recommendations of the study.
CHAPTER TWO
Literature Review

2.1 History of desertification:
Olsson (1981) and Dregene (1986) stated that desertification is not a new phenomenon, since it began before the 1969-1973 Sahelien drought. Spooner (1989) and Grainger (1990) agreed to that and added that, archaeological evidence suggests that desertification began several centuries ago and can be traced back to the mediaeval and even Neolithic period.

2.2 Desertification definitions:
The word ‘desertification’ is used to describe degradation of various types and forms of vegetation, including sub-humid and humid forest areas. It was first defined by Stebbing (1938) desertification as encroaching Sahara. The United Nations, (1977) described desertification as the diminution or destruction of the biological potential of local land that can lead ultimately to desert-like condition and added that it is an aspect of widespread desertification of ecosystem, which diminished or destroyed its biological potential. Dregene (1976) described desertification as deterioration of ecosystem in arid, semi-arid, sub-humid regions by the combined impacts of man’s activities and drought. Dregene (1986) stated that, desertification is the impoverishment of terrestrial ecosystem by impact of people. It is the process of deterioration in these ecosystems that
can be measured by reduced productivity of desirable plants, undesirable alteration in the biomass and the biodiversity of the micro and macro fauna and flora, accelerated soil deterioration. The United Nations Conference on Environment and Development (UNCED, 1992) defined desertification as land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variation and human activities. This definition is adopted by United Nations Convention to Combat Desertification (UNCCD). Mainguet (1994) defined desertification as the “ultimate step of land degradation to irreversible sterile land”. FAO (1993) also defined desertification as “the sum of geological, climatic, biological and human factors which lead to the degradation of the physical, chemical, biological potentials of lands in arid and semi-arid zones, and endanger biodiversity and the survival of human communities”. Desertification is a single word used to cover a wide variety of effects involving the actual and potential biological productivity of an ecosystem in the arid, semi-arid and dry sub-humid regions (Hillel and Rosenzweig, 2002).

According to the definitions above, desertification appears as land degradation in arid, semi-arid and dry sub-humid climates, whatever the cause, but land degradation can occur under all sorts of climates. The United Nations Environment Programme (UNEP) has estimated that the area prone to desertification worldwide is approximately 38 million km\(^2\) of which 6.9 million km\(^2\) (19%) are in sub-Saharan Africa (Nana-Sinkam, 1995).

Desertification includes not only soil erosion but also potentially genetic erosion of the plant, animals and microorganisms that form the living elements of the dryland environments. When a dryland plant, animal or
soil microorganism species adapted to dry condition is lost, it is very likely that it is lost forever (El Wakeel, 2004).

2.3 Drought:
Droughts are unique in that unlike floods, earthquakes, or hurricanes; during which violent events of relatively short duration occur, droughts are like a cancer on the land that seems to have no recognized beginning (Mather, 1985). Droughts covering a few hundred square kilometers do exist but these are usually of limited duration and modest severity. It is more common for droughts to cover relatively vast areas, a significant proportion of a continent or sub-continent approaching millions of square kilometers (Mather, 1985). Drought is a creeping phenomenon making an accurate prediction of either its onset or end a difficult task. (Wilhite and Glantz, 1985). Tannehill (1947) noted: “We have no good definition of drought. We may say truthfully that we scarcely know a drought when we see one. We welcome the first clear day after a rainy spell. Rainless days continue for a time and we are pleased to have a long spell of such fine weather. It keeps on and we are a little worried. A few days more and we are really in trouble. The first rainless day in a spell of fine weather contributes as much to the drought as the last, but no one knows how serious it will be until the last dry day is gone and the rains have come again, we are not sure about it until the crops have withered and died”.

The definitions of drought can be categorised broadly as either conceptual or operational (Wilhite and Glantz, 1985). The encyclopedia of Climate and Weather (Schneider, 1996) defines drought as “an extended period - a season, a year, or several years – of deficient rainfall relative to the
statistical multi-year mean for a region”. Operational definitions attempt to identify the onset, severity and termination of drought episodes. Subrahmanyam (1967) has identified six types of drought: meteorological, climatological, atmospheric, agricultural, hydrological and water-management. Many others have also considered economic or socio-economic drought. According to Wilhite and Glantz (1985) four commonly used definitions of drought are as follows:

2.3.1 Meteorological drought:
Is defined as a period when rainfall is significantly less than the long-term average or some designed percentages, or less than some fixed value (Linsley et al., 1982; Downer et al., 1967).

2.3.2 Agricultural or ecological drought:
Is defined as “a deficit of rainfall with respect to the long-term mean, affecting a large area for one or several seasons or years, that drastically reduce primary production in natural ecosystems and rainfed agriculture” (WMO, 1975).

2.3.3 Hydrological drought:
Is the natural occurring phenomenon that exists when precipitation has been significantly below normal recorded levels causing a hydrological imbalance (Linsley et al., 1982).

2.3.4 Socio-economic drought:
Occurs when water supply is insufficient to meet water consumption for human activities such as agricultural activities, industry, urban supply, irrigation etc (Heathcote, 1974; Gibbs, 1975).

Droughts occur frequently in the Wadi Al Muggadam area. Drought in 1983 1984 and low rates of rain from the normal average have significant
impact on livelihoods of people in terms of vegetation cover, the quantity and quality of livestock in addition to agricultural activity.

2.4 Land degradation definitions:
Degradation processes include erosion, compaction and surface sealing, acidification, declining soil organic matter, soil fertility depletion, biological degradation and soil pollution (Lal and Stewart, 1990). Land degradation describes circumstances of reduced biological productivity (UNCCD, 1994; Reynolds and Stafford Smith, 2002). Most types of degradation result in a loss of plant and available water capacity, the most important factor affecting soil productivity in many soils. Deterioration of natural vegetation is the prime indicator of land degradation. Vegetative indicators are characterized by a visible degradation of the natural plant cover up to the point of complete destruction. Vast areas entirely cleared of natural vegetation show an irreversible loss of the natural regeneration of the tree, shrub or herbage cover. A change in the composition of the species can be a further indicator (Akhtar and Mensching, 1993). Williams and Balling (1996) defined land degradation in drylands as a “reduction of biological productivity of dryland ecosystems, including rangeland, pastures and rainfed and irrigated croplands, as a result of an acceleration of certain natural physical, chemical and hydrological processes, including erosion and deposition by wind and water, salt accumulation in soils, and groundwater and surface runoff; a reduction in the amount or diversity of natural vegetation, and a decline in the ability of soils to transmit and store water for plant growth”.

9
The soil characteristics that affect plant growth are nutrients contents, water holding capacity, organic matter contents, soil reaction (acidity), topsoil depth, salinity, and soil biomass. Changes over time in these characteristics constitute “degradation” or “improvement” (Lal and Stewart, 1990). An important criterion of soil degradation is the loss of the soil organic matter. Compared to soils in more humid regions, those in arid regions tend to be inherently poor in organic matter contents, owing to relatively sparse natural vegetative cover and to the rapid rate of decomposition due to relatively high temperatures (Hillel and Rosenzweig, 2002). Plant residues over the surface protect the soil from the direct erosive impacts of raindrops and from erosion by wind and help to conserve soil water by minimizing evaporation. When the natural vegetative cover is removed, there follows rapid processes of organic matter decomposition and depletion: accelerated erosion also removes the layer of the topsoil that is richest in organic matter; consequently, the destabilized soil tends to form a surface crust that further inhibits infiltration. Water losses by both runoff and evaporation increase. Moreover, the soil loses an important source of nutrients (Hillel and Rosenzweig, 2002). Surface soil not protected by permanent vegetation becomes subject to erosion by water and wind, crusting by raindrop splash, trampling by animals, salinization by evaporation, and water logging in topographic depressions since water is no longer extracted by permanent vegetation (Le Houéréou, 1995, 1996). The most widespread cause of land degradation in drylands is water erosion, followed by wind erosion, chemical, and physical degradation. Overgrazing accounted for half of all degradation, followed by agricultural activities, deforestation and over-exploitation (Le Houéréou, 1996). Water erosion is a serious form
of land degradation that leads to desertification throughout the world. Vast areas were permanently ruined by water erosion (Fadul et al., 1999). Ellison (1947) defined soil erosion as a process of detachment and transportation of soil material by erosive agents. The detachment of soil particles and runoff are linked to the intensity and duration of rainfall, as well as the slope and roughness of the landscape. Soil properties, plant cover and cultivation practices also play an important role in water erosion (Heede, 1976; Wollman and Miller, 1960). Mainguet (1999) has stated that water erosion is a natural mechanism of topography shaping, which when accelerated by human activities and water action causes land deterioration.

The components in semi-arid ecosystem degradation processes are increased surface albedo (reflectance of solar radiation) and increased generation of dust, both of which are consequences of the exposure of the bare soil as dry ground following removal of the original vegetative cover (Hillel and Rosenzweig, 2002). The albedo of a bare soil depends on the organic matter content and the mineral composition of the topsoil. It also depends on the moisture content of the soil surface. A moist soil is generally less reflective than a dry soil (Hillel, 1998).

2.5 Desertification causes in Sudan:

2.5.1 Overgrazing:

Overgrazing is the most prevalent cause of desertification in almost all over Sudan. This is especially around water points and where water table is often lowered after increased or excessive use of water. Sudan with its rich livestock is vulnerable to desertification through overgrazing. Overgrazing has led to the disappearance of some palatable species and
replacement by non-palatable types in some rangelands in Western Sudan. The carrying capacity of most of the rangeland areas in Kordofan, Darfur and Butana can hardly support the large number of livestock in the area (NDDCU, 2006)

2.5.2 Deforestation:
Felling of trees for different reasons and the use of fuel wood energy are the main causes of deforestation leading to desertification in forest areas (NDDCU, 2006). Abdallh (1991) ascribed desertification to over cutting of forestry for charcoal production.

2.5.3 Over-cultivation, cultivation of marginal lands and irrational use of heavy machinery:
The over-cultivation and cultivation of marginal land especially in low rainfall areas is a serious cause of desertification in Sudan. This often causes:
   a) loss of soil fertility.
   b) soil impermeability.
   c) loss of nutrients and biological activity (NDDCU, 2006).

2.5.4 Bush removal and unplanned burning:
The uprooting of bushes for wood and burning of grass and forest shrubs for crop cultivation can lead to desertification. This is practiced in some areas in Central Sudan. Fires destroy the soil cover leaving it bare and vulnerable to erosion and desertification, (NDDCU, 2006). EL.Tayeb (1991) stated that the major cause of desertification is land clearing for mechanized farming

2.5.5 Drought:

High fluctuations of climate and land degradation in the study area have become an effective factor behind the extended desertification.

2.6 Impact of drought and desertification at the local and national level:

Desertification is accompanied by a reduction in the natural potential of the land and depletion in surface and ground-water resources. But above all it has negative impacts on the living conditions and the economic development of the people affected by it. Desertification not only occurs in natural deserts, but can also take place on land which is prone to desertification processes. Desertification affects about two-thirds of the countries of the world, and one-third of the earth's surface, on which one billion people live, namely, one-fifth of the world population (Kooehafken, 1996).

Droughts occur frequently in the areas affected by desertification, and are generally a feature of their natural climate. The relations between desertification and drought on the one hand, and human influence on the other, are complex. Occasional droughts (due to seasonal or inter-year variations in rainfall) and long-term droughts covering wide areas are both caused or aggravated by the influence of man on the environment (the reduction in vegetation cover, changes in the local climate.). Human influence can also hasten desertification and aggravate the negative
consequences on man. But the degradation of land due to desertification has a serious compounding effect on drought, and thus reduces the chances of the local people to cope with difficult periods (Koohafken, 1996).

2.6.1 Sand encroachment:
There are few fragmented studies which showed that the desert is expanding from the north of Sudan at disturbing rate threatening the livelihoods and ability of affected areas. Dixey and Aubert (1962) estimated the advance of sand dunes encroachment in some agricultural land in Sudan to be at rate of 1 to 3 meters per year. Salih (1996) stated that sand moves from north to south at an alarming rate, and under those conditions 13 Sudanese states out of 29 states in Sudan were affected by land degradation. He reported that sand and sand dunes in the area between latitudes 10 and 18 N had originated from the weathering of basement complex Nubian sandstone, together with the alluvial deposits. Doka and Hamiud (2006) stated that many cultivated areas in Sudan, both irrigated and rainfed, have been subjected to desert encroachment, mainly by wind erosion and related sand invasion. Sand encroachment is one of the main problems threatening the agricultural production in Wadi Al Muggadam area.

2.6.2 The impact on crops productivity:
Desertification reduces agricultural yields, making them more unpredictable. It thus affects the food security of the people living in the affected areas (Koohafkan, 1996). Scotney and Dijkhuis (1989) reported that, crops yield could be decreased to half within 40 years according to
the continuous rate of degradation of cultivated land. A severe effect of the described desertification is decline of food and meat production. Food production has declined and continues to decline because of soil deterioration associated with desert encroachment and because of loss of lands especially lands buried by sand (Sudan Government, 1977). The decline in rainfall level has resulted in low growth in cereal production, largely because of short – run effects on yield, as evident from a comparison of growth estimates with and without the drought year of 1984. The cereal production is also marked by considerable and increasing year to year fluctuation. Yield variability has been strongly associated with variability of rainfall. Drought-production relationships show that a 10 percent drop in annual rainfall from mean levels implies a 5.0 percent drop in cereal production and a 3.7 percent drop in yield at country levels. Sorghum yield and consequently sorghum production are shown to be more affected than millet by decline in rainfall. A 10 percent drop in annual rainfall results in drops of 7.3 and 3.6 percent in sorghum and millet production, respectively (Tesfaye, 1991)

The yield in the study area was highly influenced by drought and desertification.

