PARTICIPATION OF RURAL COMMUNITIES IN MANAGEMENT AND CONSERVATION OF RANGELAND RESOURCES: THE CASE OF ELODAYA PROJECT, SUDAN

BY

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DECLARATION

I hereby declare that this thesis is my original work and has not been presented for a degree in any other university.

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DEDICATION

This thesis is dedicated to my beloved mother, brothers and wife for their moral support and sacrifice made during the period of my study away from home.

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ABSTRACT

PARTICIPATION OF RURAL COMMUNITIES IN MANAGEMENT AND CONSERVATION OF RANGELAND RESOURCES: THE CASE OF ELODAYA PROJECT, SUDAN.

The study was carried out to determine the roles of community participation in management and conservation of rangelands and the socio-economic impact of Elodaya project on the local communities using direct interviews and a questionnaire between February and April 1995. The study of effectiveness and sustainability of technical interventions introduced in the study area was done by determination of the changes in some vegetation attributes which might take place as a result of the project interventions. The stratified random sampling was adopted to divide the study area into project area and non-project area. Information generated by the questionnaire was computed in terms of percentages and analysis of variance to analyze the data on vegetation attributes.

The study revealed that community participation approach has proved to be successful in mobilizing voluntary labour force to take part in different project activities. It has therefore proved to be a key factor to the success of management and conservation of rangeland resources. The Village Development Committees were helped by local communities to become more aware of the strong relationships existing between the different components of the local ecosystem

and the causes of the natural resource depletion and land degradation. The technical interventions introduced in the project were contributed positively to bio-physical and socio-economic improvements. Some vegetation parameters such as herbaceous plant cover, botanical composition, plant density and standing crop biomass were changed in the positive direction since the project implementation.

The Percentage ground cover increased from 20.97% to 62.25% while percentage bare soil declined from 79.03% to 37.75% between 1983 and 1995. Analysis of botanical composition and field observations showed that, plant species have increased from undesirable to more desirable ones, an indication of rangelands improvement. Herbaceous biomass production in the project area was significantly different ($p < 0.05$) from that outside the project area. Elodaya project was contributed positively to the conservation of rangeland resources, income generation and water development.

Considering the adverse environmental conditions and increasing human activities these bio-physical and socio-economic changes might be partially attributed to technical interventions introduced in the study area. The study also revealed that there are some factors contributing to natural resource deterioration and some constraints restricting people from involvement in natural resource conservation activities. If these factors are properly addressed, rehabilitation of natural resources and improvement of

living standards of local communities could be achieved.

The study recommended that inherent ecological features of study area and human activities which are incompatible with productivity of the rangelands should not be ignored in future planning of resource management. Application of new techniques related to land-use and natural resource management should be based on simple traditional measures which could be easily understood and adopt by local farmers and herdsmen. They must be adapted to local ecological conditions and relevant to needs and circumstances of local communities. The study also recommended that there is urgent need for an extensive inventory and mapping of grazing resources and socio-economic status of rural population to be carried throughout the country to facilitate check in ecological deterioration and assure sustainable future resource utilization.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE PROBLEM

Sudan is characterized by diverse ecological zones resulting from interaction among a number of complex interrelated factors such as climate, soil types and geological formations. The wide range of environmental variations is determined mainly by the amount of annual rainfall which varies from 75 mm in the north to 1300 mm in the south. This variation of rainfall coupled with difference of soil types are responsible for the diversity of vegetation cover not only in its species composition but also in the size and density of plants (DANIDA 1989).

The arid and semi-arid lands comprise approximately 60% of the Sudan's total area (2.5 million km^2) and provide the most important rangelands of the country (Suliman and Darag 1983). Vegetation cover of these ecological zones has been changed qualitatively and quantitatively by many factors such as low rainfall, overstocking, improper agricultural practices, seasonal fire outbreaks, frequent droughts, wind and water erosion (Elmangori 1990, Darag and Yousif 1996). These areas are vulnerable to degradation as more pressure is exerted upon them. Improper expansion of rainfed and irrigated cultivation at the expense of arid and semi-arid lands occupied large areas which were formerly considered as grazing lands. These activities encroached upon the rangelands reducing not only the total area available for grazing but also led to decreasing of

highly palatable range plants such as *Blepharis linariifolia* "Pers" (Darag 1988). Another factor which causes great loss in rangeland resources is seasonal wild fires which annually destroy large areas of Sudan's potential rangelands and eventually lead to further rangeland deterioration.

As in many other arid and semi-arid regions of the world, Sudan suffers from periodic drought which have been more frequent in recent years. Teklu et al. (1991) observed that Sudan was seriously affected by the major Sahelian drought of 1968/73 and 1984/85 which intensify the problem of natural resource degradation. The drought coupled with human activities such as intensive cultivation and overgrazing have caused a sharp decline in the rangelands productivity and consequently diminished the capability of rangelands to support the increasing human and livestock population.

Forage production of Sudan's rangelands varies between 0.24 tons/ha in the northern areas of the country and about 1.43 tons/ha in the central areas (DANIDA 1989). Browse is also considered as an important component of range resources particularly during the latter period of dry season and more so during the years of low rainfall. In drier areas where *Acacia* species predominate, pods and fruits are the main browse components. Some rangelands are inaccessible during the dry season because of water scarcity while others with water sources, are overgrazed due to high concentration of livestock particularly around water points.

Estimates of grazing resources conducted by Range and Pasture Administration of Sudan indicated that the total forage production of the country's rangelands (117.3 million ha) amounted to 77.7 million tons which was equivalent to 23.1 million tons (DM) of total digestible nutrients (TDN) per year. On the assumption that annual feed requirement of one animal unit (AU) amounts to 1.04 tons TDN/year, it was concluded that the proper carrying capacity of Sudan grazing resources (22.2 million AU) is far below the actual livestock population which amounts to 27.7 million AU. This estimate indicated that Sudan's grazing resources were overstocked by almost 5.6 million AU (AOAD 1980).

Darag and Yousif (1996) cited Suliman (1985) who reported that the herbaceous biomass productivity of Kordofan region, where the study area is located, has been continuously decreasing due to over-use and environmental stress. The botanical composition of herbaceous plants has been changed from domination of perennial and high palatable grasses to inferior and less productive annual and ephemeral plant species (AOAD 1980). It is therefore necessary for the government to identify appropriate measures for rehabilitation of depleted rangelands and improving living standards of the people inhabiting these areas.

In an attempt to alleviate this situation, The Sudan government formulated a national plan (The Salvation, Recovery and Development Programme) to offset the adverse economic, social and ecological imbalances in arid and semi-arid areas of the country (UNDP 1991). Currently, many development projects have been

implemented in these areas by the Government with assistance of Non Governmental Organizations. The Integrated Resource Management for Desertification Control Project initiated in the study area is an example of these projects, designed in line with the broad development policy of the country to combat land degradation. Attainment of maximum natural resource utilization for the welfare of pastoral communities was the top priority of Elodaya project. It was suggested to be achieved through the following measures:

(1) Rehabilitation of depleted rangelands by application of proper range management practices implemented by the local population on self-help basis.

(2) Improvement of living standards of pastoral community through development of water sources and animal production systems.

Participation of pastoralists people in development projects is very important because human activities are the main causes of natural resource deterioration and they are the first to be affected by this problem (Bares and Olivars 1988). Joint efforts to solve common problems of pastoralists based on self-help projects were recently viewed as essential elements for community development. Holdcroft (1978) observed that rural communities are usually less motivated to participate in development projects unless they perceive that benefits arising from such projects are likely to meet their needs.

The economy of the study area predominantly dependent on rain-fed farming system with livestock raising through nomadic and village-based system on communal rangelands. The rangelands of the area have been utilized seasonally by nomadic groups and year-long by village-based livestock producers. Consequently, excessive grazing and other human activities through felling of trees for firewood and charcoal, improper expansion of cultivation and wild fire are the most important factors which have modified the original vegetation cover and exposed the soil to wind and water erosion (Omer 1994). Although, description of the vegetation cover of the study area is well documented (Harisson and Jackson 1958, Darag 1988, Elmangori 1990, Ahmed 1988), no detailed research has been carried out to document the roles of pastoral communities in management and conservation of rangeland resources.

1.2 STATEMENT OF THE PROBLEM

Understanding of the importance of pastoralisits' participation in development programmes is essential for their successful management. Therefore, determination of local community roles in managing their environments and appraisal of sustainability of improvement measures introduced into the study area becomes obvious. In assessing the external factors causing natural resource deterioration, it is essential to identify some principles and guidelines which help to establish proper natural resource utilization and management polices. The study is also proposed to determine how the new technical interventions introduced

in the study area influence the socio-economic status of pastoral people.

The results generated from this study will be used to draw policy recommendations which could provide useful guidelines for proper resource management in the future. It is hoped that if the factors contributing to natural resource deterioration and constraints restricted people from participating in project activities were properly addressed, rehabilitation of the depleted rangelands and improvement of the living standards of the rural communities could be achieved that.

1.3 SPECIFIC OBJECTIVES

Specifically the study objectives were to:

(1) determine the role of pastoral community participation in planning and management of rangeland resources;

(2) determine the socio-economic impact of Elodaya project on local people; and

(3) study the effectiveness and sustainability of the technical interventions introduced in the study area.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 PEOPLE'S PARTICIPATION

In the present situation of developing countries there is little rural communities can do to improve their living standards using the available limited resources. This may be due to the low income which characterized the entire African rural communities and the fragile nature of their resources (Mehta 1984). However. development strategies must focus on setting clear priorities including community participation in solving their own problems and raise their productivity. To overcome the complicated environmental problems, local people should be involved in designing and implementing plans emphasizing the soil conservation and protection of natural vegetation. Faced with a task of this scale, it will be difficult for the developing countries, even with international aid, to reverse the course of events without grassroots involvement in different development activities (IUCN 1989).

