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Research on Poverty Alleviation (REPOA)
P.O. Box 33223, Dar es Salaam, Tanzania
157 Mgombani Street, Regent Estate
Tel: +255(0)(22) 270 00 83 / 277 2556
Fax: +255(0)(22) 277 57 38
Email: repoa@repoa.or.tz
Website: www.repoa.or.tz

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Changes in the Upland Irrigation System and Implications for Rural Poverty Alleviation

A Case of the *Ndiwa* Irrigation System, West Usambara Mountains, Tanzania

Cosmas H. Sokoni
&
Tamilwai C. Shechambo

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GDP	Gross Domestic Product
NIS	*Ndiwa* Irrigation System
PRS	Poverty Reduction Strategy
SAP	Structural Adjustment Programme
SECAP	Soil Erosion Control and Agroforestry Project
TIP	Traditional Irrigation Programme / Project
URT	United Republic of Tanzania

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ABSTRACT

Rural poverty is a major problem in Tanzania that has become the focus of different development strategies. Poverty alleviation is a priority objective in the national development strategies. The Agricultural and Livestock Policy of 1997; the Agricultural Sector Development Strategy of 2001; and the Tanzania Development Vision 2025 recognize the critical importance of agriculture to poverty reduction. However, inadequate and unreliable rainfall has restricted the potential of the rain-fed agriculture for rural poverty alleviation. Consequently, there has been an increasing appreciation of the role of small-scale traditional irrigation development. Yet, traditional irrigation systems face numerous constraints that have to be solved in order to realise their potential for rural poverty alleviation.

Ndiwa is an indigenous traditional irrigation system that is practiced on the West Usambara Mountains. The *Ndiwa* Irrigation System (NIS) has been experiencing various changes that influence its potential for poverty alleviation. This study identifies and explains the changes in NIS and examines their implications to rural poverty alleviation. A sample of seven villages was drawn from three divisions. Data was collected from current, previous and non-ndiwa users through a household questionnaire; group discussions and key informants.

The findings of the study show that NIS contributes to poverty alleviation as it enables upland farmers to produce products especially vegetables during the dry season. This not only rescues farmers from unreliable rain-fed agriculture, but also generates higher incomes since farmers can grow high values crops more frequently. *Ndiwa* farmers are better off compared to non-ndiwa farmers in their possession of material assets such as better houses, more livestock, fields, durable household items and farm implements. These have resulted from the better income earned from using the NIS. However, various constraints threaten this positive contribution of NIS to rural poverty alleviation.

The NIS has been changing over the decades. The number of farmers relying on NIS has kept growing. But the quantity of water for NIS is decreasing. This has led to the disappearance of some *Ndiwa* structures, although in some localities new *Ndiwa* structures have been constructed. The time it takes to fill a ndiwa reservoir has also increased, leading to long intervals of accessing water for irrigation. Also water no longer reaches distant fields. Growing demands for water while the supply decreases has often been the cause of conflicts among *Ndiwa* water users. Over time, the management of *Ndiwa* and the social organisation of *Ndiwa* users have changed hands from clan elders to village government leaders and in some cases to private users.

The major factors that have had impacts on the quantity of water include prolonged dry seasons; poor management of the *Ndiwa* water catchment areas including the removal of water conserving vegetation; planting of eucalyptus tree species that use much water; and farm encroachment into water sources. The problem of water scarcity has been exacerbated by the growing population that needs irrigation water. This includes returning youths, migrants from urban areas and school leavers.

The changes in NIS threaten its role in rural poverty alleviation. However, there are potentials for improving the situation. The quantity of water can be improved through better ndiwa catchment management techniques that enhance greater infiltration of water during the rain season. Removal of eucalyptus tree species and planting of water conserving plant species is recommended. Water harvesting farming techniques such as terracing, contour bunds, and ditches are important. Techniques that save water are also important. Structures that reduce water loss, such as pipes instead of furrows, are recommended. The Traditional Irrigation Programme TIP intervention of improving *Ndiwa* structures by enlarging and strengthening them should be promoted in all localities using NIS.

The study recommends that policy on irrigation should emphasise both the enhancement of agricultural production and the conservation of water sources. Better management of the *Ndiwa* water catchments requires greater effort of delivering agricultural extension services. There is also the need for further research on appropriate water harvesting and water saving techniques for *Ndiwa* irrigation.

1. INTRODUCTION

1.1. Introduction and Background

Poverty in sub-Sahara Africa rates high and has been increasing[1] and, therefore, becoming a major impediment to socio-economic development. Consequently poverty alleviation has become an overriding goal of development policy and planning in developing countries. Tanzania, like other developing countries, faces the problem of rural poverty. Shitundu and Luvanga (1996) and Narayan (1997) have emphasized that poverty in Tanzania is mainly a rural phenomenon. Ferreira[2] classified 42 per cent of all rural households in Tanzania as living in abject poverty. Furthermore, rural households account for 92 per cent of the Tanzanian poor. Poverty encompasses both inadequate income and inadequate access to non-income dimensions such as basic services, personal security, empowerment to participate in decision-making, and others. Other indicators of poverty include low levels of education, poor nutrition, high vulnerability to diseases, calamities, etc[3]. Most studies show that rural population is significantly poorer than the urban population. It is estimated that about three fifth of the rural inhabitants are below the poverty line[4].

Poverty alleviation is a priority objective of the national development strategies of Tanzania. The Agricultural and Livestock Policy of 1997; the Agricultural Sector Development Strategy of 2001; and the Tanzania Development Vision 2025 recognise the critical importance of agriculture for the reduction of rural poverty. The Tanzania Water Policy of 1991 emphasizes the need for improving water harvesting for industry and domestic uses. Through the Traditional Irrigation Development Programme (TIP), Tanzania has demonstrated the recognition of the importance of development and management of scarce water resources for agricultural production. Raising rural agricultural production through better management of water resources should lead to increased income and food security for farmers and consequently should reduce poverty among rural households.

However, strategies for alleviating poverty vary over time and space with the resource potential of an area. Inadequate and unreliable rainfall and the resulting soil moisture deficiency restrict the potential for the development of rain-fed agricultural production in semi-arid areas. This has great implications for the livelihoods of the majority of smallholder agricultural producers, whose livelihoods depend on agriculture. Thus, the effective utilization of the scarce water resource is essential for sustainable agricultural development[5]. The development of irrigation systems, has been a common intervention measure for minimizing crop production risks, raising incomes and increasing food security. There is a growing appreciation that the development of irrigation plays an important role towards poverty reduction through enhancing higher and stable production levels.

For these purposes, agricultural communities in Tanzania and elsewhere in sub-Saharan countries have developed different irrigation systems. Various research works have demonstrated the importance of traditional irrigation systems in enhancing rural production[6]. In traditional irrigation systems, water is conveyed to the fields by traditional furrows that are managed by local farmers. The preference for the development of small-scale farmer managed irrigation schemes is partly due to the limitations of modern large-scale irrigation schemes. Modern irrigation technology is often capital intensive, expensive and therefore not accessible to most small-scale farmers. Due to the limitations of modern technology, only 0.2 million hectares out of 1.0 million hectares suitable for irrigation, are currently being irrigated[7]. There has been, therefore, a growing appreciation of the contribution of small-scale irrigation for rural development[8].

[1] IFAD, 2002
[2] 1994, quoted in Narayan, 1997:1-2
[3] URT, 2003
[4] World Bank, 1993
[5] Hatibu et al., 2002
[6] Shibundu and Luvanga, 1998; Mkavidanda and Kaswamila, 2001; Tagseth, 2002
[7] MAFS, 2002
[8] Yoshinda, 1988:76

Although the role of traditional irrigation systems in enhancing rural agricultural production and alleviating poverty is widely recognized, this role has not been successfully implemented everywhere. The poor performance of the traditional irrigation systems has been the reason for establishing upgrading schemes through traditional irrigation programmes. Where upgrading has not been undertaken some traditional irrigation systems have declined. The TIPs have not been able to cover all the traditional irrigation systems and areas within the Usambara Mountains.