2.6.3 The impact on livestock population and rangeland production:
Effects of drought on livestock and rangelands are linked with decreased range resources. Livestock are more vulnerable to drought. Overgrazing over a period of less than 10 years may reduce the annual productivity of degraded rangelands from around 100 to 30 kg/ha of dry matter. Overgrazing not only reduces the protective ground cover but also reduces plant diversity and consequently the dry matter available from range plants.
Natural pasture provides grazing land for nearly all livestock. Production of animal feed is subject to fluctuations from one year to another, affected by varying quantities of rainfall and fire hazards (Ministry of Environment and Physical Development, 2003).

In the study area, crops productivities and animals’ numbers continue to decrease since 1980, resulting from a variability of climate and land degradation.

2.6.4 Migration by number of immigrants, type of migration and reasons for migration:

Desertification considerably heightens the effects of climatic crises (droughts) and political crises (wars), generally leading to migration, causing suffering and even death to hundreds of thousands of people worldwide (Koohafkan, 1996).

Land degradation brings hunger and poverty. People living in areas threatened by desertification are forced to move elsewhere to find other means of livelihood. Usually they migrate towards urban areas or go abroad. Mass migration is a major consequence of desertification (UNCCD, 2003).

Sudan has the largest population of displaced persons in the world. There are more than 2.4 million internally displaced persons in Darfur alone, and the total number of internally displaced persons and international refugees comes to nearly 5 million. Displaced persons rely on the areas surrounding refugee camps for firewood, food, and water (Ibrahim et al, 2007). This trend of high rural-urban migration is due mainly to recurring droughts (Ministry of Environment and Physical Development, 2003).

Seasonal migration: Seasonal rural migration has long been a livelihood strategy for semi-arid regions of Sudan, with principal destinations being
wetter parts of southern Darfur and central Sudan (e.g. Western Kordofan). Regional differences in the rainy seasons allow both male and female labourers of all age groups to temporarily migrate and return for their own cultivation. However, once the dominant strategy for agro-pastoralists in poor areas, rising transport costs and increased competition of labour markets since the 1990 have rendered seasonal migration less money-making, driving labourers further distances and for longer periods (over three years) away from home (Bakhit, 1991).

Longer-term migration in Darfur has a long history of migration to east Sudan, such as Gedaref, where (male) migrants commonly stay for 3 or more years to generate cash incomes that can be remitted home. The small number and unequal distribution of cities has also exacerbated migration to urban central Sudan, particularly for the better-life qualification. Between 1970 and 1990, for example, the population of Khartoum quadrupled, and it is now sub-Saharan Africa’s third largest city (Grawert, 1998).

Annual urban growth rates between 1990 and 2001 have stood at 5%, more than double the national average. This has put considerable strain on urban infrastructure, resulting in the rapid growth of urban slums (5% per year over the same period) which now account for 86% of the urban population (UN-habitat, 2007). The study area is suffering from high rate of migration to seek alternative livelihoods in neighboring cities.

2.7 Climate variability and climate change:
Climate variability means the fluctuation between the normal climate conditions and a different, but recurrent, set of the climate conditions over
a given region of the world (IPCC, 1998) and also refers to a shift in climate, occurring as a result of natural and/or human interference (Wigley, 1999). Climate variability and climate change have gone on throughout time; but has now become a pressing issue on the world’s agenda.

Climate variability may be divided into three types:

1) Internal variability
2) Natural externally forced variability
3) Anthropogenic externally forced variability (Wigley, 1999).

The contribution of the anthropogenic factors to the change in the natural climate is not slight (Hare, 1993), and there is now strong evidence for a human influence on the global climate. This effect will continue for the predictable future due to continued emissions of carbon dioxide (CO₂) and other greenhouse gases from burning of fossil fuels as well as other sources (Howden, 2003).

The large-scale change in land-use characteristics resulting from drought as well as from over-cultivation, overgrazing and deforestation can generate climate change on local and regional scales (Eltahir and Bars, 1994). When Zheng and Eltahir (1997) used a simulation model to study the response of West Africa monsoon to desertification and deforestation they found that the impact of deforestation is more serious than desertification. This result upholds the notion about the role of the Equatorial forest (Elsayem, 1986) and the evaporation of the soil water from the neighboring Bahr El Ghazal basin (Eltahir, 1989) in promoting rainfall in central Sudan. However, this should be the subject of a different detailed study.
Destruction of the permanent vegetation cover increases surface albedo, thus reducing the surface absorption of solar energy. Albedo may rise from about 25% for a well vegetated area to 35% or more for a bare, bright, sandy soil (Hillel and Rosenzweig, 2002).

Reduction or destruction of the vegetation cover accelerates surface runoff due to less interception and infiltration of rain water. In this case, soil water levels are likely to decrease, resulting in more energy being available to heat the air and the soil (sensible heat) than to evaporate water (latent heat). This increase in temperature levels would lead to a cycle of drying. The cloud cover may be reduced as less moisture is returned to the atmosphere via evaporation, certainly causing large reduction in the chance for rainfall (Elagib and Mansell, 2000). Hoffmann and Jackson (2000) concluded that conversion of tropical savannah to grassland reduced precipitation by approximately 10% in four of the five savannah regions. This is associated with an increase in the frequency of dry periods within the wet season and an increased in mean surface air temperature of 0.5°C.

Climate variability and climate change contribute to the vulnerability by economic loss, hunger, famine and move in Africa. The African Sahel provides the most dramatic example worldwide of climate variability that has been directly and quantitatively measured. Precipitation is much more variable in both time and space than other climate factors. The year-to-year variability is a dominant characteristic of the rainfall record and this variability becomes more pronounced if a smaller region is examined (Wigley, 1999). Precipitation varies in a number of its characteristics from total annual precipitation through precipitation seasonality to variability in characteristics of storms (duration, temporal, spacing, total storm
precipitation) and variability in the intensity of immediate and daily precipitation (Mulligan, 1998). African rainfall has changed substantially over the last 60 years. This change has been distinguished as rainfall during 1961-1990 declined by up to 30% compared with 1931-1960 (Sivakumar et al., 2005). Nicholson et al. (2000) concluded that a long-term change in rainfall has occurred in the semi-arid and sub-humid zones of West Africa. The rainfall during the 30 years (1968-1997) has averaged some 15-40% lower than during the period 1931-1960. Averages over 30 year intervals, showed that the annual rainfall in the Sahelian region fell by between 20-30% between 1930 and 1950 and the decades post 1960 (Hulme, 2001). Kidson (1977) suggested that the low rainfall was associated with a weaker meridional circulation and warmer temperatures over much of Africa. Newell and Kidson (1984) link the Sahelian rainfall variability to a modulation of the general circulation. Haile (1988) linked the drought in Ethiopia with Sea Surface Temperature (SST) anomalies in the southern Atlantic and India Oceans combined with anthropogenic activities. Eltahir (1996) used two extensive data sets describing Sea Surface Temperature of the Pacific Ocean, and the flow of water in the Nile River. The analysis suggests that 25% of the natural variability in the annual flow of the Nile is associated with El Niño oscillations. The primary natural forcing factors are linked to the change in solar output. Nicholson (1999) discussed the hypothesized role of surface-atmosphere interaction in the interannual variability of the Sahel rainfall.

Climate variability has been, and continues to be, the principal source of fluctuations in global food and production in the arid and semi-arid tropical countries of the developing world. In combination with other physical, social and political-economic factors, many African countries
have experienced severe drought and higher flood frequently in the 20
century. Extensive droughts have afflicted Africa, with serious namely
1995 (WMO, 1995). The cumulative impact of drought on the economies
of Africa can be large; for example 8-9% of GDP in Zimbabwe and
has a stronger effect than the small change in the mean of the climate
factors (Wigley, 1985). Elagib and Mansell (2000) reported that the mean
annual temperatures in Sudan have increased significantly by 0.076o –
0.2o C per decade specifically in the central and the southern regions.
They also concluded that the intramural variability of the rainfall ranged
between 13.8-122.9%.
It has been noticed that climate variability occurred over years in the
study area have affected the livelihood of local community.

2.8 Desertification and desert cultivation:
Desertification can be reduced by long term planting. Many rehabilitation
programmes and project have been implemented in order to prevent
environmental degradation from taking place. Specifically, they attempted
to curtail the existing destructive forces affecting the environment (Leena
and Riikka, 2000).
Some measures have been taken to arrest the spread of desertification and
to rehabilitate already degraded land. Most programmes have
concentrated on reforestation projects, tree planting along gullies,
terracing. Contour –cultivation, bund formation, planting shelterbelts,
windbreaks and stabilization of sand dunes (Rodda, 1991).
2.9 Concept of rural development:
Rural development is defined as improving living standards of the low-income population residing in rural areas and making the process of their living self-sustaining (Uma lele, 1975).
Another definition of rural development views it as far-reaching transformation of the socio-economic development structures, institutions, relationships and processes in any rural area. It conceives the goals of rural development not simply as agricultural and economic growth in the narrow sense but a balanced social and economic development (Oakley, 1985).
Allen, et al (2000), who analyzed the relationship between poverty and development, argued that it might at first appear that the two are virtually opposite; surely poverty means a lack of development, whereas development implies moving towards getting rid of poverty.

2.10 Concept of participatory development:
The concept of popular participation as an alternative to the top down development approach is considered a viable development activity.
Durno (1989) argued, a program of participation implies that people participate because they have realized that their needs can be best addressed through co-operative efforts. Van and Hawkins (1985), as cited by Mohamed (2000), view participation as a way of policy-making in organizations for which the decisions have consequences are given the opportunity by the administration to express their opinion about policy proposals and make their wishes clear.
The Organization for Economic Co-operation and Development (OECD 1991) development assistance committees Chairman’s report, as cited by
Mohamed (2000), had a chapter on participatory development. This was defined as strategies, which combine effective economic policies, equitable access to basic social and economic services and broader popular participation in decision making on the orientation of government policies and programs.

2.11 Sustainable development:
Sustainable development attempts to attain the need of all people to achieve the objective for a better life and maximized interests without depriving future generations.

Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development in agriculture, forestry and fisheries sector conserves, land water, plant and animal genetic resources, is environmental non-degrading appropriate viable and socially acceptable (FAO, 1989).

The FAO’s working definition of sustainable development emphasizes equally environmental, technological, economic and social aspects of sustainability were supported by Oakley and Garforth (1985) who believed that sustainability is one other essential element necessary for successful rural development programs. They state that it is important that the programs plans and solutions are relevant to local economic, social, and administrative development situation.
Sustainable development is also characterized as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (http://www.worldbank.org/ 2008)

2.12 Definitions of sustainable livelihood (SL):
Conceptually, “livelihoods” connote the means, activities, entitlements and assets by which people make a living. Assets, in this particular context, are defined as not only natural/biological (i.e., land, water, common-property resources, flora, fauna), but also social (i.e., community, family, social networks, participation, empowerment, human (i.e., knowledge, creation by skills) and physical (i.e., roads, markets, clinics, schools, bridges).
The Brundtland Commission in 1987 introduced SL in terms of resource ownership and access to basic needs and livelihood security, especially in rural areas.
The International Institute for Sustainable Development (IISD) defines sustainable livelihoods as being “concerned with people's capacities to generate and maintain their means of living, enhance their well-being, and that of future generations”
The definition used by the UK's Department of Foreign and International Development (DFID) incorporates these sentiments. 'A livelihood comprises the capabilities, assets (including both material and social resources), and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the
future, while not undermining the natural resource base' (Chambers, and Conway, 1992).

The United Nations Development Programme (UNDP) differentiates between a job and a livelihood which are often used interchangeably. "A livelihood, on the other hand, is engagement in a number of activities which, at times, neither require a formal agreement nor are limited to a particular trade. Livelihoods may or may not involve money. Jobs invariably do. Livelihoods are self-directing. Livelihoods are based on income derived from "jobs", but also on incomes derived from assets and entitlements."

"A job connotes one particular activity or trade that is performed in exchange for payment. It is also a formal agreement, as manifested by a contract, between an employer and employee. A job can, however, comprise part of an overall livelihood, but does so only to complement other aspects of a livelihood portfolio.

The World Summit for Social Development, was held in Copenhagen in March 1995, where the world's leaders committed themselves to "promoting the goal of full employment as a basic priority of our economic and social policies, and to enabling all men and women to attain secure and sustainable livelihoods through freely chosen productive employment and work" http://www.undp.org/sl/Overview/activities.htm

2.13 The sustainable rural livelihood framework

The sustainable livelihoods framework is a tool to improve understanding of livelihoods, particularly the livelihoods of the poor. It was developed over a period of several months, building on work by the Institute of development (Figure 2.1)
The sustainable rural livelihood framework identifies five livelihood assets:

- **Natural capital**: consists of lands, water and biological resources such as trees and pasture. The productivity of these resources may be degraded or improved by climate change and/or human activities.

- **Physical capital**: includes infrastructure, irrigation work, agricultural tools and also producer goods such as machinery.

- **Financial capital**: consists of stock of money or other savings in liquid form.

- **Human capital**: is constituted by the quantity and quality of labour available, at household level: there it is determined by household size, but also by the education, skills and health of household members.