There is an urgent need for pastoral communities to participate in management and conservation of natural environment. Hence the human resources are the main driving forces for improvement of the social and economic conditions local communities. Schreiber and Hill (1994) suggested that the key to successful development projects is a strong community involvement in diagnosing problems, formulating appropriate set of actions and implementing the agreed upon action plans. Holdcroft (1978) stated

that problems of rural people can not be successfully tackled without full involvement of the concerned villagers in the decision-making process. The physical, social and economic dimensions must be taken into consideration when dealing with development programmes in rural areas. In this respect, Mehta (1984) suggested devolution of power and decentralization of administration so that execution of development programmes could be accomplished by popular representatives from local people. He concluded that implementation of community participation approach is successful in creating consciousness and taking the perception and priorities of targeted people into account.

Involvement of human resource in development of rural areas can be achieved through co-operative efforts on a self-help basis supported by material and financial assistance from the concerned governments or NGO's. The process of incorporating local communities in development programmes through popular participation is slow and requires much organization and flexibility. Grouping of rural people in organizational structures such as village or nomadic development committees are the most efficient means which enable pastoralists to take part in management and conservation of natural resources. In this respect, it is worth while to quote Eden (1987) who stated that:

> "Throughout the developing world, diverse environmental limitations hinder man's attempt to exploit land resource. In many instances these limitations may be overcome by application of modern technology, but even with effective organization and financial success, successful land resource exploitation depends mainly on the quality of human resources."

Success of community participation in development programmes can be shown by the experience of some African countries such as Kenya, Tanzania and Ethiopia. The Kenya Tea Development Authority and Ujamaa Movement in Tanzania have adopted involvement of local people through direct participation in project administration. Chilalo Agricultural Development Unit in Ethiopia has attempted to encourage people's participation through use of model farmers. The high yields realized by selected farmers as a result of adopting new farming techniques are expected to encourage other farmers to adopt new innovations (Lele 1975). The social Forest Programme in India is a global example of successful community participation in which involvement of society and government in preservation of vegetation cover has been achieved. Indian experience has proved to be the most successful method of afforestation (Gupta 1988).

In the past Sudan government has been heavily dependent on the local tribal administration in implementing and enforcing legislation dealing with natural resources and environmental protection. The power of land allocation and resource management were controlled by the central government according to Land Registration Ordinance of 1970 (DANIDA 1989). Recently the government institutions responsible for environmental protection suffer from weaknesses as a result of competition and lack of cooperation. This is apparent in land acquisition between Ministry of Agriculture on one hand, and Forestry and Range Departments on the other hand. Furthermore, the government institutions rarely involve the local communities in planning and implementation of

development programmes in their areas. There is a need for overall coordination whereby these institutions can resolve problems hindering proper natural resource utilization and work together more effectively to overcome these contradictions.

The contribution of local people to development projects combined with governmental technical support can yield great progress and make the people more concerned about the success of such projects to which they have committed their time and resources. Community participation is practiced as a tradition in daily life in form of voluntary help to needy individuals (Naffir) and involvement in different social occasions. The spirit of mutual sharing of labour provides an opportunity for pastoralists to help each other and identify their own potentials based on their own culture and innovative abilities. This is necessary for developing a sense of responsibility among local communities towards the achieved results.

Regardless of the fact that systematic rural participation approach has shown to be a success in other environments, it has continued to be ignored in Sudan. Change of policies in project planning, implementation and evaluation need to be done so as to involve local communities in all project stages. The target beneficiaries can acquire some technical knowledge through mutual interaction with officials in charge of these development programmes. Incorporation of indigenous knowledge with modern technical interventions is needed to achieve appropriate natural resource management strategies.

2.2 LAND DEGRADATION PROBLEMS

Difficulties of developing arid and semi-arid lands stem from the physical and biological constraints imposed by factors including inadequate water sources, shallow soils and sparse vegetation. Speth (1988) suggested that failure to initiate and implement projects that work within these constraints is another factor that hindered development of arid and semi-arid lands. These ecosystems are fragile such that any slight changes in their balance can lead to rapid degradation of natural resource. On the other hand they are characterized by high resilience and quick recover from heavy degradation once disturbing factors cease unless the basic ability of the system to recover is damaged (Mohammed et al. 1996, Wood and Ryden 1992).

The causes of continuous change of vegetation composition and erosional features in arid and semi-arid regions have been a subject of considerable debate, with explanations ranging from natural fluctuations in weather patterns to man-caused perturbations (Warren and Hutchinson 1984, Elmangori 1990, Falloux and Mukendi 1988, Wood and Ryden 1991). Deterioration of rangelands is attributed to combined effect of inherent ecological features of arid and semi-arid habitats and the socio-economic behaviors which are incompatible with environmental and developmental requirements of these ecosystems (Obeid 1980). Existence of human activities presuppose social and biological influences and interactions with other ecosystem components. If these influences are not well understood and adequately accommodated in resource management

plans, the consequences could be disastrous.

Walter (1988) argued that centres of human and animal concentration in arid and semi-arid regions have expanded rapidly and spread in ever widening circles as people move further and further away in search of arable lands, grazing grounds and fuelwood resources. These practices can easily accelerate the rate of soil erosion and desert encroachment. The degree of land degradation depends mainly on the intensity of use and the land can degrade less under the same intensity of use if appropriate techniques are used to minimize the negative effect of use (Young and Solbrig 1993). It is, therefore, important to develop improved land use systems that can reverse the trend of land degradation and sustain land productivity for the coming generations. Strategies adopted should increase efficiency of land use, minimize land degradation and must be acceptable by the pastoralists.

During the last two decades overgrazing, wild fires and irrational removal of woody plants for cultivation and fuel wood have spread into marginal and ecologically fragile semi-arid lands of Sudan which receive minimal annual precipitation. This has inevitably led to deterioration of grazing resources (Obeid 1980). Control of land degradation problems can be achieved by implementing appropriate range management plans and land use systems which work within this complicated situation to boost economic development of arid and semi-arid regions. Failure to effect such interventions can exposes land resources to further degradation and ultimate loss of the capacity to support increased

human population (Edington and Edington 1979).

Improper farming systems and continuous cultivation of the same plots may contribute to land degradation. However, the rotational cultivation system practiced in the study area which involves establishment of *Acacia senegal* trees during specific fallow periods can lead to gradual accumulation of nutrients, regenerate soil fertility and increase ground cover which protects the soil surface from erosion hazards. Freeman (1994) described this traditional land management systems in which cultivation and fallow periods are alternate as stable, biologically efficient and sustainable. However, with increasing human population, rotation period has gradually become shorter. The breakdown of this traditional practices has resulted in intensive crop production with significantly reduced fallow periods.

Substantial areas of Sudan rangelands, which were previously considered as grazing grounds, has recently been converted into other activities. According to Speece (1982), about 800,000 ha of land are cleared annually for mechanized crop production and 400,000 ha for traditional agriculture and forest products. In Western Sudan, where the study area is located, over-cultivation and overgrazing have led jointly to a serious depletion of natural resource base. People and animals have been forced to move southward and thus causing reduction in the per capita cultivable land as well as the fallow periods (Abouli 1994). As productivity per unit area of cultivable land has decreased, larger areas have been cultivated to compensate for low production and consequently

more grazing lands and forests have been converted to agricultural lands.

The study area has become a focus for permanent human settlement as well as a centre for livestock concentration due to availability of water resources almost all year-round. The high demand for arable lands and grazing resources has led to severe environmental degradation. High concentration of livestock has a negative effect on the rangelands particularly during the growing season when grasses are heavily utilized to the extent that natural regeneration does not take place. Moreover, removal of crop residues after harvesting exposes soil surface to more wind and water erosion hazards and accelerates land degradation. The northern parts of the study area are characterized by degraded grazing lands where shallow sandy soils are exposed to wind erosion. Some plant species have disappeared from around settlement centres and their seeds may have been buried and lost under the shifting sand dune formations (Darag 1988). In the south-east and south-west parts of the study area soil surface has been exposed to sheet erosion due to excessive over-grazing and animal trampling (Ahmed 1988).

The phenomenon of grazing resources deterioration in the study area has resulted in reduction of vegetation cover and changing species composition. This is often associated with vegetation change in favour of unpalatable plant species which have ability to compete and withstand such harsh changes. The problem of increasing land degradation can be contained through incorporation of land,

water and forest resources in well-defined management systems. This will ensure that such systems using rangeland resources are used according to their production capacity to sustain their productivity.

2.3 CONSERVATION OF RANGELAND RESOURCES

Natural resource conservation is defined as "the use of natural resources for the greatest good, for the greatest number and for the greatest time" (Burton and Kates 1960). It has also been defined by Camp and Daugherty (1988) as "the wise use of natural resources to minimize waste and maintain the resources in as good condition as is practical". Both definitions emphasize the sustainable use of natural resources to maintain their productivity for future use by preventing damage and misuse. Reducing unnecessary waste of natural resources is vital for sustaining their long-term economical productivity.

Burton and Kates (1960) remarked that in earliest tribal life, relationship between productivity of hunting grounds and welfare of the tribe must have been very clear. In early days, there was a balance between human population and environment, but currently, environmental degradation has significantly increased as a result of excessive increasing in human and livestock populations. These factors have led to a greater demand for natural resources particularly agricultural lands. The cultivated lands are neither given long fallow period to regenerate their fertility nor fertilizers are applied to compensate for loss of nutrients removed

annually. Throughout the world, arid and semi-arid lands are frequently exploited and damaged with little apparent concern for the future. This abuse brings about not only the consequences of lower productivity and diminishing economic return from the land but its impact seems to go beyond the environment to affect the entire economic and social fabric of the people (Dasmann 1976).

The total world's human population which was estimated at 1.6 billion in the year 1900, increased to 4.3 billion in 1979 and is expected to rise to 6 billion by the year 2000 (Camp and Daugherty 1988). Therefore, careful management of the world's natural resources becomes very important so as to accommodate the rapid increase in human population. Karrar and Stiles (1984) estimated that about 31 million km^2 of the world's rangelands have been affected by desertification and a considerable area of arable land (200,000 km^2) is annually rendered economically unproductive. They have concluded that about 75% of productive land within the world's dry lands are becoming desertified due to the effect of a combination of factors including high human and animal population growth, chronic droughts and inappropriate land-use practices. If this rate of desertification and increase in human population continue unabated the situation could likely become disastrous.