Whereas most of the traditional irrigation systems have been operating for many decades, the environments under which they operate have been changing. The decline in some traditional irrigation systems is probably a response to the changing environmental, socio-economic and spatial circumstances under which they develop and operate. Analyses of water resource management for irrigation in the Pangani Basin[9] suggests that changes in these circumstances have had some impact on small-scale irrigation systems. There is, therefore, the need to understand the nature and causes for changes in traditional irrigation systems and their implications to rural livelihoods.

The Usambara Mountains fall within the Pangani Basin. It is an area that is remarkable for rural poverty[10]. Due to various constraints, irrigation has not succeeded in substantially reducing poverty in this area. The TIP has intervened in improving rural livelihoods in the Usambara Mountains through traditional irrigation improvement, and soil and water conservation[11]. However, in areas where TIP has not reached, the traditional irrigation system requires more support. This study concentrates on areas where the traditional *Ndiwa* irrigation system (NIS) has not been improved through TIP efforts. However, some areas where the TIP has been operating are included for comparative purposes. It is geared towards a better understanding of the changes taking place in the traditional irrigation system, farmers' coping strategies to changing physical, socio-economic environments and the implications these have for their livelihoods and poverty alleviation.

1.2 Statement of the Problem

The West Usambara Mountains region is an important agricultural area in Tanzania. It is the major producer of especially fruits and vegetable for urban markets in Tanzania. However, the agricultural systems of the area are constrained by inadequate and the often unpredictable rainfall, which is suitable for rain-fed agriculture. Its mean annual rainfall ranges between 1,200 – 1,400mm, and rainfall levels as low as 600 mm have been recorded in recent years[12]. This is a major constraint to rain-fed agriculture as it has often disturbed agricultural activities. Crop withering due to prolonged dry conditions is not uncommon (see Photo 1.1).

The West Usambara is one of the most densely populated areas in Tanzania. Jambiya estimated the arable land density at 254 persons per km^2 (Jambiya, 1998). The censuses of 1978 and 1988 recorded the population density of the area at 153 and 198 persons per km^2 respectively[13]. This high population density implies a high demand for land and water resources for irrigated agriculture. Whereas the traditional irrigation systems are well acknowledged for their importance in enhancing agricultural production and alleviating poverty and food insecurity, the physical and socio-economic environment under which they operate have changed over time. This has led to changes in the traditional irrigation systems. This, however, is not peculiar to the West Usambara area. Tagseth (2002) observes a decline in the number of '*mifongo*' traditional irrigation schemes between the 1940 and 1990 in the Pangani Basin. Similarly Hatibu, et al, (2002) have observed changing historical trends in soil and water conservation practices in semi-arid regions of Tanzania.

[9] Ngana, 2002
[10] Mascarhenas, 200
[11] Mgendi, 2001
[12] Lynch, 1999: 176
[13] Lynch, 199

Photo 1.1. Maize Crop Withering Due to Inadequate Rainfall at Emao Village

Ndiwa is best described as an overnight reservoir or farm pond (Plate 1.2). It is often dug on mountain slopes and is fed by springs. Spring channels are dammed, the water is allowed to accumulate for 12 to 24 hours and then released for irrigation. Sometimes a dam is constructed beside a spring or a stream channel. It is therefore a means of accumulating spring water. Although it is relatively small in scale compared to other irrigation systems, *NIS* provides supplementary water during critical times, especially during the dry season. *Ndiwa* is an indigenous traditional irrigation system that has been in operation on the Usambara Mountains for several decades dating as back as the 1940s. Unlike the furrow and lowland irrigation systems that rely on stream / river water, the *Ndiwa* system is designed to harvest water from springs. It is, therefore, an upland irrigation system. The traditional *Ndiwa* irrigation is not based on harvesting of surface water from rainfall. It relies more on accumulating spring or stream water until sufficient quantity is attained for irrigating fields. However, in some improved NIS, water harvesting techniques have been included in the catchment's management. These include the use of cut-off drains, terraces, planting vegetation, and contour bunds.

The *NIS* has been changing over the decades. This is not peculiar to the West Usambara Mountains. The decline of *Ndiwa* traditional irrigation system on the North Pare Mountains has been reported by the TFAP project that started in 1992[14]. Significant changes have taken place in the physical and socio-economic environments of the West Usambara Mountains. However, the knowledge of the nature and reasons for the change in the NIS and their implications to rural livelihoods has not been well documented.

[14] TFAP, not dated

Photo 1.2. *Ndiwa* – A Traditional Water Storage Structure at Dule Village

This study seeks, first, to identify the nature and reasons for the changes in the traditional NIS. Secondly, it investigates the implications of the changes in NIS to the livelihoods of the local communities. Thirdly, the study explores the potential of the *NIS* for enhancing rural livelihoods and alleviating poverty.

1.3. Objectives of the Study

The principle objective of this study is to explain the changes in the *Ndiwa* traditional irrigation system in the West Usambara and investigate the implications for rural poverty alleviation.

The specific objectives of the study include:

a) to understand poverty in the West Usambara Mountains;
b) to identify changes in the ndiwa irrigation system;
c) to discuss factors and processes which have contributed to the changes in ndiwa irrigation system;
d) to study the implications of the changes in ndiwa irrigation system for the livelihoods of rural households and local communities of the West Usambara Mountains;
e) to consider the potential for improving the ndiwa irrigation system for poverty alleviation;
f) to identify other alternative livelihood strategies and their roles in enhancing rural livelihoods and poverty alleviation; and
g) to suggest policy and planning recommendations for improving the contribution of NIS to poverty alleviation and enhancing rural livelihoods.

1.4. Research Questions

The study was guided by the following research questions:

1. In what ways has the *NIS* changed in the area over time? This question involves the identification of the components / elements in the traditional NIS that have changed over the years.
2. What reasons account for the changes in the NIS? This question identifies the changes in the physical, socio-economic and spatial contexts that have influenced changes in the NIS.

3. How have the changes in the NIS affected agricultural production of households? This question captures information on the effects of changes in *Ndiwa* irrigation on households production – crops grown, output levels, incomes from agriculture, access to land and water, food availability, access to labour, etc.
4. What strategies do households adopt in response to changes in the NIS? This question intended to capture the coping strategies of households with respect to changes in the NIS. These may include efforts to improve the *Ndiwa* system and solutions sought outside of irrigated agriculture.
5. To what extent are the strategies adopted relevant for alleviating rural poverty in the West Usambara? This question intended to collect information that enables the assessment of the relevance of the changes in the NIS to rural poverty alleviation.

1.5 Significance of the study

Agricultural production in Tanzania is threatened by the inadequacy and unreliability of rainfall. It is estimated that about 80 per cent of the country has a negative water budget during crop growing seasons even on the basis of mean rainfall. The West Usambara is no exception to this fact. Although the West Usambara is an important agricultural area, many farmers face water shortages during a longer period of the year. Rain-fed agriculture is no longer reliable for sustainable agricultural production in the semi-arid areas of the Lushoto district. Hence, the development of irrigation is crucial for sustainable agricultural production and for enhancing the rural livelihoods of the local communities. As modern agricultural irrigation systems are not viable due to their high expenses, the development of traditional irrigation systems remains essential.

Rural poverty alleviation is a priority in the development programmes of Tanzania. This research will bring forth a better understanding of the changes in the *Ndiwa* traditional irrigation system and its implication to rural livelihoods. This is very important, as it will enable us to identify strategies of improving traditional irrigation systems in the study area. The study will also create greater awareness among members of the local community of the need to further improve the traditional irrigation systems.