- **Social capital**: included any assets such as right or claims which are derived from membership of a group. This includes the ability to call on friends or family for help in times of needs, support from trade or professional associations and political claims on chiefs or politicians to provide assistance.
2.14 Sustainability:

Sustainability has many dimensions, all of which are important to the sustainable livelihoods approach. Livelihoods are sustainable when they:

- are resilient in the face of external shocks and stresses;
- are not dependent upon external support (or if they are, this support itself should be economically and institutionally sustainable);
- maintain the long-term productivity of natural resources; and
- do not undermine the livelihoods of, or compromise the livelihood options open to others (Sustainable livelihoods guidance sheet).

Source: DFID (1999) Sustainable Livelihoods Guidance Sheet Section 2

3.1 Materials:
The research methodology in this study uses two types of data: primary and secondary data. The primary data was collected through personal interviews with individuals using structured questionnaire (appendix 1), group discussion and observations. The primary data was supplemented with secondary data from different governmental and nongovernmental sources: reports, documents, scientific papers and internet.

3.2. The data collection methods:
A questionnaire was used to collect the primary data; it was designed according to sustainable livelihood five capitals as a following:
- Natural capital: consists of lands, water and biological resources such as trees and pasture. The productivity of these resources may be degraded or improved by climate change and/or land degradation.

- Physical capital: includes climate changes or stability, rainfall rate, irrigation type, farming equipment such as the use of agricultural mechanization.

- Financial capital: consists of financial stability, income sources, credits access and indebtedness level.

- Human capital: constitutes the quantity and quality of labour available at household level and is determined by household size, skills, migration type and reasons.

- Social capital: includes organized community, women participation level, government role, local committees' role. A field survey was conducted by visits to the villages and the projects in rehabilitated areas. 100 from 3200 person were simple randomly selected from four villages affected by desertification: 25 person from each village: Wad Omer and Um Harout represented rehabilitated areas and Ageeb and Bohat Alguhawi represented non rehabilitated areas.

The Secondary data were obtained from governmental and nongovernmental records, documents and internet about drought and desertification and their impacts on sustainable rural livelihood. These data were closely examined to help in assessing the impact of climate change and land degradation on sustainable livelihood.

3.3 Analysis methods:
Descriptive statistical methods were used to analyze the data. This is process was accomplished by critically examining the data through the used of statistical package for Social Science (SPSS).
Construction of sample tables allows for capturing the answers to questions being asked in the survey. The results are presented as figures, graphs, tables of comparison and percentage.

- Independent samples t-test:
The comparison between the groups were done through mean comparison (t-test) at 1% and 5% levels of significance

3.4 The study area:
3.4.1 Location:
Wadi Al Muggadam lies between latitudes 15° 13’ - 16° North and longitudes 31° 30’ - 32° 15’ East. It is located in Khartoum State - West Omdurman localits along the western bank of White Nile and River Nile, from westwards of Kordofan state to northward of southern boundaries of Northern state (Figure 3.1).

3.4.2 Topography:
Wadi Al Muggadam is a large depression moving from south to north beginning from north Kardofan state with a total area of 200 km² of water harvesting and it represents flat plain with several sand dunes (goz) across it in north part, as Goz Ubodaloa with 500 km long, 5 -20 km broad and 15 m height (Ali, et al, 1995).

Shakesty (1986) stated that the study area is almost flat, except some small rocky hills lying in the western part on the boundaries between Khartoum state and northern part of kordofan state. Generally all area is sloping slightly to north east direction.

3.4.3 Climate:
Wadi Al Muggadam lies within semi-desert climate with summer rains and cool to warm winters. In the southern part of the Wadi, the average
rainfall ranges between 100- 225 mm, the mean maximum temperatures of the hottest months (May or June) are 41 - 42°C and minimum temperatures of the coldest (January) are 8 - 16°C.

Figure: 3.1 The study area location

Source: http://en.wikipedia.org/wiki/File:Map_Sudan_Omdurman.png
In the northern parts, the rainfall is erratic and in some years there may be no rains at all in some places. The mean annual rainfall is generally below 100 mm, and in all months the average rainfall is less than 20% of the average potential evapotranspiration. The relative humidity of the air is only 25 – 30% throughout the year.

3.4.4 Water sources:
Represented in surface run consisting of Wadi Al Muggadam and its branches, which are running from south west to north east direction, the majority of these are seasonal water courses. Wadi Al Muggadam extended about 384 km from north Kordofan state and it ends in River Nile in Ompikol village (northern state). Only 61 km are located in Khartoum state (from Jabra Saeed to Peir Alajami). This Wadi passes through some high hills, constituted of sandstone, 1 - 1.5 km it is a broad in certain parts and then become narrow (200 m) ending in Mhila and Koh Elroda area.
Also, several seasonal water courses are existing and draining into Wadi Al Muggadam constituting large deltas. Wadi Almuggadam usually floods in July and August but in recent years it rarely floods due to the declines rainfall rate.
Shallow wells are distributed along the Wadi. Each “Farige” (small village) dug one or two wells for their family utilization. Also found are some deep wells drilled by some organizations around Um Harout area for agriculture use, some are operating and the other need repairs and maintenance to work. The Special Programme for Food Security (SPFS) drilled 5 deep wells and another 5 deep wells were drilled by Khartoum state Ministry of Agriculture and Animals health and Irrigation, in different places.

3.4.5 Geology:
According to Mula (1993) the general geological feature of the study area are Nubian sandstone that consists mainly of consolidated sediments of conglomerate, sandstone and mudstone, which outcrop in low levels indicating the major processes that took place erode of these rocks. These stones are highly joined and sometimes cemented with silica and iron. Musa (1986) reported that the characteristics of the soil of the study area are outcome of interaction between parent materials. The climate variability and movement of soil, hinder vegetation presence. The study area rocks belong to Nubian sandstone series, which cover the pre-Cambrian Basement complex

3.4.6 Vegetation cover:
Wadi Al Muggadam lies within the semi-desert zone which is characterized by low precipitation, and uneven distribution of rainfall. These factors effect quality and density of vegetation cover. Also frequent droughts (particularly in 1983/1984), overgrazing and deforestation led to vegetation cover degradation.
According to soil type there are two types of vegetation cover:
- on **sandy soil**: which is characterized by low moisture storage potential, drought resistant plant species are dominated and few annual grasses appear during rainy season.

- on **clay soil**: in bed and adjacent to the Wadi a high relatively vegetation cover of different plant species is found due to the availability of surface water and fertile soil.

For that reason people concentrated their economic activities on clay bed soils where their animals' feeds depend on growing plants.

3.4.7 Population:

Wadi Al Muggadam is inhabited by three main nomadic tribes: Hassania, Geriate and Hawaweer tribes. Their original tribes were derived from Arab Island across Egypt since the nineteenth century.

According to the basic survey of 2006, they were about 13090 person representing 2295 families. They lived in randomly scattered groups (small villages). Their houses are constructed of one room build of mud and woods, in addition to shade known as rakoba made from wood and hay. There are distances large between a village and another so as to allow animal grazing in between.

Along the Wadi, Hassania tribe occupied the southern part, the Geriate tribe in the northern part and Hawaweer tribe in the west area beyond the Geriate.

Their main activities are raising camels, sheep and goats. Also they cultivate some crops and vegetables when conditions are favorable for agricultural production (good rainy season) (ADRA, 1986).

3.4.8 Family characteristics:
Like other rural families, the family in the study area is an extended family which comprises the elder households and families with sons around. There are six persons per family on average. Illiteracy rate is high among family members where: about 50% are of limited education (Khlawa and primary school) and another 50% are not educated due to social habits in addition to:

- limited perception to education importance.
- the long distance between houses and schools.
- shortage of teachers in most schools.
- preference of work for family additional income (Food security unit 2006).

For these reasons, economic activities are limited to traditional crops growing and animal grazing.

3.4.9 Economic activities:
Due to nature, the resident people, their life is not complicated and the majority of them are pastoralists and others practice a kind of traditional agriculture and grow some rainfed crops during rainy season. So two systems can be distinguished as follows:

- Animal grazing system:
Animal grazing is considered as the essential activity. People move with their animals for pastures and water from place to other. Camels' owner move for far distances to Arshkol mount in White Nile and north Kardofan, but sheep graze in neighboring areas. The goats represent family supplements of milk and meat. They graze round villages(Ali et.al, 1995).

- Animals' ownership:
Recurrent drought affected animals' ownership quantity and quality; people focus on goats and sheep raising to produce milk and sell some to meet family's requirements (food and clothes).

Table (3.1) below shows that the average animal ownership of goats and sheep is four, ownership of camels on average is two and is used for transport and ownership of donkey on average is one. While the cattle disappeared totally after droughts due to the disappearance of all conditions suitable for their raising. In general, the livestock numbers decreased along years due to dry weather condition.

Table (3.1) animal ownership

<table>
<thead>
<tr>
<th>Type</th>
<th>Average ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camel</td>
<td>2</td>
</tr>
<tr>
<td>Sheep</td>
<td>4</td>
</tr>
<tr>
<td>Goat</td>
<td>4</td>
</tr>
<tr>
<td>Donkey</td>
<td>1</td>
</tr>
</tbody>
</table>

(Food security unit, 2006)

- Traditional rainfed agricultural system:

It represents the second activity and comes after animal breeding. It is practiced in Wadi Al Muggadam bed (clay soil) and in banks of Wadies. Farmers depend on direct rainfall water. The Wadi water usually breaks down every 5 years. People grow early maturing crops such as sorghum and vegetables (okra, cucumbers and water melon). In good rainy seasons it is possible to cultivate millet on sandy soils. Productivity of the crops depend on several factors: i) mount of water running in the Wadi ii) good land preparation iii)clear land before farming iv) root up grasses during stage of growth v) pest control.
According to these factors yield varied from season another. Average yield / fadden ranges between 6 – 10 sack in good rainy season, and decreases to one or less than one sack when precipitation is low (bad rainy season) (Ali, et al, 1995).

- Land ownership:
The land ownership usually remains under the elder household name. Each of family members cultivates part of land which has been given to him. This pattern limited land area to 6 feddans for every one.

3.4.10 The Special Programme for Food Security (SPFS):
The Libyan trust fund to support the SPFS in the Sahel and Sahara Group of States had been granted by the Libyan Government. A joint FAO/Libya mission was sent to Sudan in November 2000, to prepare project documents for SPFS activities to start on three sites: Khor Abu Habil, Lower Atbera River, and West Omdurman. Sudan has received 1.9 million US dollars out of this trust fund. The support of the SPFS in Sudan was declared on 20 December 2003. A detailed and scheduled implementation work plan for each site was prepared.

However, at the time of implementation, the cost of proposed activities was very low compared with current market prices for all project components, especially the cost of water control activities and diversification supplies. Therefore, review of the cost items was performed by the end of the first year and it was agreed that the cost differences should be covered by the Government from the local component.

3.4.10.1 Local Component:
• About 175 thousand US$ to support the Libyan component in the three sites.
• The salaries, incentives and training are conducted by the State Ministry.

The State government shares in the local Component:

- Preparation irrigation networking and pumps for 5 wells, digging of a new well, fuel, and operating expenses.
- improved seeds for six sites.
- tree seedlings for 5 sites.
- provision of 20% of animals for rearing.

For purposes of the SPFS, the following facilities were present:

- Good potentials for intensification and diversification of the production system.
- Areas representing wide ecological zones and environmental and socio-economic settings.
- Areas with irrigation facilities and infrastructures but lacking efficient irrigation water management.
- Availability of suitable technologies.
- Accessibility.
- Community willingness.
- Availability of supporting institutions and human resources needed.

Based on these criteria West Omdurman area was elected for implementation of SPFS.

3.4.10.2 The objectives of SPFS:

- To improve and enhance livestock and crop production through enhancing and sustaining local technologies and practices that proved successful.
- To reduce the large year-to-year variation in livestock and crop production.
- To improve and/or introduce income-generating activities for the low-income groups.
- To identify and analyze the causes of food insecurity and the production constraints.
- To identify and quantify the issues concerning poverty levels in each site.
- To promote social equity and conserve natural resources base and assess accessibility and other poverty issues in the process of interventions, implementation and technology transfer.
- Intervention whenever possible would target the poor and be gender sensitive.
- To ensure the sustainability of any successful intervention, participation of local farmers, community, and institutions is essential.

3.4.10.3 Implementation of Activities:

*Training:*

The project has the deliberate aim of strengthening the institutional capacity of the targeted States and related institutions for working in genuine partnership with rural population, using methodologies that emphasize farmer participation. Participative farmers training, based on the Farmers’ Field School approach, was used to introduce the project technologies.

Project staff in teamwork with the qualified staff of the universities and other resource persons, who has acquired considerable experience in training extension staff in the application of the Farmers’ Field Schools (FFS), played a leading role in the design, delivery and training of the
staff, (Training of Trainer’s program), which included extensive field work with farmers. Special training programs were implemented to assist technical staff in the implementation of the FFS and in the technical subject matter.

- Farmers training:-
Two types of farmers training are distinguished:

i) Farmer seasonal planning (FSP)
This was used for farmers, identify at the start each season with assistance of the extension staff, the program for demonstration technologies to be introduced for the season in the seasonal planning relevant agricultural practices and the suitable water management techniques were identified in each area. The various requirements and inputs to be procured prior to each season were defined during the FSP including the participation of the farmers.

ii) Farmer Field School training (FFS)
Regular sessions are planned to be organized every two weeks over the duration of the project by extension staff to closely follow and monitor the implementation of various technical and agricultural technologies in line with the seasonal plan. The extension staff carefully prepares the program of each FFS session and topics introduced relate to the specific technique relevant to the growth stage

- Staff training:-
. The main objective is to prepare field staff adequately trained for the planning and implementation of the demonstration and farmer’s training program and to monitor closely progress and constraints. Training was organized at the state level. Two training sessions/ season of seven days were organized for extension staff in technical aspects and extension
methodologies. One was conducted before the beginning of the season to help the farmers in developing their seasonal work plans and the second before the start of the growing season to equip the staff to support the farmers during FFS session to implement their seasonal plans.