The solutions to problems created by land misuse are not necessarily all achieved through physical interventions. Application of technological solutions to ecological problems has to take into account the socio-economic and cultural background of the people concerned to persuade them to utilize land resources

properly (Gupta 1988). The responsibility of natural resource management must rest with farmers and land users. With respect to the role of land-users in natural resource conservation, local commitment toward land-use plans is best achieved if the people are given a chance to decide and identify their needs rather than decisions being imposed upon them (Braatz et al. 1994). Once the land users accept new ways of natural resource conservation these measures soon become part of their daily life. Programmes implemented without consultation of local community will not be appreciated and might collapse when outside interventions withdraw.

The ideal natural resource management defined by Ackerman (1960) as "sustainable-yield production" by which these resources maintain continuous production at an optimum level. However, this ideal management is practically difficult to apply for the reason that productivity of natural resource sometimes varies within a wide range due to effect of different climatic factors. High human population pressure and competing claims to land, water and rangelands are creating a situation in which people now need to manage them consciously to ensure their sustainability for future production (Schreiber and Hill 1994).

In this respect Teklu et al. (1991) emphasized the preservation and protection of natural resources, particularly in arid and semi-arid regions, to enhance the productive capacity of these regions. They were concluded that many factors including drastic climatic changes, increase of human and animal population, and past policy failure have contributed to natural resource

deterioration. Consequently, farmers have expanded into areas of higher climatic risk and many seasonal grazing lands have thus been converted to agricultural lands. The farmers have abandoned their traditional system of crop rotation to face shortage of arable lands by clearing new areas. Furthermore, annual fluctuations of rainfall have forced them to clear more woodlands for fuelwood and charcoal production to minimize the risk of crop failure.

It is essential to develop strategies for protecting natural resources to slow down the rapid environmental degradation and encourage pastoral communities to participate in natural resource conservation (Teklu et al. 1991). Some of these strategies such as site requirements and integral planning were discussed by Edington and Edington (1979) who argued that rural lands must be rated according to their site requirements in relation to natural physical features of the environment. They were concluded that appropriate planning for use of water, soils, flora and fauna with the objective of reducing ecological deterioration and assuring sustainability is essential for proper management of these resources.

The study area is a crossover to several tribes who use grazing resources almost all year-round during both dry and wet seasons. The high concentration of animals has resulted in grazing resource deterioration particularly around water points. Improper timing of utilization of rangelands in the study area has devastated the available grazing resources. Early grazing during growing season has inhibited the growth of some desirable grass

species giving way to invasion of annual forbs and less desirable shrubs. As a result of excessive grazing during dry season, only a thin layer of vegetation is usually left around water sources exposing soil surface to erosion hazards. This has led to a decline in quality and quantity of rangeland resources in the area leading to a decline in the economy of the inhabitants. Urgent measure to control rangeland deterioration is therefore, becoming vital.

2.4 TECHNICAL INTERVENTIONS BY ELODAYA PROJECT

Before the initiation of the Elodaya project excessive grazing and improper expansion of cultivation activities had caused environmental degradation through mismanagement of natural resources. The main objectives of Elodaya project were to address the ecological and socio-economic problems in the study area. The project area become a focus of settlement due to availability of water in this harsh environment, where water is the main determining factor for many activities. This called for more organized form of intervention which could alleviate these problems. The project adopted community-focus approach for combating land degradation, developing water sources and promoting sustainable rural development at village level. This approach is based on the facts that environmental conservation is essential for community development and rural communities need to be empowered to take decisions concerning their well-being.

Community participation approach used as a tool for involving local people in solving their own problems on a self- help basis.

Involvement of local communities in activities aimed at combating land degradation was believed would raise level of awareness among people and make them more concerned about conserving their environments. One of the project strategies was to initiate a campaign against land degradation by involving local communities to take responsibility of natural resource conservation through the following activities:

(i) Establishment of fences, fire-breaks and collection and reseeding of native plant species to combat rangeland deterioration;

(ii) Improvement of traditional water harvesting techniques by use of artificial water ponds (Hafirs) and shallow wells;

(iii) Mobilization of local people to participate actively in planning, implementation and evaluation of project activities; and

(iv) Soil conservation activities such as afforestation, gully control and reclamation of degraded sandy clay soils to improve soil physical and chemical characteristics.

Land degradation has continued to be a problem in Sudan due to many factors, including adverse ecological conditions, overgrazing, overcultivation, and increased human and livestock populations which lead to high demands for farming lands, rangelands and fuelwood. It has been noticed that community participation performs vital roles in planning and implementation of development projects in rural areas. However, little if any intervention has been done in the study area before initiation of Elodaya project despite the

recognition of its importance for tackling the problems of resource deterioration. A study on the effectiveness of community participation in natural resource conservation is important because it may come up with appropriate recommendations to avert land degradation.

Water development and reseeding with appropriate plant species under proper soil treatments suggested by Elodaya project could improve rangeland resources in the study area. Ecological and socio-economic impacts of the project with such interventions need to be studied to establish whether they are successful or not. The study considered strongly the concept that local communities have a potential which if combined with proper technical knowledge would achieve appropriate remedial measures for rangeland deterioration. It was in the light of the foregoing described situations that this study intended to document some of the community participation roles to conservation of rangeland resources and the effectiveness of the technical interventions introduced in the study area.

CHAPTER THREE

3.0 BIO-PHYSICAL DESCRIPTION OF THE STUDY AREA

3.1 LOCATION AND SIZE

The study was carried out from February to April 1995 in Elodaya project area and its environs. The area is located in Elnahud province. Western Kordofan State, Sudan. The project is estimated to cover an area of 3000 km^2 and it is approximately circular in shape with its centre in Elodaya town. The study area lies between latitudes 11^0 54" and 12^0 21" N, and longitudes 27^0 58" and 28^0 31" E (Figure 3.1).

3.2 TOPOGRAPHY AND SOILS

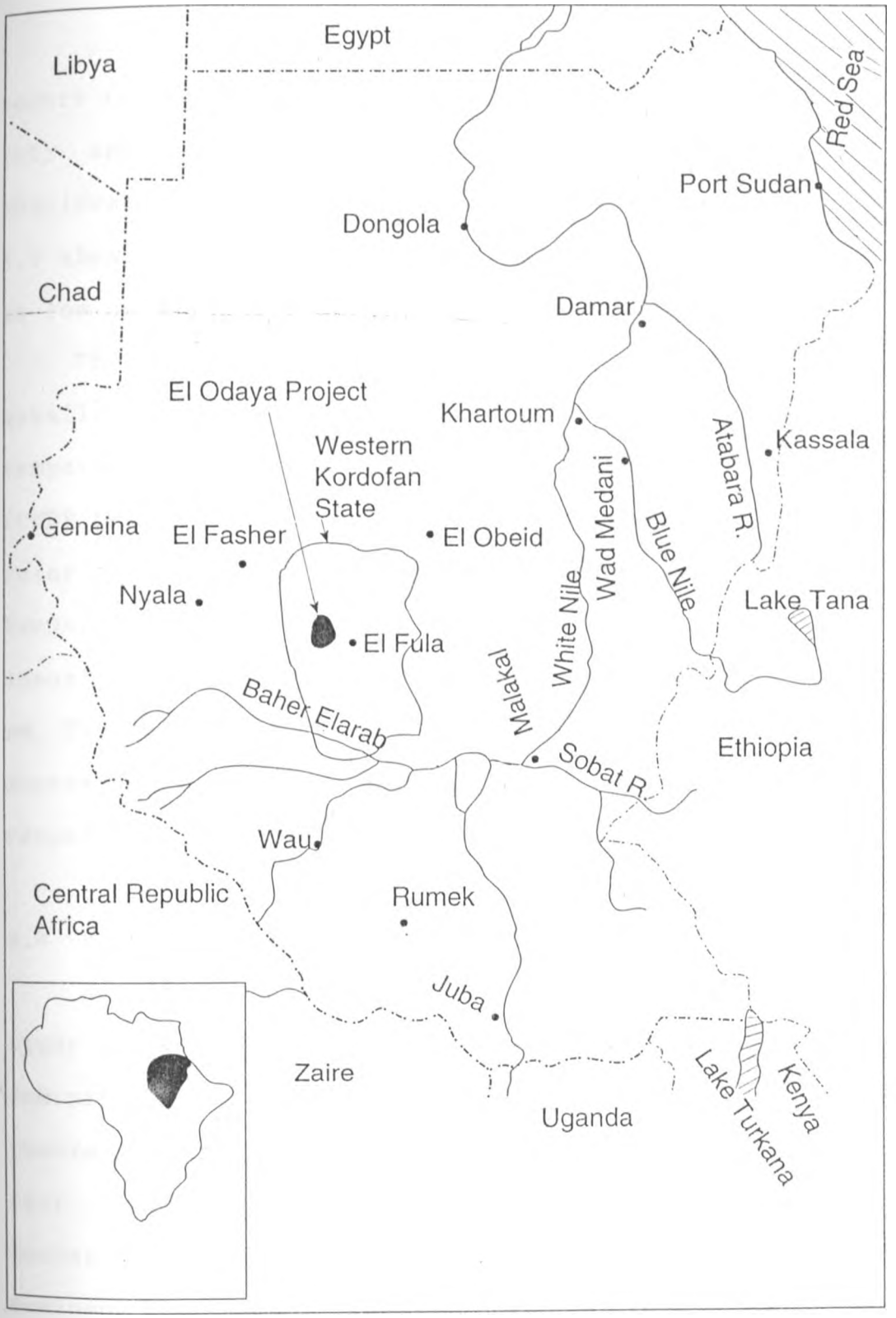
The general landscape of the study area is relatively flat, consisting of undulating sandy plains sloping from south-east and south-west towards the centre. Omer (1994) described the major land forms of the study area as:

> "The land forms are predominantly sand dunes which are composed of mixture of stabilized sand, sandy loam, and isolated deposit of sandy clay soils. Sandy soils are characterized by low organic matter content and low water holding capacity. Sandy clay soils have adequately higher nutrients and water holding capacity compared to sandy soils but they have been exposed to surface run-off and wind erosion due to continuous cultivation activities."