Water management is a growing area of research in Tanzania. Whereas there has been growing literature on water management in the Pangani Basin, the West Usambara Mountains has drawn little attention. This study adds to the knowledge on water resource management in the Basin.

Agriculture is and will continue to be an important means of livelihood in Lushoto. It is, therefore, important to understand the constraints to agricultural production in the area. This study adds useful information to our understanding on the use and management of water resources for agricultural production and rural poverty alleviation in Lushoto. The study enables us to acquire a better understanding of similar agricultural systems elsewhere in Tanzania.

The NIS is still an important means of harvesting water for agricultural production. Its importance is reflected in the TIP project proposal for 2001 in which the construction of overnight reservoir was one of the proposed activities for Mlalo, Mtae and Soni divisions. Also the construction of night storage reservoirs is a component of the farmers training offered by the TIP.

1.6 Limitations of the Study

The study was concentrated on the highland zones of the Usambara Mountains whose conditions are quite different from the lowlands and river valleys of Lushoto. Due to resource limitations, the study did not cover all the areas of the West Usambara Mountains. However, it draws a representative sample of areas that did and did not receive support from TIP.

The sampling strategy intended to compare and contrast current, previous and non-*Ndiwa*-users. However, it was very difficult to find previous *Ndiwa*-users who no longer use *Ndiwa* water for irrigation. Another limitation is that the NIS varies over seasons. More information could have been acquired

if the fieldwork covered the complete year of seasons; but this was not possible due to resource constraints.

Ndiwa structures are erected on uplands stream sources. The nature of the terrain is a major constraint as it limited the number of *Ndiwa*s that could be visited by walking. The *Ndiwa* sites could not be accessed easily by car, therefore movement from one ndiwa site to another was both time and energy consuming.

2. LITERATURE REVIEW

2.1 Rural Poverty Alleviation in Tanzania

The Poverty and Human Development Report 2002 provides a comprehensive analysis of the status of poverty and the Poverty Reduction Strategy (PRS) in Tanzania. It states:

"The 1990s have not brought significant net gains in the reduction of income poverty for the majority of the population. Income poverty has only significantly declined in urban areas. While the proportion of people living below the poverty line has decreased, their number has increased. Unless the rate of decline in poverty headcount ratios is accelerated significantly as a result of PRS it will be impossible to meet the very ambitious target of halving the proportion of people living below poverty line by 2020."

The PRS aims to halve the proportion of the population living below the poverty line by 2010 both for food and basic needs poverty lines in urban and rural areas.

The report recognises the existence of rural poverty and emphasizes the need for poverty reduction. Poverty reduction strategies take different ways depending on resources available. Despite the noted increase in farmers' diversification to non-farm activities[15] agriculture is still a key sector in the rural sector. Many of the non-farm activities rely upon and have linkages to the agricultural sector.

2.2 The Role of the Agricultural Sector in Rural Poverty Alleviation

Food production in sub-Saharan countries has not kept pace with the growing demands of the region's rapidly growing population. This has implied more incidences of famine and poverty. Moreover, inadequate and unreliable rainfall and recurring droughts have reduced the potential of rain-fed agriculture for meeting the livelihood needs of the population.

Increased agricultural production is essential for increasing the per capita income for rural people and the GNP as a whole. Agriculture is the most important sector in Tanzania generating about 50 per cent of the GDP, 55 per cent of the foreign exchange and 70-80 per cent of employment[16]. This underscores the important role of the agricultural sector in rural development and poverty alleviation. Although a change towards non–farm and off-farm activities has been an emerging feature of the rural sector in Tanzania[17], (agriculture is still an important source of income and a basis for rural livelihood.

Agriculture is the principal land use and remains the major source of livelihood for the rural poor people[18]. The 1994/95 national agriculture census, for example, estimated that there were 3.87 million small-scale agricultural holdings in the rural areas of Mainland Tanzania. Smallholder producers dominate the agricultural sector.

2.3 Some Constraints of Rain-fed Agriculture

The agricultural sector in Tanzania strongly relies on rainfall. Unfortunately changes in climate and related recurrence of drought and inadequate rainfall have been a common phenomenon. This has put rain-fed agriculture at great risk and has often threatened rural people's livelihoods. The West Usambaras have not been an exception to this. Inadequate rainfall, longer dry seasons, and unreliable rainfall have threatened the performance of the agricultural sector. In some divisions of Lushoto district, there is only one major rainfall season (*vuli*) and even this rain's timing is unpredictable. In the whole district the rainfall trend shows a decrease in the average annual rainfall[19]. There is also an extremely high variation within the year and between years. Therefore harnessing available water resources for irrigation is an important strategy for sustaining incomes and rural livelihoods.

[15] Bryceson and Jamal, 1997, Mwamfupe, 2002
[16] URT, 2002:69
[17] Mwamfupe, 2002; Bryceson and Jamal, 1997
[18] URT, 1997
[19] Mwihomeke and Huwe, 1990

2.4 The Role of Irrigation for Rural Poverty Alleviation

2.4.1. Modern Irrigation

Irrigation is one of the possible means of feeding the rapidly growing population[20]. Consequently, numerous modern and large-scale irrigation projects have been established in the region. However, many large irrigation schemes in Africa have failed to fulfill their potential[21]. Reasons for the failure of most of the large-scale irrigation schemes have been widely documented[22]. Vaishnav (1994) notes that modern large-scale irrigation projects have failed because they have been very expensive (due to reliance on imported materials, equipment and expertise) and deficient in management and organisation. Turrah (1995) attributes the failure partly to a poor understanding of farmers' priorities and inadequate markets for the produce. Poor/low farmer participation in the use and management of water resources in large-scale projects also implies that the projects have not succeeded in reducing the poverty of the majority of the local population. Other factors include: faulty planning, speed of implementation, political pressures, project size, land tenure, size of holding and technology[23]. There has also been a growing concern over the impacts of large-scale water development projects on the environment.

Consequently, there is a growing importance of small-scale irrigation systems managed by individual farmers or the farming community. There is a growing interest in small-scale irrigation development for food as well as for rural development[24]. The development of small-scale irrigation schemes managed and controlled by farmers is seen as a viable and practical alternative to large-scale conventional schemes. Small-scale irrigation schemes can be adopted easily to suit local socio-economic and environmental conditions[25].

2.4.2. Traditional Irrigation

Traditional irrigation systems form an important component of the small-scale irrigation activities in Africa. Traditional small-scale irrigation plays an important role in alleviating poverty through its generation of rural incomes and food security especially where rain-fed agriculture is limited. In their study of the traditional *vinyungu* irrigation system of Iringa district, Mkavidanda and Kaswamila (2001) found that irrigation enabled income increase through the multiple cropping seasons and higher prices fetched in the dry season. Mowo, et al, (2002) note that irrigation has improved yields and has led to a shift by most farmers to production of high value crops. In traditional irrigation activities, the local communities use and manage the water resources. Traditional irrigation offers greater participation of farmers and is more adapted to local environmental conditions than large-scale projects. However, the physical, socio-economic environments under which the traditional irrigation systems operate have kept changing. The implications of these changes to rural producers are a subject that draws attention of researchers.

2.5. Changes in Traditional Irrigation Systems: Nature and Features

Unfortunately, not all traditional irrigation systems have managed to survive from numerous changes in the physical and socio-economic-cultural environments in Africa at large and in Tanzania in particular. Population growth and the related increase in population density have placed greater pressure on resources for traditional irrigation systems. The commercialization of the rural sector has brought significant changes that have transformed the functional environment of traditional

[20] Vaishnav, 1994
[21] Groenewald, 1986:667
[22] See for example Bembridge, 1986; Groenewald, 1986
[23] Bembridge, 1986:608 - 9
[24] Bembridge, 1986
[25] Vaishnaw, 1994

irrigation systems. The structural adjustment of 1980s has also changed the operating environment for traditional irrigation systems[26]. However, little information is available to explain related changes in various traditional irrigation systems in Tanzania.