- Achievement constraints:
  - Limited finance for training led to incompletion of the planned activities.
  - The weakness in farmers training was due to many reasons, these were:
    - The beneficiaries were so busy in gaining income to satisfy their basic needs
    - Lack of transportation between sites.

3.4.10.4 Project Components

1- Water Control Component:

- The proposed activities:
  * Peri-urban agriculture development based on the exploitation of the Nubian aquifers. Activities in the water control and management component is focusing in developing irrigated farm plots to be selected to groups of poor farmers. Each farm is to be assigned for about 20 families. A unit of about 10 farms is proposed for establishment.
  * The depth of the ground water does not exceed 100 m, and the yield of deep wells could meet the water requirements of around 10 hectares faithful to intensive vegetable and forage crops.
  * The investment consist of drilling deep tube wells, procuring pumping units (with electrical and diesel engines), irrigation equipments and installation and structural elements building.
  * The progress of activities undertaken was:
* The work in irrigation networking and installation of pumps for the five sites was done by The State Ministry of Agriculture, Animal Resources, and Irrigation to command 175 feddans at Wadi Elmilih, Wad Omer, Gabrat Saied, Fatasha, and El Kamounab sites in West Omdorman. Three of the new sites were prepared for the winter season 2007/008 and planted by different crops.

* Rehabilitation and maintenance of irrigation networks was done in the first five sites.

2- Intensification Component:

The proposed activities were targeting 200 households or around 2000 people in 10 farms / villages. This will represent a peri-urban site within the project, for intensive production of vegetables, forage, crops, and fruit trees. Due to limited availability of water from deep tube wells for irrigation in this arid area, the size of the farm for each household will be limited to 0.8 hectare. Two seasons are considered, i.e. summer and winter.

-The progress of activities undertaken was:

- Farm cultivation operations for season 2006/007 began by 24 fd in Um Harout 1, 22fd in Um Harout 2, and 14fd in ElZiraiat, planted by okra, fodders, sorghum and other vegetables. The low production was due to many obstacles:

- Damages in the irrigation network and lack of training in maintenance.

- Transition of the community from pastoralist to farmers is a big problem facing the implementation.

- Damages caused by the animals surrounding the farms, and absence of supervision by the beneficiaries.
- Weak production in 2006/007 was due to water shortages because of the damages in the irrigation network and shortage in fuel supply.
- Shelter belt were planted with tree seedlings at 3 villages. The early cultivated trees were damaged by animals.

The situation improved in 2007/008, to reach about 210 fd, in winter season. The area cultivated by forage, okra, tomato, onion, melon and water melon.

Table (3.2) bellow shows the development of cultivated areas and crops:

Table (3.2): Cultivated area and Crops planted in season 2007/008:

<table>
<thead>
<tr>
<th>Sites</th>
<th>Cultivated area/fd</th>
<th>Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Um Haroat 1</td>
<td>30</td>
<td>forage, okra, Bioneer, onion, water melon, melon, and maize</td>
</tr>
<tr>
<td>Um Haroat 2</td>
<td>30</td>
<td>forage, okra, Bioneer, onion, water melon, melon, and maize</td>
</tr>
<tr>
<td>EL Ziraiat</td>
<td>30</td>
<td>forage, okra, Bioneer, onion, water melon, melon, and maize</td>
</tr>
<tr>
<td>Wad Abdu</td>
<td>30</td>
<td>forage, okra, Bioneer, onion, water melon, melon, and maize</td>
</tr>
<tr>
<td>Wad Omer</td>
<td>30</td>
<td>forage, okra, Bioneer, onion, water melon, melon, and maize</td>
</tr>
<tr>
<td>Funga</td>
<td>30</td>
<td>forage, okra, Bioneer, onion, water melon, melon, and maize</td>
</tr>
<tr>
<td>Wdi ELMelih</td>
<td>30</td>
<td>forage, okra, Bioneer, onion, water melon, melon, and maize</td>
</tr>
<tr>
<td>Total</td>
<td>210</td>
<td></td>
</tr>
</tbody>
</table>

(Food security unit, 2008)

Table (3.3) bellow shows the progress in cultivated areas:

Table (3.3) Development of cultivated areas:

<table>
<thead>
<tr>
<th>Cultivated areas</th>
<th>% increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005/006</td>
<td>35</td>
</tr>
<tr>
<td>2006/007</td>
<td>60</td>
</tr>
<tr>
<td>2007/008</td>
<td>270</td>
</tr>
</tbody>
</table>

% Increase in cultivated area (Food security unit, 2008)
3- Diversification Component:

- Activities:

  - The proposed activities; the beneficiaries gave priorities to activities that focused on: i) restocking and fattening of small ruminants; ii) improvement of backyard poultry production; efforts were made to gear the activities to the most disadvantaged sections of the community.

  - The project assisted in the access of inputs, treatments for veterinary cares, through credit on basis of a rotating fund system.

  - Small ruminants' batch was distributed to the women to involve them in the production cycle.

Activities of backyard poultry production and honey production were not implemented for financial limitation.

*Sheep Restocking:

  - The number of sheep births is reasonable compared with the time factor.

  - The number decreased by 0.7 %, due to drought and shortage of fodder.

Table (3.4): Sheep Restocking:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Sites</th>
<th>Received number</th>
<th>Existing Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Births</td>
<td>Mortality</td>
</tr>
<tr>
<td>Restocking</td>
<td>Um Haroat 1</td>
<td>58</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Um haroat 2</td>
<td>58</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Wad Abdu</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Funga</td>
<td>65</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>ELZiraiaat</td>
<td>65</td>
<td>0</td>
</tr>
</tbody>
</table>
*Goats Restocking:

- The mortality occurred due to the drought cycle that existed for a long period.
- Increase in number by 1.6 % from the received number

Table (3.5): Goats Restocking:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Sites</th>
<th>Received</th>
<th>Existing Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Births</td>
</tr>
<tr>
<td>Restocking</td>
<td>Um Haroat 1</td>
<td>58</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Um Haroat 2</td>
<td>58</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Wad Abdu</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Funga</td>
<td>65</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>ELZiraiat</td>
<td>65</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Wadi ELMilih</td>
<td>55</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Gebrat Saeed</td>
<td>36</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Wad Omer</td>
<td>50</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Fatacha</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>ELKamonab</td>
<td>50</td>
<td>19</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>487</td>
<td>113</td>
</tr>
</tbody>
</table>

*(Food security unit, 2008)*
4- Constraints Analysis Component:

- Objectives:
The constraints analysis consists of several agro-economic studies aimed at identifying constraints experienced in the course of implementation of Phase I. Constraints analysis was carried out at each site, in order to identify the constraints to farm level productivity and access to technology, land, inputs, marketing, processing and credit facilities. This will provide an adequate feedback on progress and results achieved, identify problems encountered and propose means of overcoming such problems. The constraints analysis is not an activity in itself, but is an essential part of the components of water control and management, intensification of plant production systems, and diversification of production. It is a continuous activity carried out before, during and after implementation of the activities of the three previous components. The constraints analysis component emphasizes participatory approach in identifying the constraints and the appropriate means of intervention to overcome them.

- Activities:
Hiring of a national consultant was done, two months during 2004 and five month in 2005 when actually employed for base to implement the activities of the components of water control and management, intensification of plant production systems, and diversification of production. The consultant was hired for the following reasons: (i) hiring of consultants for a long period is against SPFS philosophy, as the Program is implemented within and by the relevant government institutions for sustainability purposes; and (ii) the Government assign a monitoring and evaluation staff who is responsible with farmers and
farmer organizations to carry out the constraints analysis on a continuous bases. Hence, there was only five months for the national consultant in 2006 to help in implementing structure together with participating farmers and farmer organizations and carryout the constraints analysis, as related to monitoring and evaluation.

3.4.10.5 Summary of Results:
- Increased returns from crop production in the program sites compared to the traditional system.
- Recommended research to increase yields vertically in the program sites to help increase income of farmers despite the clear improvement in returns. However, this has not reached its end-sufficient.
- The communities in the site are distinguished and their experience in agricultural practices is very weak. They need intensive training and great efforts to practice agriculture. SPFS follows the training program within farmers' field schools according to the plan to strengthen benefits and transfers technology according to the technical packages of the program, but still they are in need of training.
- Through meeting with farmers to identify all problems, they highlighted the following constraints:
  - Some of the beneficiaries do not exist in the site during the season because most of them are working in Omdurman city in marginal works, and this should weaken the community monitoring.
  - High needs of training in agricultural extension and permanent monitoring from the State Ministry of Agriculture in particular, (the extension department).
3.4.10.6 The impact of the program:
- Enabled the application of agricultural technologies in program sites.
- Increased production and productivity in the areas of the program.
- Increased income due to the remarkable increase in production compared to traditional system.
- Created income-generating activities which contributed to increasing the income of beneficiaries.
- Contribution of the program to achieve food security and improve nutrition by the indicators mentioned earlier.
- According to the program philosophy, the beneficiaries have benefited from the target of animal products to improve nutrition.

3.4.10.7 Constraints to the implementation of the program:
- The Problem of desertification and drought and erosion of soil threaten the future of agriculture in the sites. This needs to be solved.
- The continuous attack from the animal to the plants and lack of fences, lead to clashes between shepherd and farmers.
- Land ownership (hiaza) problem existed in some villages, especially in Gabrat Saeed village. One of the beneficiaries, pretended to own all the land after land preparation, which is against the objectives of the program.
- There is a delay in salaries from The State ministry for the staff working in the field.
- Failure to implement training program in veterinary care.
- The irrigation networks in some sites were damaged and need maintenance.
- Lack of awareness of agriculture caused delay of implementation

3.4.10.8 Gender mainstreaming:
One of the main objectives of the program is sensitivity toward gender equity and mainstreaming. In case of organizing the beneficiaries, establishment of associations and organizations including men and women, the following activities were implemented:

Table (3.6) bellow explains the mainstreaming of gender in different activities in year 2005/2006.

Remarks:
- sheep restocking; this activity targeted the women to improve their income and nutrition.
- sheep fattening; this activity was not implemented according to beneficiaries willing.

<table>
<thead>
<tr>
<th>Activities</th>
<th>% of women</th>
<th>% of men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crops Intensification</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>Sheep Restocking</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Goats Restocking</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Sheep Fattening</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other Activities</td>
<td>30</td>
<td>70</td>
</tr>
</tbody>
</table>

*(Food security unit, 2008)*

3.4.10.9 Why is the expansion of SPFS?

- Limited area under cultivation in the pilot phase.
- The training budget was not enough for the training plans.
- Some activities were not yet implemented.
• Expansion is necessary to involve more population and leads to settlement.
• Expansion should enhance the income activities to be improved.
• Livelihood improved by diversifying income and improves food security.
• The results gained by the beneficiaries are achievement of food security and poverty reduces. This can enhance the process of expansion for more benefits, because the beneficiaries involved in the program at this stage represented a small fraction of the population.
• Vertical productivity through technical packages is a good reason for expansion to replicate the practice in other areas within the sites and to intervene in other states. (Food security unit, 2008)
4.1 The general characteristics of population in Wadi Almuggadam area:
The characteristics of respondents are very important elements. In the analysis, they reflect the main socio-economic features of people living in study area. These characteristics comprise age, gender, marital status.

4.1.1 Distribution of respondents by age:
Table (4.1) shows the characteristics of respondents by age in four villages. It was found that the majority of respondents (80%) are of age ranging between 20 – 60 years. Among the four villages, Wad Omer and Um Harout (rehabilitated villages) have 84 - 92%, and Ageeb and Bohat Alguhawi (non-rehabilitated villages) have 68 - 76% of people lying within this age group.
Also, it was found that 15% of respondents in all villages were of age above 60 years, most of them were in Ageeb and Bohat Alguhawi (non-rehabilitated villages)
It may be concluded that people in rehabilitated villages were younger than people in non-rehabilitated villages. This may relate to available job opportunities and improvement of livelihoods status of people living in rehabilitated areas.

Table (4.1) Distribution of respondents by age

<table>
<thead>
<tr>
<th>Age range (years)</th>
<th>Wad Omer %</th>
<th>Um Harout %</th>
<th>Ageeb %</th>
<th>Bohat Alguawi %</th>
<th>All villages %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>21 – 40</td>
<td>4</td>
<td>36</td>
<td>32</td>
<td>40</td>
<td>37</td>
</tr>
<tr>
<td>41 - 60</td>
<td>44</td>
<td>56</td>
<td>44</td>
<td>28</td>
<td>43</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>16</td>
<td>4</td>
<td>24</td>
<td>16</td>
<td>15</td>
</tr>
</tbody>
</table>

*Source: field survey (2009).*

4.1.2 Distribution of respondents by gender and marital status:
Table (4.2) gives characteristics of respondent by gender in four villages. The gender is an important characteristic of population existing in the study area. It was found that in all villages about 47% were males and 53% were females.