3.3 CLIMATE

The study area lies in northern limits of the semi-arid zone which is characterized by erratic monomodal rainfall pattern with short wet season and long dry season. Annual rainfall is unreliable and erratic in distribution both spatially and temporally. It

Figure 3.1: Map of Sudan showing the location of the study area



occurs from June to September with over 60% of annual total fall in July and August (Omer 1994). Annual rainfall variation is considerable with a long term average of 450 mm (UNDP 1991). Table 3.1 shows a twelve year rainfall pattern (1983-1995) ranging from as low as 142 mm to 532 mm giving an average of 335.9±37%SE mm.

The long term minimum temperature ranges from 13^0 C to 25^0 C usually recorded during January and February while the maximum temperature ranges from 30^0 C to 40^0 C recorded during April and May (UNDP 1991). Evaporation rate is high year-round except during the rainy season when factors enhancing evaporation rate like temperature, radiation and wind velocity are at minimum. The total annual potential evaporation (PE) varies between 1450 mm and 2100 mm. The daily PE generally increases to 7 mm in April and May and decreases to 4 mm or 5 mm in July and August. Annual water deficit ranges from 1100 mm and 1600 mm (Omer 1994).

3.4 Vegetation Cover

According to Harrison and Jackson (1958) vegetation of the study area is classified as low rainfall savanna type which is dominated by woody species including *Albizzia amara* "(Roxb') Boiv", *Combretum cordofanum* "Lofel", *Dalbergia melanoxylon* "Guill and Perr", *Acacia senegal* "(L.) Willd", Sclerocarya birrea "(A. Rich) Hochst", *Guiera senegalensis*, and *Commiphora pendunculata*. The dominant herbaceous species in the 1950's included *Cetenium elagnus*, *Andropogon gayanus* "(L.) Rozhiv", and *Stylothanthes flavicanus* "(Retz) Alston". Vegetation composition has been

extensively altered by expansion of agricultural activities, high concentration of animals, high frequency of the wild fire, severe droughts and wind erosion. The pure stand of desirable perennial forage plants such as *Andropogon gayanus* and *Blepharis linariifolia* "pers" have disappeared giving way to the spread and domination of low quality annuals (Darag 1988). Some of the major plant species identified in the study area are shown in Appendix 3.

Table 3.1: Total Annual Rainfall at Elodaya Over a 12-year Period

Year	Rainfall (mm)
1983	$174 \pm 37\%SE$
1984	142
1985	465
1986	376
1987	315
1988	532
1989	333
1990	199
1991	250
1992	468
1993	364
1994	412

Source: Elodaya project files.

3.5 HUMAN ACTIVITIES

Human population size of the study area is estimated at 40.438. About 50% were the target population benefiting directly from Elodaya project activities and who were settled in eleven village councils. In addition, a considerable number of nomads enter the project area with their animals on a seasonal basis (UNDP 1991). Majority of the population live around Elodaya town in northern and western parts where water sources are available and soils are relatively fertile compared to other parts of the study area. Some people move seasonally from their home villages to Elodaya town in dry season and return home during rainy season for cultivation. Distribution of human population depends mainly on availability of water sources and length of rainy season.

Livestock raising is practiced by both sedentary people and nomads. The sedentary livestock herding is practiced by villagers who keep animals throughout the year within village boundaries on natural rangelands and crop residues. The permanent presence of livestock cause destruction of vegetation and soil compaction. The rainfed agriculture is one of the main activities despite the fact that the study area lies in northern limits of the semi-arid zone which is characterized by low rainfall. Field crops like millet and sorghum are grown for local consumption while groundnut, sesame and water melon are grown for income generation. Intercropping of millet/melons and millet/*Acacia senegal* (gum arabic) are favoured by most farmers because this system reduces risk and maximizes farm revenue. Other crop combinations which dominate the homestead

farming system (Jubraka) are include okra, maize, cucumbers and beans.

Gum arabic which is considered as major source of income for some farmers is closely linked to rain-fed farming through traditional agroforestry system. In the past, millet and sorghum were usually grown continuously for 4-5 years and the land left fallow for 15 to 20 years under gum arabic trees. However, this bush-fallow system has been disintegrated due to expanding human population and also because of severe droughts. Farmers cut down gum arabic trees for fuelwood and charcoal to offset the effect of frequent crop failures.

Nomadic groups adopt systematic movement from north to south and vice versa through the study area. The cattle herders visit the study area during rainy season to avoid the tsetse flies in the marshy southern lands. The camel and sheep herders visit the area during the dry season when water and grazing resources in their home land become insufficient. The main rangelands of this group which located in the margins of semi-desert zone have been depleted by drought and overgrazing. Sometimes they advance South to the high rainfall areas looking for good grazing lands and water sources. The sensible movement of the nomadic groups is dependent mainly on availability of water resources, natural pastures and phenological stages of plants. It allows animals to migrate to different areas according to the seasonal changes of grazing resources. The specific traditional migration routes are seldom respected especially during years of low rainfall. Consequently,

farm crops and gum arabic fields are usually targeted, resulting in frequent conflicts between settled villagers and nomadic groups.

CHAPTER FOUR

4.0 INSTRUMENTS AND DATA GATHERING METHODS

4.1 SOCIO-ECONOMIC DATA

Investigation of the role of pastoral community in management and conservation of rangeland resources as well as socio-economic impact of Elodaya project on target population was done by use of a questionnaire. The questionnaire approach, as described by Weisberg and Bowen (1977), based on both open-ended and closed-ended questions was used to collect data relevant to this part of the study (Appendices 1 and 2). The data were collected by interviewing households within and outside the study area, project staff members and affiliated departments. Not all data or information gathered through formal interviews using questionnaire and hence informal discussions were held where necessary.

For the purpose of socio-economic data collection stratified random sampling procedure was adopted and a typical household was considered to be a sampling unit. The target population was divided into two strata; the first being the project population which consist of those who benefitted directly from the project activities and the second stratum consist of non-project population. Eighty households were considered for the interviews, forty from each stratum. Four villages were chosen randomly from each stratum and households to be interviewed were also randomly selected.

The number of interviewee in each village were proportionally allocated as follows; Fayog (8), Marbota (10), Shagro (12), Hariri (10), Elsoback (14), Umkashmain (9), Elbeja (10) and Elbobya (7). However, it was impossible to include some nomadic households in the interview because at the time of data collection both nomadic groups were either at the far North or far South of the study area. The socio-economic data collected using questionnaire consisted of questions that dealt with the following:

(i) Social characteristics (level of education, gender division, occupation and family size);

(ii) Land tenure and land-use (farm size, land use, ownership of farm land);

(iii) Household income (household income obtained from crop farming, livestock production and other income generation activities);

(iv) Community participation (role of local people in resource management, self-help approach as a system for protection and management of natural resources);

(v) Deterioration of rangeland resources (response of local people to land degradation problems, water availability, general features of vegetation cover); and

(vi) Technical intervention (effectiveness of construction of fences and provision of water sources, local people perception).

4.2 VEGETATION SURVEY

The experimental sites were selected randomly for studying some vegetation attributes in the project and outside the project area using complete randomized design (Steal and Torrie 1980, Gomez and Gomez 1984). For the studying of effectiveness and sustainability of technical interventions introduced in the study area, investigation of change in some ecological components was also done. Plant density, botanical composition, cover and biomass were determined for the study area and the adjacent area and comparison of different vegetation attributes was done. No emphasis was placed on individual species due to scarcity of financial resources and time. General observations and remarks on climate, topography and other features of vegetation cover were also recorded.

To determine whether the vegetation changes were significant or not, comparison of information collected with those done previously in the study area was done. Information on vegetation measurement carried out during the initial stages of the project implementation was obtained from the project documents and annual reports. Analysis of variance (ANOVA) was conducted on some vegetation data to compare vegetation attributes during the time of the study with the data before project implementation using figures from the project records.

4.2.1 HERBACEOUS BOTANICAL COMPOSITION AND COVER

Analysis of herbaceous botanical composition and cover was done using Point-Step Method (see for example, Tadingar 1995, Shaabani et al 1992). Measurements were done by pacing across selected sites along an imaginary transects of 100 paces long and recording whatever material was encountered at the tip of the boot as a hit. Recordings were made where plant portion, litter, or bare soil encountered. Four transects were selected in each of the four sites in the study area and the whole process repeated in the control experiment outside the project. Data collected was analyzed for botanical composition, plant cover, ground cover and bare soil by use of the following formulae:

$$\% \text{ Composition for Species A} = \frac{\text{Total No. of Hits for A}}{\text{Total No. of Plant hits}} \times 100$$

$$\% \text{ Total plant cover} = \frac{\text{Total No. of plant Hits}}{\text{Total No. of Paces}} \times 100$$

4.2.2 HERBACEOUS PLANT DENSITY

Herbaceous plant density was measured by selecting four sampling sites in both the project area and its environs. Six plots of $1m^2$ size were located randomly in each site. Individual plant species inside each quadrat were counted and recorded. Herbaceous plant density was calculated using the same formulae used for woody plants as indicated in section 4.2.3 below.