A *Ndiwa* is a water storage structure that is constructed on or close to a spring[27]. Its purpose is to increase the volume of water over time and to enhance the rate of flow. Water is stored for 12 to 24 hours and then released for the purpose of irrigating crops. The water then flows through smaller canals or furrows. The NIS is known for its support of vegetable production in Mwanga and Same districts[28]. Some cases of *Ndiwa* irrigation change (decline or increase in importance) have been cited, yet explanations for their change have not been well documented. There is also a knowledge gap of the implication of such changes to rural livelihoods and poverty alleviation. In some areas more *Ndiwa*s have been established and competition for water has grown. The management of *Ndiwa* is reported to have changed over time. There has been a transfer of responsibilities in the management from traditional elders to local village government leadership. There have also been changes to farmers' access to land in response to commercialisation. Also population growth has resulted in greater pressure on water resources.

Due to their importance, there is a growing need for reviving and improving traditional irrigation systems in Tanzania. In the Usambara Mountains, the Traditional Irrigation Project (TIP) and Soil Erosion Control and Agroforestry Project (SECAP) have worked jointly to improve traditional irrigation systems. The construction of traditional water reservoirs is a common project in the Lushoto TIP yearly plans. However, the TIP has not been able to reach and improve all the areas practising *Ndiwa* irrigation in the West Usambara Mountains. There is therefore a paucity of information on the nature and causes of changes in the NIS.

2.6 Factors of Change in the *Ndiwa* Irrigation System

Developments in agricultural geography have emphasized the equally importance of the socio-economic factors in influencing changes in agricultural systems. These include changes in population densities, land tenure, technology, institutional organisations, economic set up, etc. Although they imply a shift from the environmental determinism philosophy, they do not completely deny the role of the physical environment, especially in regions with low technological development.

Information on the influence of changes in the socio-economic environment on water management for irrigation in the West Usambara is lacking. Water management for irrigation involves a number of components including: construction; routine inspection of the water storage and drainage; monitoring and regulating water level and flow; opening and closing the diversion points; cleaning of furrows; and repair in case of damage. Information is lacking on the extent to which the changes in socio-economic environments in Tanzania have influenced the existence and operation of the NIS. Sustainable intervention in the revival of the traditional irrigation systems calls for a better understanding of the processes that lead to their changes. This fills these the gaps in our knowledge.

Unlike the lowlands, where irrigation benefits from relatively more abundant water from rivers, the upland springs provide very small volumes of water that would be less useful for irrigation without some measures of accumulating the water into reservoirs. For the revival and improvement of the disappearing NIS, we need to understand the circumstances and reasons that led to its decline and the implication therefore to the rural livelihoods. Similarly where more *Ndiwa*s are being constructed, we require an understanding of the processes involved in the sharing of the water resources. One salient feature related to growing population and scarcity of water for irrigation is the emergence of conflicts. Conflict reduction requires an understanding of the nature of the conflicts. There is a need also to consider the potential of the NIS development for poverty alleviation.

[26] Tagseth, 2002; Limbu, 1995
[27] Hatibu, et al., 2002:210
[28] Hatibu, et al., 2002

Whereas inadequacy of water available for irrigation relative to growing demands is likely to account for the changes in the traditional water management systems, opinion differ on the causes for growing inadequacy of water supply. Climate change is one of the factors that are likely to influence availability of water for irrigation. However, climatic patterns appear not to account for the change. For example, Yanda and Mpanda (1999) found no noticeable change in the amount of annual rainfall in the Pangani Basin. However, seasonal variations have accounted for the seasonal variations in the stream flows.

2.7 Implications of Change in the Traditional Irrigation Systems for Rural Poverty

The implication of this change to rural livelihoods is also an important element that requires further research. Mwamfupe (2001) and Jambiya (1998) observe that diversification into non-farm activities is an important strategy for rural households where traditional production systems have failed to sustain growing household requirements. However, the sustainability of the rural non-farm activities also relies on the level of rural incomes. The development of agricultural production through irrigation is still an important means for rural poverty alleviation.

Apart from farmers' exit from water management for irrigation by seeking non-farm activities[29], there are other potential strategies that farmers might opt for, which will have different implications on their livelihoods. Farmers may change the combinations of the crops they grow to include crops with a shorter growing cycle, drought resistant crops, crops that require less water, etc. Another option is to improve the irrigation system. It is more likely that farmers' response to various constraints for irrigation development reflects the prevailing socio-economic environment.

Unlike large-scale irrigation projects, traditional irrigation systems are known for allowing participation of the local communities. Current development strategies emphasize water use management through group organisations such as water users' associations. However, newly formed organisations are often unsustainable. Yet traditional irrigation management systems have operated for many years. There is a need to explore the nature of the group management of water resources in traditional irrigation systems and to explore the potential for using such grouping for group extension systems. It is important to explore the relevance of the traditional water-user groups in the new environment. For example the change in the institutional set-up has changed the power structure and the rules and regulations that allowed the traditional system to operate.

2.8 The Conceptual Framework

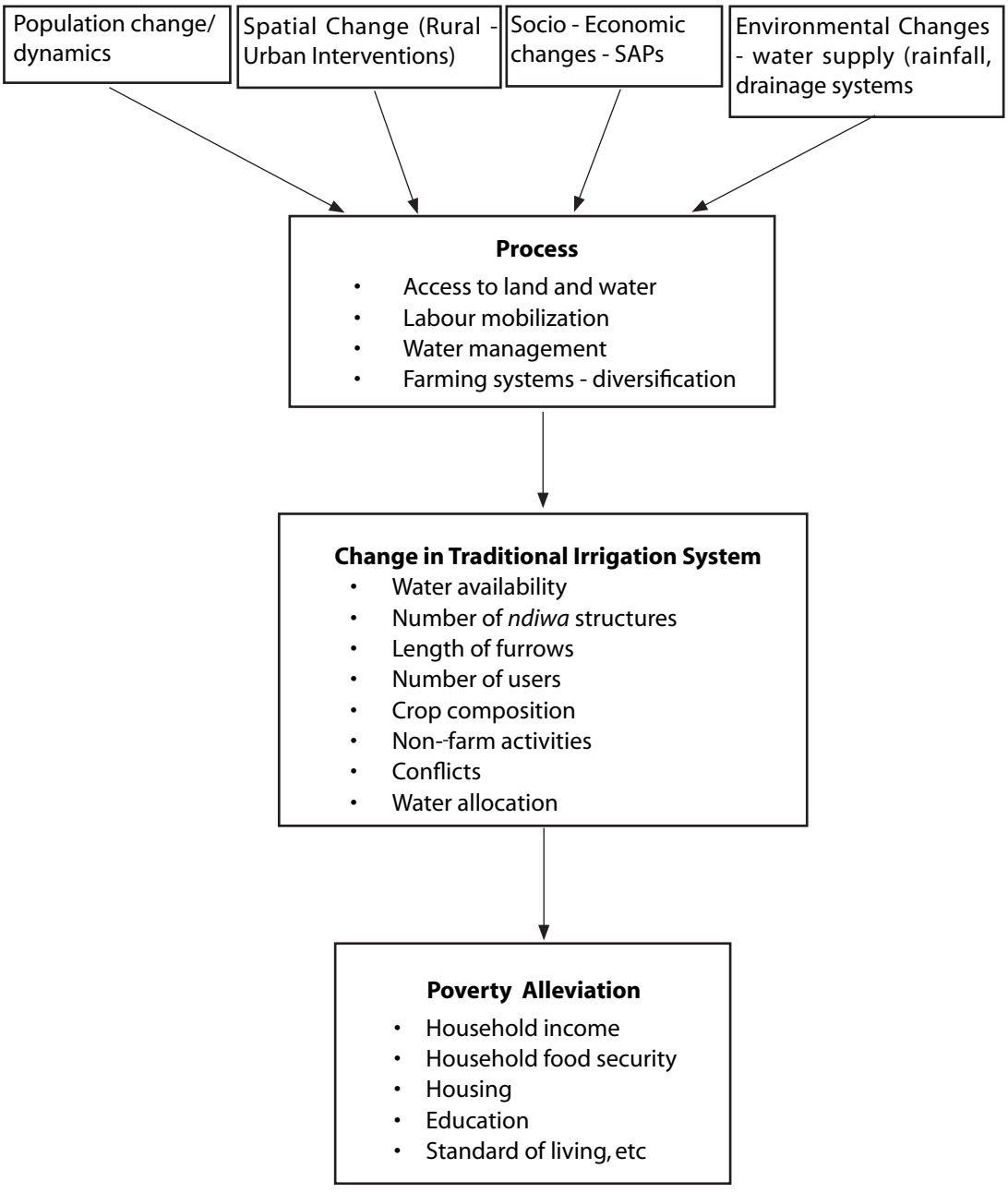
Figure 2.1 depicts the conceptual framework that guides the study. It identifies the factors that contribute to changes in the *Ndiwa* traditional irrigation system in the West Usambara. These factors influence the change in the traditional irrigation system through a number of ways such as the disappearance of technologies, changes in systems of labour mobilisation, changes in land tenure systems, changes in access to and control over water resources; changes in cultural values, etc. Rural households are expected to respond differently to changes in the irrigation system and their responses will affect household incomes, food security and the rural environment. All of these have implications for rural poverty alleviation.