Wad Omer and Um Harout (rehabilitated villages), have higher number of males 50 - 76%, while Ageeb and Bohat Alghuawi (non-rehabilitated villages) have higher number of females 60 - 80% of respondents. That have been due to the males migration from non-rehabilitated villages to other places (towns) searching for other job opportunities.
As table (4.3) shows, 94% of respondents were married in all villages and only 6% were single.

Table (4.2) Distribution of respondents by gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Wad Omer</th>
<th>Um Harout</th>
<th>Ageeb</th>
<th>Bohat Alguhawi</th>
<th>All villages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>76</td>
<td>52</td>
<td>40</td>
<td>20</td>
<td>47</td>
</tr>
<tr>
<td>Female</td>
<td>24</td>
<td>48</td>
<td>60</td>
<td>80</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: field survey (2009)

Table (4.3) Distribution of respondents by marital status

<table>
<thead>
<tr>
<th>Marital</th>
<th>Wad Omer</th>
<th>Um Harout</th>
<th>Ageeb</th>
<th>Bohat Alguhawi</th>
<th>All villages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married</td>
<td>100</td>
<td>92</td>
<td>96</td>
<td>88</td>
<td>94</td>
</tr>
<tr>
<td>Single</td>
<td>-</td>
<td>8</td>
<td>4</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: field survey (2009)

4.2 Situation of human capital indicators:
4.2.1 Education level:
Table (4.4) presents education levels for respondents in all villages. The illiteracy rate was 56% of respondents in all villages, while higher (75%) in Ageeb and Bohat Alguhawi (non-rehabilitated villages), Wad Omer and Um Harout (rehabilitated villages) have higher (44%) in Khalowa and primary level. Only 4% in high secondary level in Um Harout and Bohat Alguhawi villages
The illiteracy rate was higher in the non-rehabilitated villages compared to the rehabilitated villages. This may have been due to establishment of schools in rehabilitated villages in addition to the extension services about
the importance of education available in the rehabilitated villages. For example a new primary school was established in Wad Omer village in 2009 with two class rooms, staff office and students house. 80 students were enrolled in this school this year (2010).

### Table (4.4) Distribution of respondents by education level

<table>
<thead>
<tr>
<th>Education level</th>
<th>Wad Omer %</th>
<th>Um Harout %</th>
<th>Ageeb %</th>
<th>Bohat Alguhawi %</th>
<th>All villages %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illiterate</td>
<td>24</td>
<td>52</td>
<td>76</td>
<td>72</td>
<td>56</td>
</tr>
<tr>
<td>Khalwa</td>
<td>28</td>
<td>12</td>
<td>8</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Primary school</td>
<td>48</td>
<td>32</td>
<td>16</td>
<td>20</td>
<td>29</td>
</tr>
<tr>
<td>High secondary school</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

*Source: field survey (2009)*

#### 4.2.2 Family size:

Table (4.5) gives percentage of family size of respondents in the four villages. Family size is an important indictor which will help in knowing the population density and consequently their requirements and needs. From the table, it appears that most of family size is greater than 7 persons (44 - 52% of respondents in rehabilitated areas, and 20 - 48% in non-rehabilitated areas). This large family size is encouraged by need for labour support to increase family income. Other family size ranged between 3 – 7 persons (over between 28 - 48% in rehabilitated villages and 32- 60% in non-rehabilitated villages). This
is becoming the normal size in urban and rural areas in recent years. Small family size could be due to change in cost of living and improved education. Families with member less than 3 persons were found in about 20% of all villages except in Um Harout village where it represented 8%.

Table (4.5): Distribution of family size

<table>
<thead>
<tr>
<th>Family size</th>
<th>Respondents</th>
<th>Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rehabilitated area</td>
<td>non rehabilitated area</td>
</tr>
<tr>
<td>Wad Omer</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Um Harout</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Ageeb</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Bohat AlguhawI</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>&lt; 3</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>3 – 7</td>
<td>28</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>60</td>
</tr>
<tr>
<td>&gt; 7</td>
<td>52</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>20</td>
</tr>
</tbody>
</table>

Source: field survey (2009)

4.2.3 Labor:
It is an important factor to assist households does their work (farming and animals raising).
Most respondents (over 96% in all villages) mentioned that they depend on family members as labor, while few of respondents (4%) in Ageeb village said that they depend upon hired labor. That may have resulted from the relatively large herd sizes or large farm sizes in Ageeb village when there was a good rainy season.

4.2.4 Human skills:
The study results showed that more than 72% of respondents in rehabilitated areas said that their skills to perform their jobs (agricultural activities) are good, while over 64% of respondents in non rehabilitated areas believed that their skills are poor. That may be a consequence of offering of some training courses for farmers in rehabilitated areas.

4.2.5 Migration types and reasons:
Migration types include high and limited migration. Table (4.6) shows that 22 - 36% of the respondents in the rehabilitated villages and 28 – 64% in non rehabilitated villages ensures that migration is high. While 64 – 78% of respondents in rehabilitated areas and 36 – 72 in non – rehabilitated areas believed that migration is limited, particularly after each agricultural season, as they refer to improve situation of livelihoods locally at rehabilitated villages.

Table (4.7) presents the reasons forced people to migrate. Over 80% of respondents in four village believed that the financial reasons are behind people migration to other places (cites). Otherwise climate changes are the main cause.

Table (4.6): Migration types and percentage of immigrants

<table>
<thead>
<tr>
<th>Migration types</th>
<th>Respondents rehabilitated area</th>
<th>Respondents non rehabilitated area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wad Omer %</td>
<td>Um Harout %</td>
</tr>
<tr>
<td>High</td>
<td>36</td>
<td>12</td>
</tr>
<tr>
<td>Limited</td>
<td>64</td>
<td>78</td>
</tr>
</tbody>
</table>

*Source: field survey (2009)*

Table (4.7): Migration reasons indicated by respondents
4.3 Situation of physical capital indictors:

4.3.1 Climate status:

The climate of the study area is classified as semi arid. Average annual rainfall ranges between 100 mm and 225 mm. Rainfall as controlled by the atmospheric pressure condition over and in the vicinity of African continent. The period from July to September could be designated as the general rainy season of the study area. These months receive more than 75% of the mean annual rainfall, a reflection of the very marked seasonability of rainfall. Moreover, rainfall is fluctuating from one season to another with a frequent cycle of drought, as indicated by respondents. In Sudan, the problem of drought is not a new one: the people remember at least five drought disasters that have occurred in last century (Moore, 1973).

Table (4.8) Respondents perception about climate changes

<table>
<thead>
<tr>
<th>Climate status</th>
<th>Respondents rehabilitated area</th>
<th>Respondents non rehabilitated area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wad Omer</td>
<td>%</td>
<td>Ageeb %</td>
</tr>
<tr>
<td>Um Harout</td>
<td>%</td>
<td>Bohat Alguhawi %</td>
</tr>
<tr>
<td>Financial</td>
<td>96</td>
<td>92</td>
</tr>
<tr>
<td>Climate change</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: field survey (2009)
<table>
<thead>
<tr>
<th></th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change</td>
<td>96.2</td>
<td>92.3</td>
<td>96.2</td>
<td>100</td>
</tr>
<tr>
<td>Stable</td>
<td>3.9</td>
<td>7.7</td>
<td>3.8</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: field survey (2009)

4.3.2 Irrigation system and agricultural tools:
All respondents in non rehabilitated areas (100%) mentioned that they depend on rainfall or water flowing in wadis to irrigate their farms, while all respondents in rehabilitated areas said that they used diesel pumps for irrigating the farms.

Agricultural equipments: All respondents in rehabilitated areas indicated that they use some modern tools as irrigation spray or diesel pumps. They also use machines for land preparation particularly in Um Harout village. While people in non rehabilitated areas (100%) said that they use manual tools when there is a good rainy season.

From these results, it may be concluded that the existing water management over the year beside use of modern tools as irrigation spray in Um Harout village.

4.4 Situation of natural capital indictors:
4.4.1 Size of agricultural lands:
According to the survey in all villages, there was a difference between size of farms between rehabilitated and non rehabilitated villages. Table (4.9) shows that all farms size in rehabilitated areas fall within range from 1 to 2 fd due to SPFS which determined size farm by 1.9 fed for each household for cultivating some vegetables, forage, crops and fruit trees. While in non rehabilitated areas, 80% of respondents in Bohat Alguhawi
village said that they did not have any agricultural lands. In Ageeb village 72% of respondents stated that their agricultural land ranged between 1 to 2 fd. A few respondents (12%) in Ageeb and Bohat Alguhawi villages said that their farm exceeded 4 fd.

<table>
<thead>
<tr>
<th>Farm size / fed</th>
<th>rehabilitated area</th>
<th>non rehabilitated area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wad Omer %</td>
<td>Um Harout %</td>
</tr>
<tr>
<td>1 – 2</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>3 – 4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>&lt; 4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>no lands</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: field survey (2009)

4.4.2 Soil type:
Soil in all villages is of sandy clay type which is assumed to be good soil for cultivation. However, in recent years accelerated sand encroachment became dangerous and threatens the soil fertilely in all villages.

4.4.3 Right access to agricultural lands and land ownership:
In general, the right access to agricultural lands in the study area is obtained by inheritance. Each individual is given part of the area to cultivate. While in rehabilitated villages the agricultural land is determined and distributed by SPFS. Table (4.10) shows that most of respondents (88- 92%) in rehabilitated villages, and (48-88%) in non-
rehabilitated villages see that the access to agricultural land is easy, while 52% of respondents in Bohat Alguhawi village see that the access to agricultural land is difficult.

All respondents in non–rehabilitated areas ensures that, the land is owned for them, while in rehabilitated areas all respondents mentioned that the land is owned by agricultural committees.

Table (4.10) Respondents' opinions regarding the access to agricultural lands

<table>
<thead>
<tr>
<th>Access land</th>
<th>rehabilitated area</th>
<th>non rehabilitated area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wad Omer %</td>
<td>Um Harout %</td>
</tr>
<tr>
<td>Easy</td>
<td>88</td>
<td>92</td>
</tr>
<tr>
<td>Difficult</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Ageeb %</td>
<td>Bohat Alguhawi %</td>
</tr>
<tr>
<td>Easy</td>
<td>88</td>
<td>48</td>
</tr>
<tr>
<td>Difficult</td>
<td>12</td>
<td>52</td>
</tr>
</tbody>
</table>

*Source: field survey (2009)*

4.4.4 Forestry trees and their products:

As indicated by almost all respondents in both sectors (rehabilitated and non-rehabilitated villages) the forestry trees exist with low density in the study area, and farmers obtain the permission to collect forest products from forest administration. This indicates that there is some awareness of protection and conservation of the environment among people.

4.4.5 Crop areas (season 2008):

According to table (4.11), the total crops area (season 2008) in non rehabilitated areas (Ageeb village) was 44.3 fd, while there was no cultivated area in Bohat alguhawi village due to shortage of rainfall. In
rehabilitated areas (Wad Omer and Um Harout villages), crop area were 49.5 fedden which was more than non-rehabilitated area (Ageeb village) by 5.2 fedden. People were interested in producing sorghum and okra because they represent the staple food and they cultivate fodder to feed animals. During interview with some respondents, they indicated that sorghum is almost harvested as a fodder before it reaches maturity stage due to irrigation water shortages in non-rehabilitated areas.

Table (4.11) Total crop areas in feddans

<table>
<thead>
<tr>
<th>Crops area / fedden</th>
<th>Rehabilitated area</th>
<th>Non-rehabilitated area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wad Omer</td>
<td>Um Harout</td>
</tr>
<tr>
<td>Sorghum</td>
<td>2.8</td>
<td>0.3</td>
</tr>
<tr>
<td>Water melon</td>
<td>1.0</td>
<td>2.8</td>
</tr>
<tr>
<td>Fodder</td>
<td>8.9</td>
<td>10.8</td>
</tr>
<tr>
<td>Cucumber</td>
<td>1.9</td>
<td>4.1</td>
</tr>
<tr>
<td>Okra</td>
<td>9.4</td>
<td>7.5</td>
</tr>
<tr>
<td>Total area</td>
<td>24.0</td>
<td>25.5</td>
</tr>
</tbody>
</table>

Source: field survey (2009)

4.4.6 Corps yield, sales and consumption:
- Crops productivity:

Tables (4.12 and 4.13) shows that sorghum productivity was not significance difference between rehabilitated and non-rehabilitated areas. Perhaps this indicates that the respondents have no interest in planting of sorghum. Table (4.11) shows the area size that had been planted with sorghum ranged between 0.3 – 2.8 fedden in rehabilitated villages compared to 16 fedden in non-rehabilitated villages.
Productivity of fodder, water melon, okra and cucumbers in rehabilitated areas was significantly higher than in non-rehabilitated areas. This indicates that the rehabilitated program has significantly increased crops productivity. In general, the crops productivity in the study area was lower than other sites. As example productivity of sorghum in North Kordofan ranged between 6 – 8 sack and 12 sack in Lower Atbara (Food security Unit. 2008). This is agrees with (Koohafkan, 1996) who stated desertification reduces agricultural yields, making them more unpredictable. It thus affects the food security of the people living in the affected areas (Koohafkan, 1996).