4.2.3 DENSITY OF WOODY PLANTS

This was done using plot size of 10X10 m as recommended by Oosting (1956), for large perennial vegetation. Forty eight plots were used in total. In each site six plots were selected randomly along 1km transect and the plants encountered were recorded. Occurrence of each species was recorded in a designed form and the data analyzed for total density, relative density and absolute density using the following formulae:

$$\text{Total density} = \frac{\text{No. of plants inside plots}}{\text{Area of plots}}$$

$$\text{Relative density for species A} = \frac{\text{No. of plants of species A}}{\text{No. of all plants inside plot}} \times 100$$

Absolute density for species A = total density X relative density

4.2.4 BIOMASS PRODUCTION OF HERBACEOUS PLANTS

Standing crop biomass of herbaceous plant was determined using clipping method (see, for example, Pechanec and Pickford 1937, Tadingar 1995). Four sampling sites were selected randomly in the project area and six 1 m^2 quadrats were clipped in each site. The clippings were then air dried until a constant weight obtained. The whole process was repeated outside the project area for comparison purposes. Biomass production was calculated and measurements converted to kilograms per hectare.

CHAPTER FIVE
5.0 DATA ANALYSIS AND DISCUSSION OF RESULTS

5.1 SOCIO-ECONOMIC ANALYSIS

5.1.1 COMMUNITY PARTICIPATION

It was shown that the local people have been participating in Elodaya project activities through encouragement of Village Development Committees (VDCs), project officials and local leaders. It was found that 82.5%, 10% and 7.5% of the respondents indicated that they were encouraged to participate in the project activities by the VDCs, project officials and local leaders respectively. However, the importance of local institutions in encouraging local community to support the project activities depend on the people's perception of the role of these institutions. The VDCs were mentioned by 58% as being effective and useful and were described by 34.5% as being open to all members of the society. The rest of the respondents (7.5%) described the VDCs as being ineffective. Through these committees the people could get access to loans provided by the project and receive plant seeds and seedlings to be planted in their own land. Moreover, they benefitted from their products. The success of new innovations implemented by the project and benefits gained by the participants have gone along way to convince the non-project population of the effectiveness of the project activities thus they desire to be

included in the project.

The study revealed that the age of households varied between 21-65 years with an average of 42 years. About 52.5% of the population was found to be males while 47.5% were females. Regarding the educational status of the population it was noted that 53.8% were illiterate or had no formal education. These low level of literacy among people of the study area are likely to pose a problem when discussing involvement of the local people in management and conservation of the rangeland resources.

The study revealed that there are good prospects for combating rangeland resource deterioration in the study area. However, a number of constraints exist. These include scarcity of water sources and inaccessibility to loans. These constraints should be given due consideration to secure proper participation in the project activities. Community participation will be discouraged if environmental issues are forced to the top of the agenda without addressing other issues which are perceived as more important and without explaining how natural resource management links to priority area (Lusigi and English 1991). The inhabitants of the study area were participated in large numbers when the project addressed issues such as development of water sources and conservation of range resources. Water development is a priority in the study area due to its high cost particularly during the dry season. The high percentage (80%) of respondents who participated in development of water sources reflect the importance of water provision in such a dry area.

Analysis of the data showed that 65%, 32.5%, 17.5% and 12.5% of the respondents were participated in firebreaks establishment, construction of fences, soil conservation, reseeding and tree planting activities respectively (Table 5.1). Protection of rangelands was the second in importance according to the local people because wild fires annually destroy considerable area of rangeland. The livestock herders are usually forced to move long distances particularly during dry season to secure better grazing grounds for their animals because of the scarcity of range resources in the village vicinity.

Table 5.1: Participation of the Rural Community in Project Activities

Activity	No. and % of respondents, N=40
Construction of fences	13(32.5%)
Water development	32(80%)
Reseeding of rangelands	5(12.5%)
Soil conservation	7(17.5%)
Firebreak construction	26(65%)

5.1.2 INCOME GENERATING ACTIVITIES

Various income generating activities were examined as summarized in Table 5.2. Crop farming was found to be the main source of income for households and it was contributed 60% to total income of the participants. It was followed by gum arabic and livestock raising which contributed 16.1% and 7.5% to average income respectively. Other sources of income include trading, handicraft and non-farm wages were collectively contributed 15% to total income while farm labour and sale of fuel wood contributed 1.2% and 0.2% of the average income respectively.

Table 5.2: Respondents' Average Income in Sudanese pounds (Ls)

Activity	Participants' Income (Ls)	Non-Participants' Income (Ls)
Crop farming	233560(60%)	176854(64.4%)
Livestock raising	29179(7.5%)	20871(7.6%)
Gum arabic	62645(16.1%)	45312(16.5%)
Fuel wood	680(0.2%)	-
Farm labour	4583(1.2%)	-
Other sources of income	58365(15%)	31581(11.5%)
Total	389012	274618

* Kenyan Shilling (Ksh) = 13.15 Ls

The economic impact of the project based on comparison of the average income before and after project implementation was not satisfactorily carried out due to unavailability of reliable data on average income before the project implementation. However, comparison between average income of project and non-project populations showed that fuel wood production and farm labour are additional sources of income in the project area unlike its surrounding areas. Total household income generated from all activities was found to be higher in the project area, i.e 389012 Sudanese Pounds (Ksh 29583) as compared to 274618 Sudanese Pounds (Ksh 21883) outside the project area. Comparison of means of income for project and non project people was significantly different at 5% level using least significant difference test (LSD) (Steel and Torrie 1980).

Various factors which prevent the people from engaging in income generating activities were also examined. They included water shortage, lack of capital, marketing problems and lack of raw materials they were indicated by 67.5%, 55%, 20% and 17.5% of the respondents respectively.

5.1.3 DEVELOPMENT OF WATER SOURCES

Permanent water supply is often the determining factor for the spatial distribution of both human and animal populations. The study area was lacking sufficient water sources, and one of the project objectives was to provide water as step to achieve rangeland improvement. The main sources of water before and after

the project implementation are shown in Table 5.3. According to the respondents, water is available only during the short rainy season in ponds and wadis. During the dry season herders usually bring their cattle for watering every other day from villages as far way as 15-30 Km. Development of new water sources in the study area is vital for the reason that it would enhance proper distribution of livestock and alleviate the high grazing pressure exerted by concentration of livestock around water points which sometime exceeds the carrying capacity of range resources.

Table 5.3 Water Sources in the Study Area

Water source	No. and % of		Non-participants
	Bef.	Af.	
Bore holes	19(47.5%)	20(50%)	14(35%)
Shallow wells	3(7.5%)	9(22.5%)	5(12.5%)
Surface reservoirs	-	4(10%)	-
Hafirs	-	4(10%)	1(2.5%)
No water sources	18(45%)	3(7.5%)	20(50%)

* N = 40 for each stratum.

(1) Bef. proj. = before project implementation.

(2) Af. proj. = after project implementation.

Before the project implementation the main sources of water were bore holes and shallow wells which were further developed under the project activities. The water sources which have been developed include surface reservoirs and hafirs as indicated in Table 5.3. Comparison of water sources before and after project implementation indicate that the project has contributed much to development of water sources, particularly surface reservoirs and hafirs by application of improved water harvesting techniques. Availability of permanent water supply in the study area is important. As it was indicated by 76.3% of the participants and non-participants, time spent on looking for water was saved. Also, 56.3% of the respondents indicated that human and draught power used in water transportation was reduced. The water sources developed by the project was found to be cheap and clean as indicated by 50% and 8.8% of total respondents respectively. The social and economic benefits brought about by improved water development are therefore considerable. The manpower and time spent on looking for water could be used in crop and livestock production, education and other activities.

5.1.4 CONTROL OF RANGELAND DETERIORATION

According to the people interviewed several factors were found to have caused rangeland resource deterioration. Major ones were low rainfall, drought, improper agricultural expansion, wild fires and cutting of trees were mentioned as the main causes of rangeland

deterioration by 91.2%, 48.7%, 41.2%, 36.3% and 33.7% of the total respondents respectively (Table 5.4). According to the participants soil erosion and overgrazing were indicated to have contributing little to natural resource degradation. Analysis of variance for factors contributing to rangeland deterioration in the project and outside the project areas showed non significant difference ($p>0.05$).

The high percentage of respondents who mentioned the low rainfall as the major factor causing rangeland deterioration indicated that the people usually relate the changes of vegetation cover to climatic factors, thus indirectly denying the impact of human activities such as cultivation and burning. Some respondents argued that if rainfall was sufficient to support plant growth, abundant grass growth will enrich vegetation cover and there would be no shortage of pasture during dry season. It was not a single factor such as low rainfall or frequent drought that causes natural resource deterioration. Rather it was the effect of interaction between adverse climatic conditions and human activities through misuse of natural resources.

A study carried out in North Kordofan, Sudan by Mohammed et al. (1996) showed that land degradation and ecological imbalance associated with the combined adverse effect of years of below average rainfall and mismanagement may be favourably reversed if rational management practices are applied in accordance with rainfall patterns. They concluded that the flora and fauna of North Kordofan are ecologically resilient and when good conditions

prevail, mainly during good rainy seasons, they recover rapidly. The same findings have been reported for the semi-arid rangelands of Machakos District, Kenya (Tiffen and Mortimore 1994).

Table 5.4: Factors Contributing to Rangeland Deterioration

Factor*	Participant (N=40)	Non-Partic-ipant(N=40)	Total N=80
Low rainfall	39(97.5%)	34(85%)	73(91.2%)
Frequent drought	21(52.5%)	18(45%)	39(48.7%)
Agriculture expansion	16(40%)	17(42.5%)	33(41.2%)
Wild fire outbreaks	9(22.5%)	20(50%)	29(36.3)
Cutting of trees	8(20%)	19(47.5%)	27(33.7%)
Water and wind erosion	11(27.5%)	7(17.5%)	18(22.5%)
Overgrazing	5(12.5%)	9(22%)	14(17.5%)

* Some farmers mentioned more than one factor.

Fire is not used as a tool for rangeland management within the study area. Obeid (1980) reported that wild fire outbreaks annually destroy about 34% of the potential forage resources of Sudan and induce remarkable changes in the botanical composition of the predominant vegetation formations and individual plant communities. Desirable grasses which are susceptible to repeated burning are

being replaced by less desirable fire-resistant plant species. As a result about 95.88% of the floristic composition in 1983 was annual forbs (Table 5.8).