Some changes to Tanzania's socio-economic environments such as agricultural market liberalisation, are known to have influenced local resource management[30]. The villagisation programme of the 1970s and the formal registration of villages weakened the powers of the traditional leaders, especially clan elders. Village government leaders appointed and responsible to the central government have became more powerful in local resource management. Also, government intervention in water resource management through the TIP in the 1980s influenced change in water resource management

[29] Mwamfupe, 2002 p. 41
[30] Sokoni, 2001

for irrigation. Different forms of organisation of water users through water users' associations have replaced some traditional forms of social organisation. The Structural Adjustment Programmes (SAPs) of the 1980s have also affected rural livelihoods. Other relevant changes include climate, migration, and the growth of urban markets.

Figure 2.1: The Conceptual Framework



3. THE STUDY AREA

3.1. The Geography of the Study Area

The Lushoto district has an area of 3,497 square kilometers and occupies 11 per cent of the Tanga region[31]. The district is mostly covered with highlands rising to a maximum altitude of 2,300m above sea level. However it has some lowlands and plains. The mountains are folded and faulted massif consisting of metamorphosed, volcanic and sedimentary rocks. The up-thrust forming the mountains is steeply dissected and faulted and consequently a considerable number of slopes are steep -sided[32]. Good land for agriculture is limited to the narrow valley bottoms or to the blocks, which were down folded. However, with the increasing pressure from the growing population, hill and valley slopes have also been converted into agricultural land. There is considerable physical fragmentation of the land in the Usambara Mountains. Agriculture takes place on steep slopes and there has been extensive over-cultivation and subsequent soil erosion[33].

The climate of the West Usambara has been discussed in detail in Jambiya (1998) and Mascarenhas (2000). Although the Usambaras receive a rainfall of between 600 – 2,000 mm per annum, there is extreme rainfall variability[34]. Rain-fed crop farming is based on the short rains (*vuli*) from October to December and the *masika* rains from July to September. There are enormous variations in rainfall between ecological zones, as influenced by the interplay of altitude, position, temperature, etc. The spatial and temporal variations of temperatures and rainfall are considerable even over small distances[35].

Farmers complain of the unexpected changes in weather, such as less and unreliable rainfall and longer dry spells during the dry season; these factors disturb the farming regimes. The short rains are less reliable, yet they are the most essential for growing seasonal and annual crops such as maize and beans. Failure of the short rains is a critical element.

The Usambara Mountains are drained by three main rivers: the Umba River drains from Mtae through Mlalo into the Umba plains to the north. The Sine River flows southwards from Mlalo ward then southwards to River Pangani. The Lwengera River flows from Soni eastwards. Apart from these main rivers, there are numerous streams that provide water valuable for irrigation. The diversion of water from streams is an important source of water for irrigation on the Usambaras. Furthermore, the river valleys have been intensively used for irrigated agriculture. Unfortunately, these water sources are not available to upland farmers. The uplands are the sources of numerous springs that have small volumes of water. Taping water from these springs for irrigation dates as far back as the 1940s. However, changes in the physical environment, especially clearance of catchment forests that had trapped and stored water for these springs, has significantly altered the extent and pattern of waterflow in these springs. The changes in rainfall patterns have further aggravated the situation.

Efforts have been made for the afforestation of the Usambara Mountains. The SECAP did a commendable job of encouraging tree planting in the region in an effort to check the process of deforestation. In this attempt many species of eucalyptus trees were grown. These were preferred because they grow fast and have abundant biomass and were suitable for solving increasing demands of firewood in a relatively short time. However, it has since been realised that some varieties of the eucalyptus trees that were planted on water sources are not suitable, as they draw a lot of water and therefore reduce the amount of water that is available for the upland springs.

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[31] Mascarenhans, 2000
[32] Mascarenhans, 2000:5
[33] Jambiya, 1998
[34] Jambiya, 1998
[35] Mascarenhas, 2000

3.2. Socio-Economic Aspects

3.2.1. Population Distribution

Lushoto is one of highly populated areas of Tanzania. According to the 2002 Population Census, the total population of Lushoto district was 419,970. Lushoto has an average population density of 120 persons per square kilometre (Table 3.1). However, there are remarkable differences between the divisions. Soni division has the highest population density of 325 persons per square kilometre. Umba division is the least densely populated, because a greater part of the division is a game reserve. Most of the divisions in the highlands areas are of higher densities. The density of population between 1988 and 2002 Population censuses has increased tremendously in each of the divisions of Lushoto district (Figure 3.1).

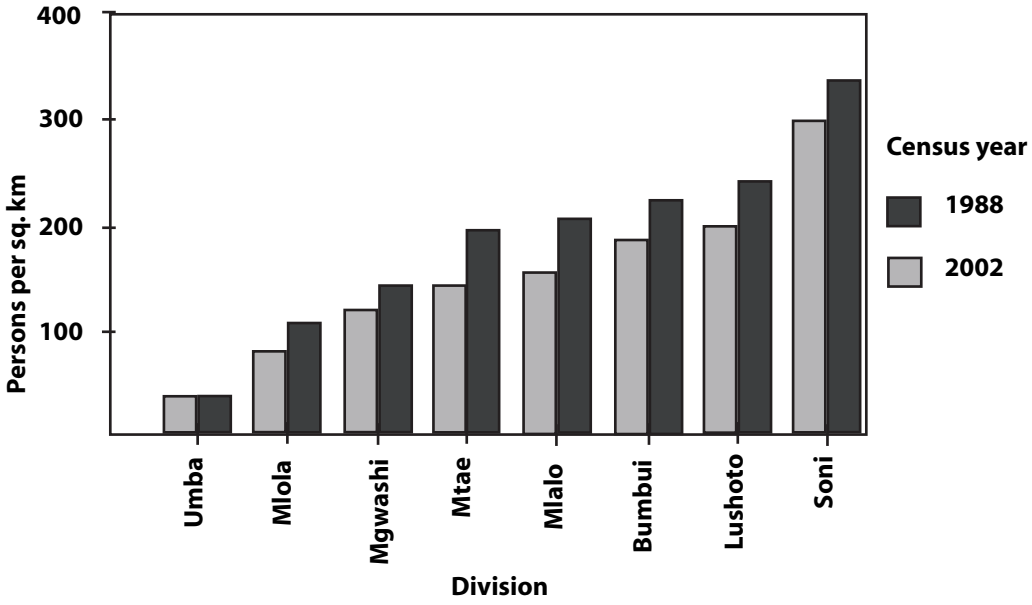
In order to relieve the area of high population density, the government attempted to move people from Lushoto to Handeni in the 1980s; but this strategy did not succeed. There has been significant rural-urban migration from Lushoto. However, with the increasing difficulties of making a living in urban areas, many migrants are returning home and seek land for agriculture. Urban migrants maintain relations and contact with their rural counterparts and some urban – rural transfer of resources such as remittances prevail.