Table (4.12): Comparisons of crops productivity (sack/fd) in Wad Omer and Ageeb villages

<table>
<thead>
<tr>
<th>Crops</th>
<th>Mean yield</th>
<th>Mean difference</th>
<th>t-test value</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rehabilitated</td>
<td>Non-rehabilitated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td>0.4</td>
<td>0.5</td>
<td>-0.15</td>
<td>-0.58</td>
</tr>
<tr>
<td>Fodder</td>
<td>27.2</td>
<td>0.7</td>
<td>26.6</td>
<td>2.77</td>
</tr>
<tr>
<td>Water melon</td>
<td>3.1</td>
<td>3.0</td>
<td>0.1</td>
<td>0.06</td>
</tr>
<tr>
<td>Okra</td>
<td>4.9</td>
<td>0.5</td>
<td>4.4</td>
<td>3.73</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>5.0</td>
<td>1.6</td>
<td>3.3</td>
<td>2.78</td>
</tr>
</tbody>
</table>

*Source: field survey (2009)*

Table (4.13): Comparisons of crops productivity (sack/fd) in Um Harout and Ageeb villages

<table>
<thead>
<tr>
<th>Crops</th>
<th>Mean yield</th>
<th>Mean difference</th>
<th>t-test value</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rehabilitated</td>
<td>Non-rehabilitated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td>0.3</td>
<td>0.5</td>
<td>-0.19</td>
<td>-0.55</td>
</tr>
<tr>
<td>Fodder</td>
<td>53.9</td>
<td>0.7</td>
<td>53.17</td>
<td>7.17</td>
</tr>
<tr>
<td>Water melon</td>
<td>14.7</td>
<td>3.0</td>
<td>11.72</td>
<td>2.26</td>
</tr>
<tr>
<td>Okra</td>
<td>7.2</td>
<td>0.5</td>
<td>6.76</td>
<td>4.04</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>7.3</td>
<td>1.6</td>
<td>5.63</td>
<td>3.47</td>
</tr>
</tbody>
</table>

*Source: field survey (2009)*

62
- Percentage of crops sales and consumption:

Tables (4.14) and (4.15) show that crops sales percentage in rehabilitated areas is higher than non rehabilitated areas. In general, consumption percentage is lower in rehabilitated areas compared with non rehabilitated area. This indicates the improved situation of livelihoods in rehabilitated areas.

Table (4.14): The crops sales percentage

<table>
<thead>
<tr>
<th>Crops</th>
<th>Rehabilitated areas</th>
<th>Non rehabilitated areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wad Omer %</td>
<td>Um Harout %</td>
</tr>
<tr>
<td>Sorghum</td>
<td>36.4</td>
<td>0</td>
</tr>
<tr>
<td>Fodder</td>
<td>38.6</td>
<td>21.2</td>
</tr>
<tr>
<td>Water melon</td>
<td>66.7</td>
<td>90.5</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>94.4</td>
<td>93.1</td>
</tr>
<tr>
<td>Okra</td>
<td>26.2</td>
<td>39</td>
</tr>
</tbody>
</table>

*Source: field survey (2009)*

Table (4.15): The crops consumption percentage

<table>
<thead>
<tr>
<th>Crops</th>
<th>Rehabilitated areas</th>
<th>Non rehabilitated areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wad Omer %</td>
<td>Um Harout %</td>
</tr>
<tr>
<td>Sorghum</td>
<td>63.6</td>
<td>100</td>
</tr>
<tr>
<td>Fodder</td>
<td>61.3</td>
<td>78.8</td>
</tr>
<tr>
<td>Water melon</td>
<td>33.3</td>
<td>9.5</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>5.6</td>
<td>6.9</td>
</tr>
<tr>
<td>Okra</td>
<td>73.8</td>
<td>61</td>
</tr>
</tbody>
</table>
4.4.7 Animals ownership:

The animals existing in the study area include camels, goats, sheep and donkeys. Table (4.16) shows that the camels mean ownership was about 1 – 1.3 camels in rehabilitated villages and 0.2 – 0.6 in non rehabilitated villages. Usually People use camels to move from place to another for grazing.

The goats mean ownership was 4.7 – 5.8 in rehabilitated villages and 3.2 – 6.9 in non- rehabilitated villages. The sheep mean ownership was 4.5 – 4.8 in rehabilitated villages, and 2.2 – 5.4 in non- rehabilitated villages. Usually People depend on goats and sheep for their subsistence and requirements of milk products and some manual works as make wearing rigs from goat's wool.

The donkeys mean ownership was 0.6 – 1.0 in rehabilitated villages and 1.0 – 1.2 in non – rehabilitated village. Donkeys are used for load of water for families and their animals. Frequent drought resulted in the decrease of numbers of all animals in the study area.

Tables (4.17 and 4.18) show that there was no significant difference in animals’ ownership between rehabilitated and non- rehabilitated areas

Table (4.16) Animals mean ownership

<table>
<thead>
<tr>
<th>Animals</th>
<th>rehabilitated areas</th>
<th>Non rehabilitated areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wad Omer</td>
<td>Um Harout</td>
</tr>
<tr>
<td>Camels</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Goats</td>
<td>5.8</td>
<td>4.7</td>
</tr>
<tr>
<td>Sheep</td>
<td>4.8</td>
<td>4.5</td>
</tr>
<tr>
<td>Donkeys</td>
<td>0.6</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Table (4.17): Comparison of animal mean ownership – Wad Omer and Ageeb villages

<table>
<thead>
<tr>
<th>Animals</th>
<th>Mean ownership</th>
<th>Mean difference</th>
<th>t-test value</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rehabilitated</td>
<td>Non-rehabilitated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Camels</td>
<td>1.3</td>
<td>0.2</td>
<td>1.08</td>
<td>4.234</td>
</tr>
<tr>
<td>Goats</td>
<td>5.8</td>
<td>6.9</td>
<td>-1.00</td>
<td>-.470</td>
</tr>
<tr>
<td>Sheep</td>
<td>4.8</td>
<td>5.4</td>
<td>-0.72</td>
<td>-.284</td>
</tr>
<tr>
<td>Donkeys</td>
<td>0.6</td>
<td>1.0</td>
<td>0.44</td>
<td>-1.713</td>
</tr>
</tbody>
</table>

Source: field survey (2009)

Table (4.18): Comparison of animal mean ownership – Um Harout and Bohat Alguhawi villages

<table>
<thead>
<tr>
<th>Crops</th>
<th>Mean ownership</th>
<th>Mean difference</th>
<th>t-test value</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rehabilitated</td>
<td>Non-rehabilitated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Camels</td>
<td>1.0</td>
<td>0.6</td>
<td>.44</td>
<td>1.135</td>
</tr>
<tr>
<td>Goats</td>
<td>4.7</td>
<td>3.2</td>
<td>1.48</td>
<td>1.923</td>
</tr>
<tr>
<td>Sheep</td>
<td>4.5</td>
<td>2.2</td>
<td>2.49</td>
<td>.757</td>
</tr>
<tr>
<td>Donkeys</td>
<td>1.0</td>
<td>1.2</td>
<td>-.16</td>
<td>-.560</td>
</tr>
</tbody>
</table>

Source: field survey (2009)

4.4.8 Herd status:
Herd status depends on availability of pastures for grazing. Table (4.19) shows the opinion of the respondents with regard to herd status. 64 - 76% of respondents in the rehabilitated areas see the status is moderate as they were able to cultivate forage for animal feeds. However, 58.3 – 72.7% of respondents in non rehabilitated areas find difficulties in feeding their animals

Table (4.19): Respondents opinion about herd status

<table>
<thead>
<tr>
<th>Herd status</th>
<th>Respondents</th>
<th>Respondents</th>
</tr>
</thead>
</table>

Source: field survey (2009)
<table>
<thead>
<tr>
<th></th>
<th>rehabilitated area</th>
<th>non rehabilitated area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wad Omer</td>
<td>Um Harout</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Good</td>
<td>32</td>
<td>8</td>
</tr>
<tr>
<td>Medium</td>
<td>64</td>
<td>76</td>
</tr>
<tr>
<td>Bad</td>
<td>4</td>
<td>16</td>
</tr>
</tbody>
</table>

Source: field survey (2009)

4.4.9 Grazing place:
The respondents in all the villages mentioned that their animals graze around the villages, possibly due to the small size of the herd and there was some annual grasses growing in the wadi. Also animals depend on fodder cultivated in the project and the remains of plants in rehabilitated areas.

4.4.10 Sand creeping:
All respondents said that sand creeping was occurring with high rates in all villages.
It was noticed that sand encroachment is considered a major factor that threatens agricultural activities in the study area. This agrees with Dixey and Aubert (1962) who estimated the advance of sand dunes encroachment in some agricultural lands in Sudan to be at rate of 1 to 3 meters per year.

4.5 Situation of financial capital indictors:
4.5.1 Income sources:
Before the changes that have occurred recently in the rain amounts and degradation in natural pastures: livestock and rain-fed agriculture were considered the main sources of income for local communities.

At present, the local communities adopted a strategy to comply with the changes in rain amounts that have occurred in periods of drought. Shortage of water and fodder led people to search for alternative sources of income such as manual work in neighboring cities. Most respondents (more than 96% in all villages) said that there was no economic stability.

Figs (4.1) and (4.2) give percentages of income sources in rehabilitated and non rehabilitated areas which comprise: livestock and agricultural activities, manual works, trade, family assistances, and monthly wages. The manual works and agricultural and livestock activities was considered the main income sources in rehabilitated areas, while the manual works was considered the main source of the income in non- rehabilitated areas (68.9 – 88.2%).

Omda Alfadol, leader Um Harout village, during interview with him, mentioned that the size of farm (1.9 feddan) is a limited area and is not sufficient for their necessary requirements that led people to search for other income sources.

From these results it may be concluded that agricultural activities have improved in the rehabilitated areas, particularly in Um Harout village and it became the main income source for households.
income sources
Wad Omer village

- manual work: 39.5%
- trade: 11.0%
- family assistance: 3.4%
- agricultural production: 12.3%
- livestock: 33.7%

income sources
Um Harout village

- manual work: 29.0%
- trade: 4.4%
- monthly wage: 5.5%
- family assistance: 6.1%
- livestock: 15.0%
- agricultural production: 40.0%
Fig (4.1): income sources in rehabilitated villages

Source: field survey (2009)
Fig (4.2) income sources in non rehabilitated villages

*Source: field survey (2009)*
- Comparison between livestock and agricultural income:

- Tables (4.20) and (4.21) show that livestock and agricultural mean income in rehabilitated areas was significantly higher than these in non-rehabilitated areas at 99% level of significance. This indicates that SPFS has significantly increased the livestock and agricultural income.

Table (4.20): Comparison of livestock and agricultural income in Wad Omer and Ageeb villages

<table>
<thead>
<tr>
<th>Sources income</th>
<th>Mean income</th>
<th>Mean difference</th>
<th>t-test value</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rehabilitated</td>
<td>Non-rehabilitated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livestock</td>
<td>1176.400</td>
<td>354.400</td>
<td>822.0</td>
<td>2.807</td>
</tr>
<tr>
<td>Agriculture</td>
<td>428.200</td>
<td>293.600</td>
<td>134.6</td>
<td>1.024</td>
</tr>
</tbody>
</table>

*Source: field survey (2009)*

Table (4.21): Comparison of livestock and agricultural income in Um Harout and Bohat Alguhawi villages

<table>
<thead>
<tr>
<th>Sources income</th>
<th>Mean income</th>
<th>Mean difference</th>
<th>t-test value</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rehabilitated</td>
<td>Non-rehabilitated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livestock</td>
<td>546.000</td>
<td>362.400</td>
<td>183.600</td>
<td>.533</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1457.680</td>
<td>354.200</td>
<td>1103.480</td>
<td>2.661</td>
</tr>
</tbody>
</table>

*Source: field survey (2009)*

4.5.2 Expenses:

Figures (4.3 and 4.4) show expenses for households in the four villages which include cost of: food, agricultural activities, animals feed, health, transport, clothes and shoes, social occasions and education. The spending was focused on food in all villages and was about SDG 43980 - 54380 in the rehabilitated villages and SDG 33373.0 – 59740.0 in non rehabilitated villages. Animals feed expenses come in
second after food about SDG 12430.0 – 5428.0 in the rehabilitated areas and SDG 14220.0 – 19998.0 in non rehabilitated areas. While the cost of agricultural activities ranged between SDG 5703.0 – 7512.0 SDG in rehabilitated areas and SDG 900.0 in non rehabilitated areas. This is a result of non-agricultural activities in these areas. It was observed that spending was fewer in services of education and health. This indicates unavailability of health care in the area. It may also indicate unawareness of education importance, especially in non-rehabilitated villages where there were no schools or teachers.
Household expenses in Wad Omer village

- clothes and shoes: 5153.00
- social occasions: 7040.00
- transports: 4390.00
- education: 3048.00
- food: 43980.00
- agriculture: 5703.00
- animals: 12430.00
- health: 4090.00

Household expenses in Um Harout village

- clothes and shoes: 4225.00
- social occasions: 5415.00
- transports: 5760.00
- education: 4160.00
- food: 54380.00
- agriculture: 7512.00
- animals: 5438.00
- health: 4960.00

Fig (4.3): Household expenses percentage in rehabilitated villages

Source: field survey (2009)
### Households expenditure in Ageeb village

<table>
<thead>
<tr>
<th>Category</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>clothes and shoes</td>
<td>2000.00</td>
</tr>
<tr>
<td>social occasions</td>
<td>1940.00</td>
</tr>
<tr>
<td>transport</td>
<td>3624.00</td>
</tr>
<tr>
<td>education</td>
<td>581.00</td>
</tr>
<tr>
<td>agriculture</td>
<td>900.00</td>
</tr>
<tr>
<td>animals</td>
<td>19998.00</td>
</tr>
<tr>
<td>health</td>
<td>1780.00</td>
</tr>
<tr>
<td>food</td>
<td>33730.00</td>
</tr>
</tbody>
</table>

### Households expenditure in Bohat Alguhawi village

<table>
<thead>
<tr>
<th>Category</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>clothes and shoes</td>
<td>3427.00</td>
</tr>
<tr>
<td>social occasions</td>
<td>2875.00</td>
</tr>
<tr>
<td>transport</td>
<td>3300.00</td>
</tr>
<tr>
<td>education</td>
<td>2062.00</td>
</tr>
<tr>
<td>animals</td>
<td>14220.00</td>
</tr>
<tr>
<td>health</td>
<td>3870.00</td>
</tr>
<tr>
<td>food</td>
<td>59740.00</td>
</tr>
</tbody>
</table>

---

Fig (4.4): Household expenses percentage in non rehabilitated villages

*Source: field survey (2009)*
4.5.3 Debts level:

Table (4.22) shows that the mean income and the mean expenses were higher in rehabilitated villages than non-rehabilitated villages, while mean expenses was higher than mean income in all villages except in Wad Omer where it increase by 0.05. This deficit due to the large family size (> 7 person) and a low rate of income also, indicates to increase debt level and poverty prevailing in study area particularly in non-rehabilitated villages. However the rehabilitated villages were in a better situation.