Considerable number of respondents indicated that range resource deterioration was a result of human activities such as expansion of agriculture into marginal lands, overgrazing, wild fire outbreak and improper felling of trees (Table 5.4). The project has succeeded in creating awareness about resource degradation problems and the urgent need for protection and proper management of these resources. However, improved resource management techniques implemented by the project have been accepted by local people and will help stem further resource deterioration. Several methods were indicated by respondents and staff of the project have been used for protection and improvement of the rangeland. Protection of rangeland from wild fires by establishing firebreak was the main effective practice as mentioned by 50% and 65% of the project participants and non participants respectively (Table 5.5). Other effective measures used for protection and improvement of rangeland resources include grazing reserves, reseeding and construction of fences, which were mentioned by 38.75%, 31.25% and 5% of the total respondents respectively. Some respondents argued that reseeding was not necessary because grass seeds are already in the soil. The important issue according to them was the protection of the seeds until they germinate and seedling develop to maturity and produce new seeds.

Table 5.5: Rangeland Protection Methods

Range land protection methods*	Participants No=40	Non participants No=40
Firebreaks construction	20(50%)	26(65%)
Reseeding of rangelands	15(37.5%)	10(25%)
Grazing reserves	14(35%)	17(42%)
Construction of fences	1(2.5%)	3(8%)

* Some respondents mentioned more than one protection method.

5.1.5 IMPROVEMENT OF VEGETATION COVER

The results derived from the questionnaire on general features of vegetation cover were in line with those of vegetation survey. The observation by the respondents indicated that there was a noticeable change in woody plant cover from disperse and medium to dense since implementation of the project (Table 5.6). According to the respondents' opinion, there has been a noticeable improvement in woody cover as a result of reseeding and fencing activities carried out by the project.

Table 5.6: Woody Cover as Described by Project Participants and non-Participants

Description of trees	No. and % of participants		Non-Participants
	Before project	After project	
Dense	10(25%)	18(45%)	12(30%)
Medium	14(35%)	8(20%)	15(37.5%)
Disperse	16(40%)	14(35%)	13(32.5%)

The local people have practical experience based on long period of observation by which they can describe the general feature of range resources, employing their indigenous knowledge which acquired through generations. Some respondents noted that, in the past, the study area was dominated by palatable plant species like *Cenchrus biflorus* " L.", *Blepharis linariifolia* " Pers" and *Echinochloa colonum* "(L.) Link". These plant species have disappeared due to excessive grazing and wild fire outbreaks and have been replaced by other less desirable species. Annual forbs are invading the area as a consequence of elimination of some grass species by overgrazing and because of the high competition of some forbs like *Sida cordofanum* "L." and *Cassia tora* "L.".

The general features of rangeland were described by 67.5% of the participants and 50% of the non-participants to have been improving, while 15% of the participants and 20% of the non-

participants indicated that there was no change since the inception of the project (Table 5.7). As observed by the respondents, direction of change in almost all indicators investigated is upward in comparison to the situation before the project implementation. These changes in vegetation cover towards improvement of woody cover and general features of the rangeland are a good indication of effectiveness and sustainability of rangeland conservation and improvement activities carried out in the study area.

Table 5.7: General Rangeland Features as described by Respondents

Description of rangeland	Participants N=40	Non participants N= 40
Continuously improving	27(67.5%)	20(50%)
No change	6(15%)	8(20%)
Gradually deteriorating	5(12.5%)	9(22.5%)
Fast deterioration	2(5%)	3(7.5%)

5.2 VEGETATION ANALYSIS

5.2.1 BOTANICAL COMPOSITION AND COVER OF HERBACEOUS PLANTS

Vegetation measurements were conducted to determine the direct bio-physical changes that might have occurred as a result of the technical interventions introduced in the study area. The results indicated that total of 46 plant species were identified in the study area, out of these 16 species were present in the sample stand. Generally there was apparent change in some vegetation parameters which might be attributed to the project interventions. Botanical composition of herbaceous plants were calculated and presented in Table 5.8. Comparison of the data from control experiment and data collected before project initiation showed that the botanical composition of herbaceous plants has been on increase since the implementation of the project. The most dominant plant species was found to be *Sida cordofolia* "L." which had a botanical composition of 37.50%. *Zornia glochidiata* "Dc" constituted 43.65% of the total botanical composition in the project area.

The botanical composition of all annual forbs has been on the decline since the inception of the project except for those of *Amaranthus graecizans* (L.), *Euphorbia sp.* (L.), *Fimbristylis hispidula, Zornia glochidiata* (Dc.). The annual forbs which had declined in botanical composition included the undesirable species such as *Acanthospermum hispidum* (Dc.), *Sida cordofolia* (L.) and *Chorchorus olitorius* (L.). Annual grasses, *Digitaria gayana* " (Kunth) Starf ex A.chev" and *Eragrostis aspera* "(Jacq.) Nees", were

Table 5.8: Botanical Composition of Herbaceous Plants

Plant Species	% Botanical Composition		
	1983*	Project Area	Outside Project
Aristida funculata	-	-	1.52
Cenchrus biflorus	0.34	7.04	2.44
Cetenium eleganus	0.34	-	-
Chloris pyenothrix	-	1.04	-
Dactyloctenium aegyptium	0.68	4.73	2.13
Digitaria gayana	0.34	10.62	-
Echinochloa colonum	-	1.73	-
Eragrostis aspera	2.05	14.09	3.96
Total annual grasses	3.75	39.24	10.05
Acanthospermum hispidum	3.42	-	2.74
Achyranthus aspera	1.71	-	0.91
Amaranthus graecizans	-	0.23	-
Cassia tora	9.25	2.66	8.23
Chorchorus olitorius	0.34	-	0.30
Euphorbia sp.	-	0.35	-
Fimbristylis hispidula	-	0.80	0.91
Indigofera diphylla	4.79	-	5.49
Ipomea cardiosepala	0.68	0.58	-
Sida cordofolia	42.81	8.54	37.50
Zornia glochidiata	32.87	43.65	32.93
Total annual forbs	95.88	56.81	89.01
Aristida pallida	0.34	2.77	0.61
Trienthema pentandra	-	0.80	-
Total perennial grasses	0.34	3.57	0.61
Mitacarpum scaber	-	-	0.30
Stylothanthes fructicosa	-	0.35	-
Total perennial forbs	-	0.35	0.30

* Source: Elodaya project files.

noted among the three dominant species in the study area which indicated some improvement in rangeland quality. Comparison of herbaceous botanical composition inside and outside the project area showed that the upward changes in plant composition were significant for all annual grasses except *Chloris pyenothrix* and *Dactyloctenium aegyptium* (Appendix 5). The percentage botanical composition of the most undesirable annual forbs and perennial grasses outside the project area were significantly different from those in the project area. In general the downward changes of herbaceous composition outside the project area are an indication of a continued decline in range condition.

The increase of desirable annual and perennial grasses and decline of undesirable and invader plant species in the study area may be attributed to introduction of desirable grass species such as *Chloris pyenothrix*, Echinochloa colonum "(L.) Link" and Trienthema pentandra. Introduction of these grasses, soil conservation measures as well as other cultural practices carried out by the project have contributed much to the improvement of vegetation cover and decrease in the seriousness of soil erosion.

Comparison of herbaceous botanical composition data for 1983 and 1995 in the project site was done using the variance test for homogeneity of the binomial distribution, X^2 (see, for example, Steal and Torrie, 1980). The comparison indicated that there was significant increase in all annual grasses except *Cetenium eleganus* "(L.) Rich" and *Chloris pyenothrix* (Appendix 4). This significant changes may indicate an improvement in rangeland quality. The

botanical composition of herbaceous plant species was also determined in a control experiment outside the project area. It was found to be 10.05% for annual grasses, 89.01% for annual forbs, 0.61% for perennial grasses and 0.3% for perennial forbs (Table 5.8). These results indicated that most of annual grasses, perennial grasses, and perennial forbs were on the decline outside the project area, while annual forbs were increasing.

Percentage plant, litter and ground cover were shown to have increased threefold, while percentage bare soil had decreased by half since the project implementation (Table 5.9). This change might be attributed to reseeding activities and soil conservation measures carried out in the study area. The control experiment outside the project area showed that small change had occurred in some cover attributes. Plant cover, litter, ground cover and bare soil were found to be 20.5%, 3.13%, 23.63% and 76.37% respectively.

The improvement of ground cover in the project area implies regeneration of soil fertility and protection of the soil surface from erosion. The contribution of individual herbaceous plant species to the total ground cover for the study area and outside the study area is also shown in appendix 6. The most dominant plant species were the annual plants which are less effective in protection of soil surface from erosion.

Table 5.9: Percentage Plant Cover, Litter, Ground Cover and Bare Soil

Attribute*	1983**	Project site 1995	Outside project
%Plant cover	18.24	54.22	20.5
%Litter	2.73	8.03	3.13
%Ground cover	20.97	62.25	23.63
%Bare soil	79.03	37.75	76.37

* %Ground cover = %Plant cover + %litter

** source : Elodaya Project files

5.2.2 HERBACEOUS PLANT DENSITY

Herbaceous plant density was calculated and the results were summarized as presented in Table 5.10. In the project area annual forbs had the highest relative density (61.98%), followed by annual grasses (30.56%), perennial forbs (6.49%) and perennial grasses (0.97%). Comparison of this data with the data before project initiation indicated that absolute and relative densities of annual grasses, perennial grasses and forbs have been increasing since the project implementation while those of annual forbs have been declining. The same trend was also true for the total plant density which increased from 67 plants/m^2 in 1983 to 81 plants/m^2 in 1995.