Table 3.1: Population Density of Lushoto District by Divisions

Division	Area (km^2)[a]	Percent[a]	Population[b] 1988	Density Persons/ km^2 1988	Population[c] 2002	Density Persons/km^2 2002
Umba	1,526	43.6	26,875	17.6	29,140	19.1
Mlola	451	12.9	39,399	81.3	50,374	111.7
Mgwashi	199	5.7	25,638	128.8	33,887	170.3
Mtae	212	6.1	36,374	171.6	42,189	199.0
Mlalo	440	12.6	78,617	178.7	94,149	214.0
Bumbuli	233	6.7	45,148	193.8	52,052	223.4
Lushoto	267	7.6	55,118	206.4	64,095	240.0
Soni	166	4.7	50,086	301.7	54,079	325.8
District	3,494	99.9	357,255	160	419,970	120.1

Sources: [a] Mascarenhas, 2000:12; [b] URT, 1988; [c] URT, 2003

Figure 3.1: Changes in Population Density by Divisions



The major economic activities are agriculture, forestry activities, with livestock ranking roughly as the third. The major crops grown are tea, coffee, vegetables and fruits as cash crops and maize, beans, rice, potatoes and bananas as the major food crops. Livestock kept include cattle, sheep, goats and poultry. Due to the increase in population and extension of land under crop farming, free grazing is declining. The keeping of dairy cows under the zero grazing system is a system increasingly being practised. This integrates well with upland irrigation as the livestock provides manure and the farming system provides fodder.

3.2.2 Water Resources Development for Irrigation

The Usambara Mountains can be considered as a major water catchment area with quite a large quantity of water resources. However, due to human interference, some of these water sources have disappeared. This phenomenon has jeopardized the irrigation potential of the district as a whole, and has resulted in the increase in competition among farmers for irrigation water during the dry season. Furthermore, rainfall is increasingly becoming unpredictable and unreliable. This has made rain-fed agriculture unreliable. The *Ndiwa*s, which are basically small scale water capturing structures at the micro watershed levels, are an alternative source of water for irrigation. While *Ndiwa*s are important means of water management for irrigation on the uplands, farmers have other ways of accessing and using water for irrigation including river valley irrigation, water holes, and high water table adjacent streams. The majority of the people on uplands have access to *Ndiwa* irrigation. A few farmers who fail to access *Ndiwa* water, do access water through other sources mentioned above.

3.2 .3 Poverty in the West Usambara Mountains

Mascarenhas (2000) has made a more in depth analysis of poverty in the West Usambaras. Our study does not intend to embark on the measurement of poverty levels in the study area. Rather it seeks to understand the extent to which NIS has been an opportunity for farmers to reduce poverty. In order to arrive at this assessment it was worth identifying some key characteristics of rich and poor households as conceived by the local community. This information was established through village level group discussions.

Rich households were identified by the use of wealth indicators which included having adequate agricultural land and water; operating off-farm businesses such as a shop, a milling machine, a kiosk,

etc; having adequate livestock (dairy cows, sheep, etc.); having a modern house (with corrugated iron sheet roofing) and having a car. Poor households were identified by lack of access to agricultural land, reliance on casual labour and living in wooden and thatched houses. The landless households were considered as being the absolute poor. Often these rely on selling their labour to other better-off farmers. This compares with the study by Mascarenhas (2000) that identified ownership of more land and livestock as measures of prosperity. In addition to ownership of land and livestock, Rutasitara (2002) uses ownership of household durable items such as bicycle, radio, furniture, etc as indicators of a household's income status.

4. RESEARCH METHODOLOGY

4.1 Data Sources and Types

The major sources of secondary data were the Lushoto District Agricultural and Livestock Development Office; the Lushoto District Irrigation Department and the ward and village offices. Other secondary data were drawn from research reports and publications.

Primary data was collected through household questionnaire survey that covered users, non-users and previous users of NIS. A sample of *Ndiwa* sites was selected for visiting and observations. Discussions were held with the local authorities at village and ward levels, with *Ndiwa* user groups and with their leaders. Table 4.1 lists the *Ndiwa* structures that were identified in the respective villages. Due to difficulties of accessing each *Ndiwa*, it is likely that the list is not exhaustive.

4.2 Sampling

The sampling procedure was as follows: three divisions (Mlalo, Mtae and Soni) where NIS is practiced were selected. Seven villages were selected; these included: Dule, Mwangoi and Viti in the Mlalo division; Emao (Rangwi) and Makose in the Mtae Division; and Shashui and Magila villages in the Soni Division (Figure 4.1). The selection of *Ndiwa* sites at the village level was guided by the village leaders and took consideration of accessibility, location and size of the *Ndiwa* structures. The objective of this purposive sampling was to have a sample that was as representative as much as possible.

Table 4.1: The Distribution of *Ndiwa* Structures by Sample Villages

Dule	Mwangoi	Emao	Makose	Viti	Magila and Shashui
Kwesabuni	Mto wa shita	Mlozo	Mwakipemba	King'weng'we	Mzungu A
Ngomei	Kwediwa	Mazizo	Bara	Kwedwayu	Mzungu B
Lutindi	Kwekuyu	Lyandaugu	Kwehambalawe	Mbughui	Kwekidau
Bombo	Vuga	Kidologhwai	Bwambo darajani	Kwemchujamazi	Magila
Kasheu	Soni	Endaugu	Ngujini	Kwekubomba	Ivumo
Ghasoi	Kilombero	Kwebura	Kitala	Sia ya Mahindi	
Bomai	Fumbai	Magagai	Fundoi	Kwekoongo	
Kwehuza	Ukinga	Mashangwe	Tambwe	Kisiwani	
Sakare				Kiuzi	
				Kwefivi	