Table (4.22): Comparison between mean income and expenses

<table>
<thead>
<tr>
<th>Villages</th>
<th>Income</th>
<th>Expenses</th>
<th>% deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rehabilitated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wad Omer</td>
<td>3485.88</td>
<td>3433.36</td>
<td>0.05</td>
</tr>
<tr>
<td>Um Harout</td>
<td>3642.92</td>
<td>3698.00</td>
<td>-0.06</td>
</tr>
<tr>
<td>Non rehabilitated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ageeb</td>
<td>2358.00</td>
<td>2582.12</td>
<td>-0.34</td>
</tr>
<tr>
<td>Bohat Alguhawi</td>
<td>2701.40</td>
<td>3579.76</td>
<td>-1.30</td>
</tr>
</tbody>
</table>

*Source: field survey (2009)*

4.5.4 Access to credit:

In Wadi Almaggudam area there was not any funding institution working to give people loans, but in the rehabilitated villages the Special Program for Food Security (SPFS) gives some specific loans to farmers in form of inputs (seeds and fuel). Also it distributes small ruminants particularly to women through credits on basis of rotating system.

All respondents in non-rehabilitated areas and 52 - 60% of respondents in the rehabilitated areas indicated that they had no access to credit.
Only few respondents (4 -12% in rehabilitated villages) indicated that they had access to credits.

4.6 Situations of social capital indictors:

4.6.1 Community organizations:

There are some community organizations in the study area, both in rehabilitated and non- rehabilitated areas. These organizations included:

1) water management committees
2) local committees
3) youth activities

These organizations helped community to achieve project objectives

4.6.2 Woman participation:

Some of respondents (48% - 92%) in rehabilitated areas and (24% – 52%) in non rehabilitated areas mentioned that women have good participation in economic activities, while (8%- 48%) in rehabilitated areas and (48% – 78%) in non rehabilitated areas believed that the participation of women was a poor (table 4.23). The good participation of women in rehabilitated villages may be referring to involvement them in SPFS programs.

Table (4.23): Perception of respondents about women participation in economic activities

<table>
<thead>
<tr>
<th>Woman participations</th>
<th>Respondents Rehabilitated area</th>
<th>Respondents non rehabilitated area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wad Omer %</td>
<td>Um Harout %</td>
</tr>
<tr>
<td>Good</td>
<td>48</td>
<td>92</td>
</tr>
<tr>
<td>Poor</td>
<td>52</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: field survey (2009)
4.6.3 Role of the government:
All respondents (100%) in the rehabilitated areas said that the government role existed among implementation of SPFS programs. While over 68% of respondents in non rehabilitated areas mentioned that there was no any government role.

4.6.4 Presence of local committees:
The participation of local communities is very important for the success and achievement of any development project. Most of respondents over (80% in rehabilitated areas) saw that local committees had a role, while over 72% of respondents in non rehabilitated areas reported that local committees had no clear role in the study area.

5-6 -5 Problems facing sustainable rural livelihoods:
Table (4.24) gives respondents opinions regarding the problems facing sustainable rural livelihoods. Most of respondents (48 - 84%) in the rehabilitated areas and (48 - 72 %.) in non rehabilitated areas believed that problems facing sustainable rural livelihoods included: sand creep, unstable income and lack of job opportunities. Few respondents (4 - 8%) in rehabilitated areas and 4% in non rehabilitated areas said that sand creep was considered the main factor threatening sustainable rural livelihoods. About 12 - 36% of respondents in the rehabilitated areas and 26-36% in non rehabilitated areas mentioned that unstable income was considered the main problem facing sustainable rural livelihoods. Also 12% respondents in rehabilitated and non rehabilitated areas said that lack of job opportunities was a major factor that threatens sustenance of livelihoods.
Table (4.24): Respondent opinions about problems facing sustainable rural livelihoods

<table>
<thead>
<tr>
<th>Problems</th>
<th>rehabilitated area</th>
<th>non rehabilitated area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wad Omer %</td>
<td>Um Harout %</td>
</tr>
<tr>
<td>Sand creep</td>
<td>4</td>
<td>8.</td>
</tr>
<tr>
<td>Un stable income</td>
<td>12</td>
<td>36</td>
</tr>
<tr>
<td>Lack of job opportunities</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>Sand creep and un stable income</td>
<td>76</td>
<td>24</td>
</tr>
<tr>
<td>Sand creep and lack of job opportunities</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: field survey (2009)

4.6.6 Proposals for area development

Table (4.25) shows percentage of respondents' opinions regarding proposals for area development. 32% - 48% in rehabilitated areas and 24% - 28% in non rehabilitated areas saw access to capital would enable them to invest in natural resources. Over 28% believed that available capital and establishment of tree belts was important. Less than 28% in non rehabilitated areas said that available employment opportunities need to make development, while less than 12% of respondents in Um Harout and Ageeb villages mentioned that establishment of tree belts was a major requirement.

In conclusion as seen by respondents, making finance available as well as establishment of tree belts would help the community combat
desertification, conserve agricultural lands and natural pastures which would in turn contribute to sustainable rural livelihood.

Table (4.25): Respondents’ proposals for area development

<table>
<thead>
<tr>
<th>Proposals</th>
<th>rehabilitated area</th>
<th>Non rehabilitated area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wad Omer %</td>
<td>Um Harout %</td>
</tr>
<tr>
<td>Capital</td>
<td>32</td>
<td>48</td>
</tr>
<tr>
<td>Existing work</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>establishing tree belts</td>
<td>-</td>
<td>12</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>existing work and establishing tree belts</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td>Capital and establishing tree belts</td>
<td>52</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: survey (2009)
4.7 Productivity, Equity and Sustainability Dimensions

The sustainable rural livelihoods indicators have been also assessed across the dimensions of productivity, equity and sustainability. The assessment aimed to identify situation of assets and reduced vulnerability to climate change and lands degradation.

4.7.1 The Productivity Dimension:

Indicators used for assessing productivity in natural capital are related to rehabilitated areas: crops productivity and herd status. Results indicated improvement in the two indicators when compared with non rehabilitated areas: 1) Significant increase in crops productivity in forage particularly, led to improvement in herd status. 2) The productivity in physical capital assessing cross irrigation type and agricultural tools indicators: the improvement in both irrigation system and agricultural tools had also led to improvement of crops production. 3) The productivity in financial capital showed positive results in increasing income of households particularly in livestock and agricultural production. SPFS provided some input (seeds and fuels) as small loans for farmers, benefiting 36% of respondents; this had directly contributed in mitigating drought impact.

4.7.2 The Equity Dimension:

The assessment of equity focused on women situation and right to access agricultural lands and loans in rehabilitated areas. Analysis showed the equity situation was much improved compared with non rehabilitated areas in general. The participation of women in economic activities, majority of respondents 48 – 92% in rehabilitated area and 24 – 52% in non rehabilitated area emphasised the women participation level was considered a good because SPFS involved them in the project program. Also, concerning the right to access agricultural lands in rehabilitated
areas, over 88% of respondents said that it was possible. While regard inequity was clear in access to credits, over of 52% of respondents ensured impossible access to credits.

4.7.3 The sustainability Dimension:
The communities need to sustain their livelihoods, increase their ability for coping and respond to climate changes impact and reduce their vulnerability and the risk. The poor situations of resources were improved in rehabilitated areas including: 1) the continuity of local committees' setup by the project, evaluated by 100% of respondents ensured that it became very effective. 2) continuous awareness of local communities especially among women with regard to conservation of natural resources (forestry products) and promoting of education level. 3) continuous improvement of herd status

4.7.4 The risks:
The main risks facing sustainable rural livelihood include: 1) fluctuations in rainfall, causing a shortage of water for agricultural activities and the deterioration of livelihood assets, which require the development of water management systems for sustainability of water supply, particularly in non rehabilitated areas. 2) Worry conditions regards sand encroachment, in four villages: sand creep became a major factor that threatens agricultural lands and production. 5) Higher migration rate constitute a major risk for sustainable rural livelihoods in non-rehabilitated villages.
4.8 Summary, Conclusions and Recommendations

4.8.1 Summary:
This study attempted to assess impact of drought and desertification on sustainable rural livelihoods in Wadi Al Muggadam. The first chapter of the study began by introducing desertification, as being a major environmental problem in the world and in Sudan, it also, gives the problem statement which led to extended land degradation and all resources inability to sustain production leading to undermining rural livelihoods, as result thousands of people migrated from their villages to the neighboring cities. The objective of study concentrated on evaluates rural livelihoods household assets and their potential to sustainability under prevailing climate variability and lands degradation condition: a comparison between rehabilitated and non rehabilitated areas.
Chapter two: reviewed the literature related to definition of desertification and drought, desertification causes in Sudan, impact of desertification and drought at local and national level, climate variability and climate change, desertification and desert cultivation, concept of rural development, concept of participation development, sustainable development, definition of sustainable livelihood, sustainable rural livelihood framework, sustainability.
Chapter three described the martial and methods used in data collection and analysis. The questionnaire was the main method used to collect the primary data from hundred respondents that represented the total population in the four villages was selected: Wad Omer and Um Harout representing rehabilitated areas and Ageeb and Bohat Alguhawi
representing non-rehabilitated areas. Secondary data were obtained from different governmental and non-governmental sources, report, documents, scientific papers and from internet. Descriptive statistical methods and independent sample t-test were used to analyze the data. The results as presented as figures tables of comparisons, mean and percentage. This chapter also, highlighted the study area describing location, topography, climate, water resources, geology, vegetation cover, population, family characteristics, economic activities, the special programme for food security and their objective, project components, the impact of the programme, constraints the implementation and why is the expansion of SPFS.

Chapter four: aimed to investigating the general characteristics of population and capitals indictors’ situation. Which concluded four villages, that affected by desertification, Wad Omer and Um Harout representing rehabilitated areas and Ageeb and Bohat Alguhawi representing non-rehabilitated areas.

From age distribution, it was found majority of respondents in all villages (80%) are of age ranging between 20 – 60 years. Among the four villages, Wad Omer and Um Harout (rehabilitated villages) have 84 - 92%, and Ageeb and Bohat Alguhawi (non-rehabilitated villages) have 68 - 76% of people lying within this age group.

It may be concluded that people in rehabilitated villages were younger than people in non-rehabilitated villages.

The characteristics of respondent by gender in four villages, it was found that in all villages about 47% were males and 53% were females.

Wad Omer and Um Harout (rehabilitated villages), have higher number of males 50 - 76%, while Ageeb and Bohat Alguhawi (non-rehabilitated
villages) have higher number of females 60 - 80% of respondents. That have been due to the males migration from non- rehabilitated villages to other places (towns) searching for other job opportunities.

Human capital condition:
It is seen, education levels in all villages. The Illiteracy rate was 56% in all villages, while higher (75%) in Ageeb and Bohat Alghuawi (non - rehabilitated villages), Wad Omer and Um Harout (rehabilitated villages) have higher (44%) in Khalowa and primary level. Only 4% in high secondary level in Um Haroutd and Bohat Alghuawi villages.
The illiteracy rate was higher in the non – rehabilitated villages compared to the rehabilitated villages.

It appears that most of family size is greater than 7 persons (44 - 52% of respondents in rehabilitated areas, and 20 - 48% in non- rehabilitated areas). This large family size is encouraged by need for labour support to increase family income. Other family size ranged between 3 – 7 persons (over between 28 - 48% in rehabilitated villages and 32- 60% in non-rehabilitated villages). This is becoming the normal size in urban and rural areas in recent years. Most respondents (over 96% in all villages) depend on family members as labor.

Migration type, 22 - 36% of the respondents in the rehabilitated villages and 28 – 64% in non rehabilitated villages ensures that migration is high. While 64 – 78% of respondents in rehabilitated areas and 36 – 72 in non – rehabilitated areas believed that migration is limited, particularly after each agricultural season, as they refer to improve situation of livelihoods locally at rehabilitated villages.
Over 80% of respondents in four village believed that the financial reasons are behind people migration to other places (cites). Otherwise climate changes are the main cause.

Physical capital condition:
All respondents in non rehabilitated areas they depend on rainfall or water flowing in wadis to irrigate their farms and used manual tools when there is a good rainy season. while all respondents in rehabilitated areas used diesel pumps for irrigating the farms and some machines for land preparation.