Table 5.10: Summary of Herbaceous Plant Absolute, Relative and Total Densities

Life*	1983**		Project site		Outside project	
	Abs.	Rel.	Abs.	Rel.	Abs.	Rel.
An.gr.	12	17.91	25	30.86	5	7.25
An.fo.	53	79.10	50	61.73	60	86.96
Pr.gr.	2	2.99	5	6.17	3	4.34
Pr.fo.	-	-	1	1.24	1	1.45
Total	67	100	81	100	69	100

Abs. = Absolute density (plants/m^2)

Rel. = Relative density in percentage

* An.gr. = Annual grasses Pr.gr. = perennial grasses

An.fo. = Annual forbs Pr.fo. = Perennial forbs

** Source: Elodaya Project files.

The data from outside project area indicated that herbaceous plant density was 69 plants/m^2 which was far much lower than the density in the project area. Analysis of variance for herbaceous plant absolute density between 1983 and 1995 was not significantly different ($p>0.05$) (Table 5.11). This is shows that an increase in herbaceous plant density has been declining probably due to a

concurrent increase in human activities. However, the increase in plant density is applaudable considering the condition of the area before the project was initiated. A comparison of herbaceous plant densities in the project area and the control experiment showed non significant difference (P>0.05). A comparison of means also showed non-significance at $t_{0.05}$ (Steal and Torrie, 1980). This indicates that the apparent differences are too small to be detected by these statistical procedures.

Table 5.11: Comparison of Herbaceous Plant Absolute Density for 1983 and 1995

Source of variation	df	s.squares	m.squares	F	F.tab 5%
treatment	1	24.5	24.5	0.04	5.99
error	6	3345.5	557.6		
Total	7	3370			

5.2.3 WOODY PLANT DENSITY

The density of woody plants was determined for the project and outside the project areas. The results are presented in Table 5.12. The most dominant woody species was *Guiera senegalensis* with a density of 183.3 plants/ha and the least dominant species were *Acacia albida* "Del.", *Acacia senegal* and *Ziziphus spina-christi* which had a density of 4.2 plants/ha each. The most dominant woody species was found to be unpalatable to livestock and it was

introduced mainly in degraded sandy soils due to its fast growth and ability to conserve the soil. The rest of the species were found to be palatable, though they contributed less to the quality of rangelands as a source of browse due to their low densities.

The calculation of the total density of woody plants showed that the project area had 233.4 plants/ha as compared to 90 plants/ha in 1983 when the project was implemented. This represents 13.2% annual increase in woody perennial plants, which occurred mostly as a result of the project intervention measures. The data from outside the project area showed that the total woody plants density was 120.8 plants/ha which was far much lower than the figure for the project area. The analysis of variance (ANOVA) of woody plant densities in the study area and outside showed that they were non significant ($p>0.05$). The F-test procedure was not sufficiently sensitive to show significance between the woody plant densities in the study area and outside. The apparent differences in plant densities might be attributed to afforestation activities carried out by Elodaya project. In contrast, the low woody plant density outside the project area may be due to excessive cultivation and fuel wood collection activities.

Table 5.12: Woody Plants' Densities in the Project and Outside Project Area

Plant species	Project area		Outside project	
	Abs.*	Rel.**	Abs.	Rel.
Acacia albida	4.2	1.8	-	-
Acacia senegal	4.2	1.8	-	-
Albizzia sericocephala	29.2	12.51	12.5	10.34
Balanites aegyptiaca	8.3	3.56	4.2	3.47
Combretum corfofanum	-	-	20.8	17.22
Guiera senegalensis	183.3	78.53	75	62.08
Sclerocarya birrea	-	-	8.3	6.8
Ziziphus spina-christi	4.2	1.8	-	-
Total	233.4	100	120.8	100

* Abs. = Absolute density (plants/ha)

** Rel. = Relative density in percentage

5.2.4 BIOMASS PRODUCTION OF HERBACEOUS PLANTS

Standing crop biomass production of the study area was found to be 0.62 ton/ha. This was about two times the biomass before project implementation which was 0.33 ton/ha. Considering that

human activities have been on the increase since the initiation of the project. this is a considerable increase in biomass production. The analysis of standing crop biomass outside the project area showed that herbaceous plants biomass was 0.38 ton/ha. which was far much lower than the value for the project area. Analysis of variance for herbaceous biomass production between the project area and outside the project area indicated a significant difference ($p<0.05$) (Table 5.13). The difference in biomass production was apparently caused by combination of factors including technical interventions introduced in the study area and the difference in soil types.

Table 5.13: Comparison of Herbaceous Biomass in the Project and Outside the project area

Source of variation	df	s.squares	m.squares	F	F.tab 5%
treatment	1	6348	6348	9.16	4.08
error	46	31880	693		
Total	47	38228			

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSIONS

The study area is located in low rainfall savannah zone where the dominant activities are rainfed farming, agropastoralism and nomadism. Due to the effect of some human activities which are incompatible with the fragile nature of the environment, rangeland resources have seriously deteriorated. Elodaya project came up with new concepts of natural resource management to tackle these problems and to prevent further resource deterioration. There are good prospects of combating resource deterioration in the study area. However, a number of constraints exist and where possible have to be addressed. Community participation is particularly important for projects concerned with natural resource management as the maintenance of the environment and biological productivity are often not of highest priority to rural communities when compared to food production, schooling and water provision (Lusigi and English 1991).

The technical interventions applied, which aimed at attainment of sustainable use of natural resources, were proper range management, soil conservation, water provision and improvement of crop farming. Community participation approach has been used as a convenient mechanism to involve local people in project planning

and decision-making process through their local institutions. The study revealed that community participation approach has been adequately adopted by local people and proved to be useful in mobilizing voluntary labour force to participate in conservation and management of rangeland resources. The VDCs were helped local communities become more aware of the strong relationships existing between the different components of local ecosystems and causes of natural resource depletion and land degradation. The technical interventions were suggested to be responsible for some of bio-physical and socio-economic changes in the study area.

Herbaceous botanical composition, plant cover, standing crop biomass and woody plants density were found to have changed in a positive direction. Percentage plant cover increased from 18.24% to 54.22%, percentage litter from 2.73% to 8.03%, percentage ground cover from 20.97% to 62.25%, while bare soil cover declined from 79.03% to 37.75% between 1983 and 1995. The control experiment showed that percentage contribution of plant cover, litter and bare soil were 20.5%, 3.13% and 76.37% respectively. Herbaceous plant density was increased from 67 plants/m^2 project implementation to 81 plants/m^2 in the study area and increased to 69 plants/m^2 outside the study area. The density of woody plants increased from 90 trees/ha before to 233.4 trees/ha in the study area and increased to 120.8 trees/ha outside the study area. The same trend was observed for biomass production which increased from 0.33 ton/ha to 0.62 ton/ha and 0.38 ton/ha in both the project area and outside it respectively. Herbaceous biomass production in the study area was

significantly different from that outside the project area ($p < 0.05$). Considering the adverse environmental conditions and increasing human activities in the study area, these bio-physical and socio-economic changes might be attributed mainly to the project interventions.

The project was contributed positively to rangeland conservation, water development, income generation and other socio-economic aspects. The self-help approach through the use of Village Development Committees was the main tool in achieving these developments. The study revealed that people have accepted application of the new interventions introduced in the study area and are enthusiastic to continue with the ongoing project activities conserve and manage their natural resources.

It may be concluded that community participation is important in creating awareness of local communities about problems of natural resource deterioration and has proved to be the key factor to the success of range resource conservation. The technical interventions introduced in the study area had a significant effect on vegetation cover and socio-economic attributes. Considerable improvements have been achieved in water sources, vegetation and social spheres of local communities. Plant species have increased from undesirable to more desirable ones, an indication of range improvement.

The project experience has shown that no single approach such as introduced technology or traditional techniques can solve the

rural people's problems. Therefore, integration of indigenous knowledge with new technology could result in sustainable use of natural resources. The local people have acquired some technical knowledge, in some environmental and socio-economic aspects, which they can use to carry on with the project activities after its termination. The fact that most people of the study area generated their livelihood from related rainfed agricultural activities calls for special attention to be paid to natural resource exploitation in such fragile environment.

6.2 RECOMMENDATIONS

Considering that the slef-help approach has been a success in mobilizing people to participate in rangeland resource conservation, it is recommended that such activities be replicated in other areas with similar problems.

Specific recommendations are as follows;

(1) Emphasis should be put on bottom-up approach whereby village and nomadic development committees become the key decision making centres for combating rangeland problems.

(2) Inherent ecological features of the study area and human activities which are incompatible with productivity of natural resources should not be ignored when planning for rangeland utilization.

(3) Technical training in natural resource management and land degradation control should be a continuous process to enable local

communities to understand the prevailing environmental problems and their solutions.

(4) Improvement techniques related to land-use and natural resource management should be based on simple traditional measures which could be easily adopt by local farmers and herdsmen. They must be adapted to local ecological conditions and relevant to needs and circumstances of local communities.

(5) The government should ensure that qualified extension agents are available to assist people in implementing introduce techniques of rangeland conservation and water sources improvement.

(6) There is need for an extensive inventory and mapping of grazing resources to be carried throughout the country to facilitate check in ecological deterioration and assure sustainable future resources utilization.

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APPENDICES

Appendix 1: Questionnaire

Questionnaire No.....

Date :.....

A/ Social data

1: village: .....

2: Respondent's name:.....

3: Participant:

Yes	No

4: Sex:

Male	Female

5: Age:

years

6: Education:

Educational level	Tick
Illiterate	
Elementary	
Intermediate	
Secondary	
High education	

7. Occupation:

Occupation	Tick
Farmer	
Herder	
Merchant	
Others "specify"	

8: Family size:

Attribute	Number
Family size	
Adult males	
Adult females	
School-age boys	
School-age girls	

B/ Land use systems

9: Cultivation:

Attribute	Codes
Area (ha)	
Soil type	0 1 2 3
Land use	0 1 2 3
Cultivation	0 1 2 3
Acquisition	0 1 2 3
Managed by	0 1 2 3

Key:

Attribute	0	1	2	3
Soil type	sand	sandy clay	sandy loam	clay
Land use	field crop	rangeland	hashab	fallow
Cultivation	single-cropping	multi-cropping	inter-cropping	mixed-cropping
Acquisition	inheritance	clearance	rent in	share
Managed by	myself	wife	relative	others

10: What are the crops you cultivate and what is the area and the yield?