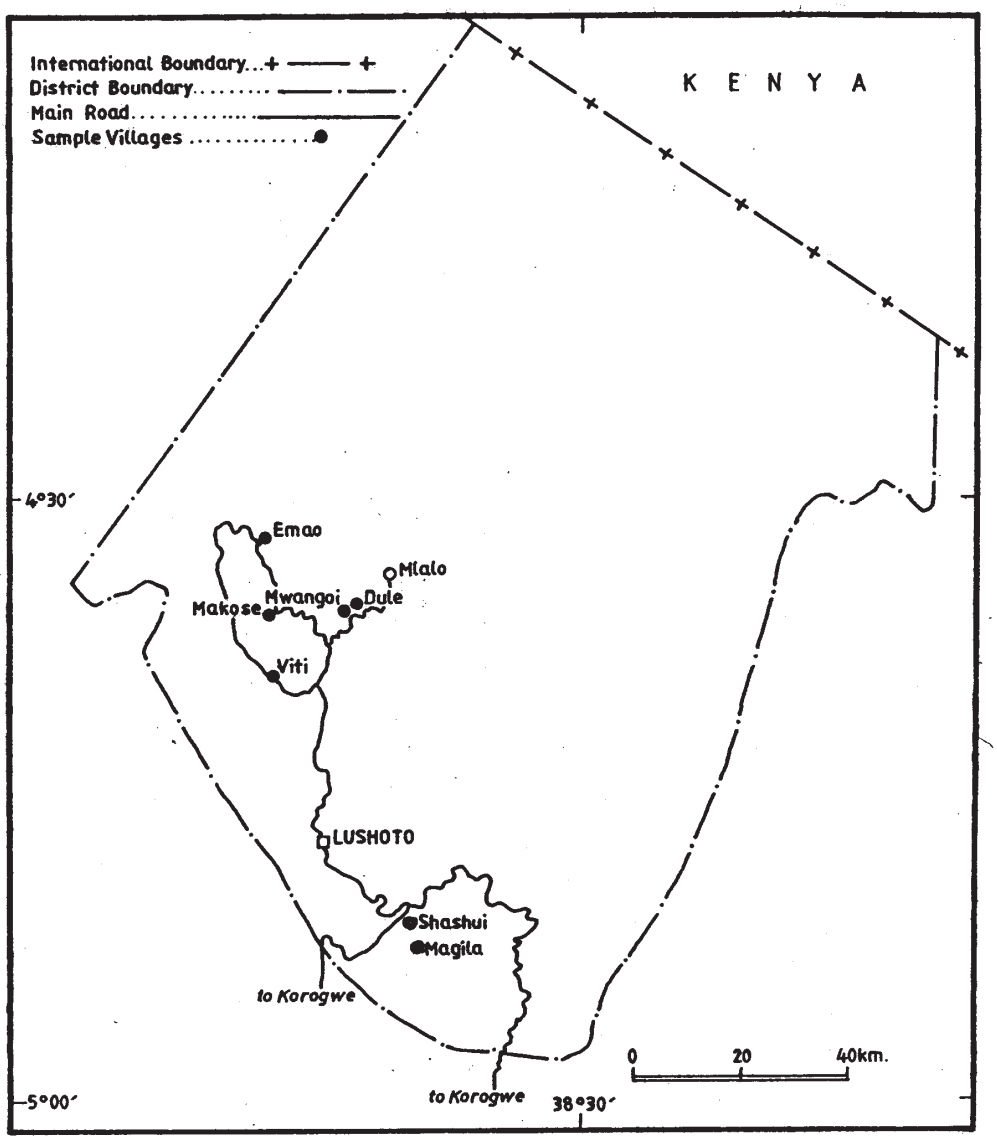
Source: Survey data

4.3 Data Collection Techniques

Since the study intended to make a detailed analysis of the traditional system of management of water for irrigation, a historical approach in data collection was used. Important events related to changes in the farming systems were documented. This was acquired through discussions with the local elders responsible for the management of *Ndiwas*. One of the principal researchers had a good working experience in the area and was able to identify and supervise such discussions. The historical

information sought to identify key changes in the physical environment, socio-economic and spatial environment that explain the changes in the *NIS*.

Figure 4.1: The Location of the Study Area and Sample Villages



The aim of the research was to understand the extent to which the *Ndiwa* traditional irrigation has been changing, its impact on food security and incomes, environmental issues related to irrigation and how all these matters related to rural poverty alleviation. A spatial sampling of villages using *Ndiwa* irrigation was undertaken in Mlalo, Mtae and Soni. These divisions were selected because they represent the major ecological zones of the West Usambara Mountains. In each village, a list of *Ndiwa* structures was constructed and a sample of them was drawn. The leaders of *Ndiwa* were interviewed to solicit information on the past, current and future status of the irrigation system. A sample of households was drawn from each *Ndiwa* catchment for a detailed interview to ascertain the impact of the changes in the irrigation system and the varying households' responses to those changes.

For comparative purposes the sample of *Ndiwa* included those that were improved through the TIP. Interviews with agricultural extension officers, village leaders and other experts operating in the study area were undertaken. Interviews with leaders of irrigation groups and participants were carried out at *Ndiwa* sites. Local leaders and elders gave information on past changes in the irrigation systems.

Other key informants for the study were the elderly (experienced) farmers, and village government leaders.

Secondary data for the study was collected from the Traditional Irrigation Improvement Programme (TIP) that has been operating on the Usambara Mountains for some years now. The Lushoto District Irrigation Department was another source of secondary data. Other sources included reports the village based extension workers had submitted to the district agricultural office.

4.4 Data Analysis and Presentation

This study collected data for depicting the trends in the use and importance of the NIS. The data established general changes in the NIS. In order to assess the importance of the NIS rural livelihoods, the study compared the-with and without *Ndiwa* situations by looking at the households that have access to water for irrigation through *Ndiwa* system and those which do not. Another way was to compare the situation of household prior to and after losing access to *Ndiwa* water.

The data analysis also focused on the relationship between the management of *Ndiwa* water for irrigation and the changes in socio-economic conditions. The implications of the decline in NIS is related to changes in household access to water; changes in cropping patterns; incomes and expenditure patterns of households. A cross-tabulation technique was used to identify associations between related variables. Descriptive statistics were used to describe the *Ndiwa* water management system and charts and diagrams ere used to depict numerical distributions and trends.

5. RESEARCH FINDINGS

5.1. Characteristics of the Respondents

A sample of 136 respondents completed a household questionnaire. Of these 75 were current *Ndiwa* users, 26 had used *Ndiwa* irrigation previously, and 35 were non-users of *Ndiwa* irrigation. 86 per cent of the respondents were males. The education level of most peasants was generally low. Only 7.5 per cent had attained the secondary level formal education and 91 per cent had completed primary education.

For the majority of the respondents, irrigated agriculture is the major source of cash income as well as food. Village level group discussions indicated that possession of assets was an indicator of the status of villagers in the socio-economic ladder. A person generally considered as well off possesse some of the following assets: a shop, a motor vehicle; corrugated iron roofed house with brick walls and plastered with cement; several large fields, a bicycle and some livestock. Poor members of the rural community owned grass-thatched houses with pole and mud walls and possessed little or no land; and their income was derived mostly from casual labour. Possession of some key household material wealth varied;75 per cent, 84.2 and 78.2 per cent of the respondents possessed dairy cows, a radio and corrugated sheet roofed house, respectively. But only 30.8 per cent and 21.1 per cent owned bicycles and burnt brick houses, respectively. As indicated above, this study did not intend to measure the proportion of population in each wealth category. Table 5.1 compares the possession of material wealth among users, previous users and non-users of NIS. The results summarised in this table show that current *Ndiwa* users perform better than previous and non-*Ndiwa* users. This suggests that generally *Ndiwa* water users are better off than non-*Ndiwa* water users. However, this only holds where a non-ndiwa water user has no access to other ways of accessing water for irrigation.

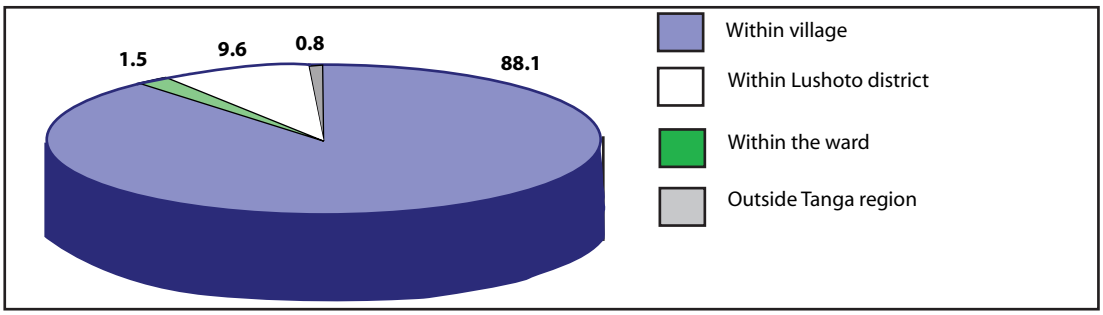
Table 5.1: Possession of Material Wealth by Categories of Households

Material Wealth Item	Ndiwa Users (N=75)	Previous ndiwa users (N= 26)	Non ndiwa users (N= 35)
Dairy cows	85.3	76.9	50.0
Bicycle	44.0	15.4	12.6
Radio	93.3	76.9	68.8
Corrugated iron sheet roofed house	90.7	76.9	50.0
Burnt brick house	22.7	19.2	18.8

Source: Household Survey, 2003

The majority (88.1%) of the respondents were born in their respective villages of residence (Figure 5.1). This could be taken as an indication that the study area is not a recipient of many migrants. This could be explained as resulting from high density of population in the areas.