Natural capital condition:
The farm size was a difference between rehabilitated and non rehabilitated villages. all farms size in rehabilitated areas fall within range from 1 to 2 fd due to SPFS which determined size farm by 1.9 fed for each household for cultivating some vegetables, forage, crops and fruit trees. While in non rehabilitated areas, 80% of respondents in Bohat Alguhawi village did not have any agricultural lands. In Ageeb village 72% of respondents their agricultural land ranged between 1 to 2 fd. A few respondents (12%) in Ageeb and Bohat Alguhawi villages their farm exceeded 4 fd.
The soil in all villages is of sandy clay type which is assumed to be good soil for cultivation. However, in recent years accelerated sand encroachment became dangerous and threatens the soil fertilely in all villages.

In general, the right access to agricultural lands in the study area is obtained by inheritance. Each individual is given part of the area to cultivate. While in rehabilitated villages the agricultural land is determined and distributed by SPFS. most of respondents (88- 92%) in rehabilitated villages, and (48-88%) in non- rehabilitated villages see that
the access to agricultural land is easy, while 52% of respondents in Bohat Alguhawi village see that the access to agricultural land is difficult.

Forestry trees and their products: As indicate almost all respondents in both sectors (rehabilitated and non-rehabilitated villages) the forestry trees exist with low density in the study area, and farmers obtain the permission to collect forest products from forest administration.

The total crops area (season 2008) in non rehabilitated areas (Ageeb village) was 44.3 fd, while there was no cultivated area in Bohat Alguhawi village due to shortage of rainfall. In rehabilitated areas (Wad Omer and Um Harout villages), crop area were 49.5 fd which was more than non-rehabilitated area (Ageeb village) by 5.2 fedden. People were interested in producing sorghum and okra because they represent the staple food and they cultivate fodder to feed animals. During interview with some respondents, they indicated that sorghum is almost harvested as a fodder before it reaches maturity stage due to irrigation water shortages in non rehabilitated areas.

Crops productivity: sorghum productivity was not significance difference between rehabilitated and non-rehabilitated areas. Perhaps this indicates that the respondents have no interest in planting of sorghum. Shows the area size that had been planted with sorghum ranged between 0.3 – 2.8 fd in rehabilitated villages compared to 16 fd in non-rehabilitated villages. Productivity of fodder, water melon, okra and cucumbers in rehabilitated areas was significantly higher than in non-rehabilitated areas. This indicates that the rehabilitated program has significantly increased crops productivity. In general, the crops productivity in the study area was lower than other sites.
Crops sales percentage in rehabilitated areas is higher than non rehabilitated areas, while crops consumption percentage is lower in rehabilitated areas compared with non rehabilitated area. This indicates the improved situation of livelihoods in rehabilitated areas.

The animals existing in the study area include camels, goats, sheep and donkeys. The camels mean ownership was about 1 – 1.3 camels in rehabilitated villages and 0.2 – 0.6 in non rehabilitated villages. Usually People use camels to move from place to another for grazing. The goats mean ownership was 4.7 – 5.8 in rehabilitated villages and 3.2 – 6.9 in non- rehabilitated villages. The sheep mean ownership was 4.5 – 4.8 in rehabilitated villages, and 2.2 – 5.4 in non- rehabilitated villages. Usually People depend on goats and sheep for their subsistence and requirements of milk products and some manual works as make wearing rigs from goat's wool. The donkeys mean ownership was 0.6 – 1.0 in rehabilitated villages and 1.0 – 1.2 in non – rehabilitated village. Donkeys are used for load of water for families and their animals. Frequent drought resulted in the decrease of numbers of all animals in the study area.

Also, there was no significant difference in animals’ ownership between rehabilitated and non- rehabilitated areas.

Herd status depends on availability of pastures for grazing, the opinion of the respondents with regard to herd status. 64 - 76% of respondents in the rehabilitated areas see the status is moderate as they were able to cultivate forage for animal feeds. However, 58.3 – 72.7% of respondents in non rehabilitated areas find difficulties in feeding their animals. In all the villages animals graze around the villages, possibly due to the small size of the herd and there was some annual grasses growing in the wadi. Also
animals depend on fodder cultivated in the project and the remains of plants in rehabilitated areas

Sand creeping: was occurring with high rates in all villages. It was considered a major factor that threatens agricultural activities in the study area. This agrees with Dixey and Aubert (1962) who estimated the advance of sand dunes encroachment in some agricultural lands in Sudan to be at rate of 1 to 3 meters per year.

Financial capital condition:

There was no economic stability in the study area. Income sources in rehabilitated and non rehabilitated areas comprise: livestock and agricultural activities, manual works, trade, family assistances and monthly wages. The manual works and agricultural and livestock activities was considered the main income sources in rehabilitated areas, while the manual works was considered the main source of the income in non- rehabilitated areas. Omda Alfadol, leader Um Harout village, during interview with him, mentioned that the size of farm (1.9 feddan) is a limited area and is not sufficient for their necessary requirements that led people to search for other income sources.

From these results it may be concluded that agricultural activities have improved in the rehabilitated areas, particularly in Um Harout village and it became the main income source for households.

The livestock and agricultural mean income in rehabilitated areas was significantly higher than these in non- rehabilitated areas at 99% level of significance. This indicates that SPFS has significantly increased the livestock and agricultural income.

Expenses for households in the four villages which include cost of: food, agricultural activities, animals feed, health, transport, clothes and shoes,
social occasions and education. The spending was focused on food in all villages and was about SDG 43980 - 54380 in the rehabilitated villages and SDG 33373.0 – 59740.0 in non rehabilitated villages. Animals feed expenses come in second after food about SDG 12430.0 – 5428.0 in the rehabilitated areas and SDG 14220.0 – 19998.0 in non rehabilitated areas. While the cost of agricultural activities ranged between SDG 5703.0 – 7512.0 SDG in rehabilitated areas and SDG 900.0 in non rehabilitated areas. This is a result of non-agricultural activities in these areas. It was observed that spending was fewer in services of education and health. This indicates unavailability of health care in the study area. It may also indicate unawareness of education importance, especially in non-rehabilitated villages where there were no schools or teachers.

It was appeared that the mean income and the mean expenses were higher in rehabilitated villages than non-rehabilitated villages, while mean expenses was higher than mean income in all villages except in Wad Omer where it increase by 0.05. This deficit due to the large family size (> 7 person) and a low rate of income also, indicates to increase debt level and poverty prevailing in study area particularly in non – rehabilitated villages. However the rehabilitated villages were in a better situation.

In Wadi Almaggudam area there was not any funding institution working to give people loans, but in the rehabilitated villages the Special Program for Food Security (SPFS) gives some specific loans to farmers in form of inputs (seeds and fuel). Also it distributes small ruminants particularly to women through credits on basis of rotating system.

All respondents in non rehabilitated areas and 52 - 60% of respondents in the rehabilitated areas indicated that they had no access to credit
Only few respondents (4 -12% in rehabilitated villages) indicated that they had access to credits.

Social capital condition:
There are some community organizations in the study area, both in rehabilitated and non-rehabilitated areas. These organizations helped community to achieve project objectives.

Woman participation: Some of respondents (48% - 92%) in rehabilitated areas and (24% – 52%) in non rehabilitated areas mentioned that women have good participation in economic activities, while (8%- 48%) in rehabilitated areas and (48% – 78%) in non rehabilitated areas believed that the participation of women was a poor. The good participation of women in rehabilitated villages may be referring to involvement them in SPFS programs.

The participation of local communities is very important for the success and achievement of any development project. Most of respondents over (80% in rehabilitated areas) saw that local committees had a role, while over 72% of respondents in non rehabilitated areas reported that local committees had no clear role in the study area.

Problems facing sustainable rural livelihoods: Most of respondents in the rehabilitated areas and non rehabilitated areas believed that problems facing sustainable rural livelihoods included: sand creep, unstable income and lack of job opportunities. Few respondents in rehabilitated areas and non rehabilitated areas said that sand creep was considered the main factor threatening sustainable rural livelihoods. About 12 - 36% of respondents in the rehabilitated areas and 26-36% in non rehabilitated areas mentioned that unstable income was considered the main problem facing sustainable rural livelihoods. Also 12% respondents in rehabilitated
and non rehabilitated areas said that lack of job opportunities was a major factor that threatens sustenance of livelihoods. While the proposals for area development it was found that 32% - 48% in rehabilitated areas and 24% - 28% in non rehabilitated areas saw access to capital would enable them to invest in natural resources. Over 28% believed that available capital and establishment of tree belts was important. Less than 28% in non rehabilitated areas said that available employment opportunities need to make development, while less than 12% of respondents in Um Harout and Ageeb villages mentioned that establishment of tree belts was a major requirement.

In conclusion as seen by respondents, making finance available as well as establishment of tree belts would help the community combat desertification, conserve agricultural lands and natural pastures which would in turn contribute to sustainable rural livelihood.

4.8.2 Conclusions:
The rehabilitated villages (Wad Omer and Um Harout) were endowed with young generations compared to the non rehabilitated villages (Aheeb and Bohat Alguhawi).
Increased females' percentages in non rehabilitated areas refers to increased males number who migrated from non - rehabilitated villages to other places (towns) searching for job opportunities.
The SPFS project in rehabilitated areas contributed to mitigation drought and desertification impact and emphasized improved access to assets (natural, physical, financial, human and social).
Illiteracy rate it was found higher in non-rehabilitated areas compared with rehabilitated areas is attributed to unawareness of importance of education as well as unavailable of schools and teachers in non-rehabilitated areas. The rehabilitated areas showed relatively more awareness of education for example in Wad Omer village; a new modern school was established. Family size mostly greater than 7 persons, this large family size was encouraged by need for labours support to increase family income.

Improvement in irrigation system and agricultural tools was occurred in rehabilitated areas, as used diesel pumps for irrigating the farms and some machines for land preparation.

Improvement in natural capital condition due to land rehabilitation included: better land management, access to agricultural land was improved, planting of different crops and vegetables, increased crops yield significantly, increased crops sales and decreased crops consumption percentage and herd status improved. Whereas no significance difference in animals ownership between rehabilitated and non-rehabilitated areas due to drought and desertification processes and the lack of veterinary care. There is high sand creep rate in the study area.

There was no economic stability in the study area. Agriculture, livestock and manual works were considered the main income sources in rehabilitated villages while the manual works were considered the main income source in non-rehabilitated villages. There was a significant increased in income from livestock and agricultural production in rehabilitated villages compared to non-rehabilitated villages. Most expenditure was presented in food and animals feed in all villages and there was few spending in education, health and agriculture activity. Also,
the mean expenditure was higher than mean income in all villages except in Wad Omer village indicated to the debts level and poverty prevalent in the study area. There is a limited access to credit except little loans as the form of seeds and fuel in rehabilitated areas.

In social capital, improvement included: setup of community organizations which helped to enhance living conditions of people particularly in women through their participation in project components and increased government role in rehabilitated areas.

Several factors including sand creep or encroachment, unstable income and lack of job opportunities are posing a complex problem to sustainable rural livelihoods.

A proposal for rural livelihood development is presented in making finance available as well as establishment of tree belts which will help the community to combat desertification, conserve agricultural lands, natural pastures and contribute to sustainable rural livelihood.

4.8.3 Recommendations:
In the context of sustainable livelihoods, it is recommended to increase access to natural, physical, financial, human and social assets. This includes:

1- Conservation and management of natural resources for improving crops productivity, sustainability and equitable access of livelihood assets especially in non-rehabilitated villages. This includes:
   - digging more deep wells for drinking water and agricultural activities.
   - adopt some techniques to prevent lands degradation, as establishing and planting shelterbelts or use suitable methods for sand dune stabilization.
- rehabilitation of rangelands by controlling access and use of rangelands to improving the quality and diversity of grazing lands and protect the desirable species.

2- Increase awareness among population of the importance of education, illiteracy program and Increase the skills capacity of individuals...

3- Expansion of the Special Program for Food Security (SPFS) taking into consideration:
   - increasing farm size to enable farmers of production diversification and intensification to increase their income
   - using drip irrigation systems is suitable technique in dry lands.
   - cooperation with local committees to irrigate and protect the shelterbelts.
   - complete implementation of all other activities of project components to diversity income sources and reduce poverty.

3- Replicate SPFS experience in other sites with government and the state intervention for involvement more of population, people settlement and rural livelihoods development.
Plate 1: Sand encroachment (source SPFS 2008)
Plate 2: Vegetation cover (source SPFS 2008)
Plate 3: Animals grazing (source SPFS 2008)
Plate 4: Irrigation systems (source SPFS 2008)
Plate 5: Women participations *(source SPFS 2008)*
Plate 6: The project SPFS (source SPFS 2008)
References


لا يمكنني قراءة النص العربي في الصورة.
القطيع حالته:
(1/جودة)
(2/متوسطة)
(3/المتوسط دون)

الرعي مناطق:
(1/القرية حول)
(2/آخر مناطق في)

الرمال زحف:
(1/عالية بدوية)
(2/متوسط)
(3/ببطء)

المالية الإصول:

المالي الثابت:
(1/مستقر)
(2/مستقر غير)

الدخل والعاد مصدر:

 المصدر السنوي:

الحيانية الثروة:

التجارة الزراعية:

المحاصيل الفنية:

البناء من:

التحول الزراعية العمالية:

الشريعة المحتجزة:

الثروة الحيوانية الزراعة:

الصحة أولية:

التعليم:

الترحال:

الإضاءة الطاقة:

الاجتماعية المنسوبة:

الحذية الملابس:

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