Crop type	Area (ha)	Yield (kg)
Groundnut		
Millet		
Sorghum		
W. mellon		
Sesame		

11: How many livestock do you keep now compare to the period before implementation of Elodaya project?

Animal type	Now	Before
Camel		
Cattle		
Sheep		
Goats		

C/ Household income

12: Approximately how much of your gross income come from the following activities?

Activity	Income (Ls.)
Crop farming	
Livestock raising	
Gum arabic production	
Firewood and charcoal	
Farm labour	
Other sources of income	

13: Have you engaged in one or more of the following Income generation activities during the dry season?

Activity	Tick
Collect hay	
Petty trading	
Tree products e.g firewood, charcoal, building materials	
Handicrafts	
Others "specify"	

14: What are the major constraining factors rendering you from engaging in such income generation activities?

Factor	Tick
Raw material	
Water shortage	
Lack of finance	
Marketing problems	
Others"specify"	

D/ Land degradation

15: What are the main factors contributing to rangelands resources deterioration?

Factor	Tick
Improper agriculture expansion	
Low rainfall	
Water and wind erosion	
Overgrazing	
Cutting of trees	
Frequent drought	

16: What are the methods of controlling deterioration of rangelands you know?

Method	Tick
Fire breaks construction	
Reseeding of rangelands	
Grazing reserves	
Construction of fences	

17: How do you know about the problems and control of land degradation?

Source of information	Tick
Extension agent visits	
Radio programs	
Office visits to agricultural agent	
Group meetings	
Friends and neighbours	
Others"specify"	

E/ Community participation

(questions of this section are to be answer by participants only)

18: Which of the following activities have you participated in? Rank them according to their importance to you?

Activity	Tick
Establishment of Perimeters	
Water development	
Reseeding of degraded rangelands	
Soil conservation activities	
Establishment of firebreaks	

19: Are you a member of the Village Development Committee (VDC)?

Yes	No

(b) why?

Reason	Tick
Open for all people	
Restricted for some people	
Efficient and useful	
Inefficient and useless	
Others"specify".....	

20: Who encouraged you to participate in Elodaya project activities?

Source	Tick
Village leaders	
Friends	
VDC members	
Project officials	

F/ Vegetation cover

21: Is there any change in woody cover compare to the period before project implementation?

Tree cover	Dense	Medium	Disperse
Before project			
After project			

22: Have you noticed any change in the general features of the rangelands around your village?

Change	Tick
Continuously improving	
No change	
Gradually deteriorating	
Deteriorating fast	

23. What is the critical period of pasture availability?

.....

24. What are the benefits you get from the perimeters as related to your livestock? Please rank the benefits according to their importance to you?

Benefit	Tick
Available fodder at critical time	
No long distance movement of animals	
Less animal death	
More milk	
Others"specify"	

25. What is the source of water for human and animal consumption on your village after and before implementation of the project?

Water source	bore hole	Surface reservoir	Shallow well	Hafir
Before project				
After project				

26. What are the benefits you get from establishment of water source?

Benefits	Tick
Save time	
Less efforts	
Clean	
Cheap	
Others"specify".....	

Appendix 2: General Assessment of Elodaya Project Interventions

1: Can you assess to me the degree of achievement of the following project activities?

Activity	1 2 3 4
Seed collection and reseeding of rangelands	1 2 3 4
Establishing of firebreaks	1 2 3 4
Construction of reservoirs,shallow wells,hafirs	1 2 3 4
Soil conservation activities e.g. Gully control, wind breaks	1 2 3 4
Participation of people in project activities	1 2 3 4

Key: 1. Excellent 2. Good 3. Fair 4. Poor

2: What do you think the proper means to achieve a true popular participation in Elodaya project activities?

Activity	Tick
VDCs	
Cooperatives	
Through Sheikhs	
Project	
Lineage	

3: After termination of the project, do you think the people in this area capable to conserve what has been achieved?

Yes	No

If Yes why? .....

If No why? .....

4: Is there any other activities of priority you suggest to be included in the project activities?

Yes	No

If Yes, (specify) .....

5: Do you have any suggestions on how to solve the problems of natural resource deterioration in such rural areas?

1.

2.

3.

Appendix 3: List of Some major Plant Species Identified in the Study Area

Species Name	Common Name
A/trees and shrubs	
Acacia albida	Haraz
A. senegal	Hashab
Adansonia digitata	Tabaldi
Albizzia amara	Arad
Balanites aegyptiaca	Heglig
Bauhina reticulata	Kharob
Combretum cordofanum	Habil
Guiera senegalensis	Ghobeish
Lannea humilis	Layon
Sclerocarya birrea	Humeid
Tamarindus indica	Aradeb
Terminalia brownii	Darot
Ziziphus spina-christi	Seder
B/ Herbs	
Acanthospermum hispidum	Herab hawsa
Achyranthus aspera	Kashm nasiba
Alysicarpus sp.	Fresha
Amaranthus graecianis	Tamalika
Bergia sp.	Um ejena
Blepharis linariifolia	Beghil
Boerhavia verticulata	Shalop
Cassia mimosoides	Soreeb
Cassia tora	Kawal
Chrozophora brochiana	Argasi
Commelina imberbis	Bied
Corchorus olitorius	Molokhia
Ephorbia sp.	Umm libina
Fimbristylis hispidula	Fisisiat
Ipomea cardiosepala	Hantoot
Indiogfera diphylla	Angarat waral
Mitracarpus scaber	Um charbi
Monechma hispidum	Shaer
Oldandia senegalensis	Garajob
Sida cordofolia	Najada
Stylosanthes fructicosa	Natasha
Tephrosia lupinfolia	Tagtaga
Termfetta sp.	Karkaj
Waltheria indica	Erg elnar
Zornia glochidiata	Shelini

List of Plant Species (continue)

Species Name	Common Name
C/ Grasses	
Andropogon gayanus	Abu rakhis
Aristida funiculata	Gaw
Aristida pallida	Um somema
Cenchrus biflorus	Haskanit kashin
Cetenium elegans	Danab naga
Chloris pyenothrix	Daz
Dactyloctenium aegyptium	Abu sabi
Digitaria gayana	Um aaj
Echinochloa colonum	Difera
Eragrostis aspera	Benu
Hypoestis cancellata	Mahalab
Pennisetum pedicellatum	Um dofofu
Trienthema pentandra	Rabaha

Appendix (4) Comparison of Botanical Composition of Herbaceous Plants before and after Project Implementation

plant species	1983*	1995	X^2 value
Annual grasses			
Cenchrus biflorus	1	61	19.35*
Cetenium eleganus	1	0	2.97
Chloris pyenothrix	0	9	3.06
Dactyloctenium aegyptium	2	41	10.02*
Digitaria gayana	1	92	31.25*
Echinochloa colonum	0	15	5.12*
Eragrostis aspera	6	122	32.16*
Annual forbs			
Acanthospermum hispidum	10	0	29.92*
Achyranthus aspera	5	0	14.89*
Amaranthus graecianis	0	2	0.68
Cassia tora	27	23	22.96*
Chorchorus olitorius	1	0	2.99
Ephorbia sp.	0	3	1.01
Fimbristylis hispidula	0	7	2.37
Indigofera diphylla	14	0	42.03*
Ipomea cardiosepala	2	5	0.04
Sida cordofolia	125	74	180.13*
Zornia glochidiata	96	378	10.48*
Perennial grasses			
Aristida pallida	1	24	6.09*
Trienthema pentandra	0	7	2.37
Perennial forbs			
Stylothanthes fructicosa	0	3	1.01

* Source: Elodaya project files

Appendix (5) Comparison of Botanical Composition of Herbaceous Plants

plant species	Project area	Outside project	X^2 value
Annual grasses			
Aristida funculata	0	5	13.27*
Cenchrus biflorus	61	8	9.26*
Chloris pyenothrix	9	0	3.43
Dactyloctenium aegyptium	41	7	4.17
Digitaria gayana	92	0	37.75*
Echinochloa colonum	15	0	5.75*
Eragrostis aspera	122	13	24.32*
Annual forbs			
Acanthospermum hispidum	0	9	23.94*
Achyranthus aspera	0	3	7.94*
Amaranthus graecianis	2	0	0.76
Cassia tora	23	27	18.43*
Chorchorus olitorius	0	1	2.64
Ephorbia sp.	3	0	1.14
Fimbristylis hispidula	7	3	0.03
Indigofera diphylla	0	18	48.25*
Ipomea cardiosepala	5	0	1.90
Sida cordofolia	74	123	144.77*
Zornia glochidiata	378	108	11.33*
Perennial grasses			
Aristida pallida	24	2	5.21*
Trienthema pentandra	7	0	2.67
Perennial forbs			
Stylothanthes fructicosa	3	0	1.14
Mitacarpus sp.	0	1	2.64

Appendix (6): Comparison of Percentage Ground Cover by Individual Plants

Attribute	Project area	Outside project
A/ Grasses and herbs		
Aristida funculata	-	0.31
Cenchrus biflorus	3.82	0.50
Chloris pyenothrix	0.56	-
Dactyloctenium aegyptium	2.56	0.44
Digitaria gayana	5.76	-
Echinochloa colonum	0.94	-
Eragrostis aspera	7.64	0.81
Acanthospermum hispidum	-	0.56
Achyranthus aspera	-	0.19
Amaranthus graecianis	0.13	-
Cassia tora	1.44	1.69
Chorchorus olitorius	-	0.06
Ephorbia sp.	0.19	-
Fimbristylis hispidula	0.44	0.19
Indigofera diphylla	-	1.13
Ipomea cardiosepala	0.31	-
Sida cordofolia	4.63	7.68
Zornia glochidiata	23.67	6.75
Aristida pallida	1.50	0.13
Trienthema pentandra	0.44	-
Stylothanthes fructicosa	0.19	-
Mitacarpus sp.	-	0.06
Total plant cover	54.22	20.50
B/ Other categories		
Litter	8.03	3.13
Bare soil	37.75	76.37