Figure 5.1: Place of Birth of Respondents



N = 136

5.2. Changes in the *Ndiwa* Irrigation System

The study noted that the NIS contributes significantly towards improving the income and livelihood of the farmers. It is the major source of income and food requirements of the majority of the households in the study area. This study of changes in NIS in the West Usambara Mountains considers a period from pre-independence (as far back as 1940s) when some of the *Ndiwa* structures were constructed to the present. However, it was not possible to capture temporal data in great detail.

Non-*Ndiwa* users confirmed changes in NIS. 70 per cent of the non-*Ndiwa* users were of the opinion that the use of *Ndiwa* irrigation had increased. They indicated that there has been an increasing trend in the number of *Ndiwa* users; number of crops grown; number of fields per *Ndiwa*; conflicts among water users; frequency of cropping, and length of *Ndiwa* furrows. However, there has been a decreasing trend of water availability, village government involvement and the role of village elders. The data show that whereas demand for *Ndiwa* water has been increasing, the supply of water has been on a decreasing trend. However, more detailed changes were drawn from the analysis of responses from *Ndiwa* users. Table 5.2 shows the trend of change in some of the key components of NIS.

Table 5.2: Trend of Change in Components of *Ndiwa* Irrigation System

		Trend of change (in percentages)			
***Ndiwa* Irrigation Component**	**N**	**Increased**	**Decreased**	**No Change**	**Total**
Water availability	31	9.7	90.3	0.0	100
Number of *Ndiwa* users	28	89.3	3.6	7.1	100
Number of crops grown	29	89.7	0.0	10.3	100
Frequency of cropping	29	75.9	6.9	17.2	100
Number of fields per *Ndiwa*	26	80.8	0.0	19.2	100
Water users' conflicts	25	84.0	12.0	4.0	100
Length of *Ndiwa* furrows	24	79.2	4.2	16.7	100
Village government involvement in *Ndiwa*	27	11.1	77.8	11.1	100
Role of village elders	26	23.1	53.8	23,1	100

Source: Household Survey, 2003

Table 5.3 shows elements of change in the NIS as indicated by *Ndiwa* users. The data confirms the observation from non-*Ndiwa* users that there has been a decreasing trend of water quantity for *Ndiwa* irrigation while the demand for water has been growing. It is worth noting some additional elements of change including improvement in agronomic practices associated with the NIS. The organisation of *Ndiwa* users and *Ndiwa* water management is another important element. However, there is no clear-cut change in the role of village government leaders and village elders in the management of *Ndiwa* water. It is apparent that conflicts are increasing due to competition over the scarce water resources. Some key components of *Ndiwa* change are discussed further below.

Table 5.3: Changes in the *Ndiwa* Irrigation System

Change Category	Change Details	Frequency	% of N
Quantity of Water	Decrease in the quantity of water	31	53.8
	Ndiwa is losing its importance	2	
	Irrigation is more difficult now	1	
	It takes longer to fill a *Ndiwa*	1	
	Total	35	
Agronomic Practices	Improved production and income	15	38.5
	Increase in kinds of crops grown	2	
	Increase in frequency of cropping	4	
	Greater use of manure	2	
	Introduction of SWC by terracing	2	
	Total	25	
Rising Need for Irrigation water	Increase in number of *Ndiwa* water users	16	26.1
	Increase in demand for water	1	
	Total	17	
Farmers' Organisation	New organisations of *Ndiwa* water users	2	7.6
	Increase in water users' conflicts	2	
	Group *Ndiwa* ownership replace family / clan ownership	1	
	Total	5	
Improve-ments	Improved *Ndiwa* structures	2	7.6
	More *Ndiwa* water is available	1	
	More *Ndiwas* have been constructed	2	
	Total	5	

N = 65

Source: Household Survey

5.2.1 Number of Ndiwa Structures

A change in the number of *Ndiwas* over time is a proxy measure of the extent to which the importance of the NIS has grown or declined. In each ward / village it was evident that some *Ndiwa* structures

had been abandoned, some continued to operate and new ones had been constructed. Abandoned *Ndiwa*s were reported in Mwangoi, Dule, Emao, Viti and Makose villages. For the Rangwi/Emao village, new *Ndiwa* structures were constructed, normally upstream. Harvesting of spring water for irrigation is done wherever it is possible on the uplands. This has led to increased competition for water.

Related to the number of *Ndiwa* structure is the size of the structures. One way of increasing water for irrigation would have been to increase the size of *Ndiwa*s so as to reserve more water. This option is often limited by the amount of water that is available in the catchment. As discussed later, even the current sizes of the *Ndiwa*s are difficult to fill because of the shortage of water in the catchments.

Destruction of ndiwa structures during the rainy season is a common problem for all the sample villages (Plate 5.1). The rainfall often falls heavily and destroys most of the ndiwa structures by removing the embankments or filling the structures with mud. This occurs more on structures erected within spring/stream natural drainage lines. For Dule village, floods have never destroyed a single ndiwa because the village is positioned on the side, rather than inside the spring's drainage line.

Photo 5.1: A Demolished *Ndiwa* Structure at Mto wa Shita, Mwangoi Village.

5.2.2. Number of Farmers Relying on Ndiwa Water

The number of farmers that rely on water from *Ndiwa* structures has been increasing. Discussions with *Ndiwa* users showed that most of the *Ndiwa* structures were initially constructed and used by few farmers, often less than ten. However, over time the number of *Ndiwa* water users has increased twice or thrice. This has not only increased pressure on the scarce water resource, but has also complicated the water allocation system. Often conflicts between farmers occurred because of the competition for water. An increase in the number of users means that intervals of accessing water have become longer now than in the past. As this may threaten a farmer's crop survival, a number of farmers contravene the water allocation timetable. This leads to conflicts among farmers.

The number of farmers that may be supported by a *Ndiwa* depends on the volume of water coming from its catchment. Serving more farmers also implies construction of more furrows that lead water from the *Ndiwas* to fields. The distance that water may flow depends on the volume and velocity of

water. Moreover, more water is likely to be lost on the way due to evaporation and leakage. Due to this, *Ndiwa* irrigation may not be a guarantee to water availability for the rapidly increasing population of the Usambara uplands.

5.2.3 Changes in the Availability of Water

Water availability in a catchment is critical to the survival of the NIS. In all villages it was evident that the volume of water in the catchment had been decreasing. Table 5.4 shows changes in the time it takes to fill a *Ndiwa* structure, and the number of users. The time required to fill a *Ndiwa* has increased tremendously, often by two to four times. This limits the capacity to expand agricultural activities and to involve more villagers in *Ndiwa* irrigation. Water availability in a catchment also limits the number of *Ndiwas* that may be established. Farmers often make efforts to erect new *Ndiwa*s upstream. Excessive construction of *Ndiwas* beyond the water capacity of a catchment is likely to lead to more conflicts among users, as downstream farmers lose water to farmers upstream.

Table 5.4: Some Characteristics of *Ndiwa* Structures

Village/ *Ndiwa*	**Date of Construction**	**Number of Users**		*Ndiwa* **Filling Duration (hours)**	
		Initial	Current	Initial	Current
Dule/Kwekuyu	1955	10	20	10	48
Dule / Kasheu	1940	20	50	10	24
Dule/Dule juu*	1930s	Two villages	<10	12	48
Mwangoi	1964	Two villages	Unknown	3	12
Rangwi / Lyandangu	1983	6	20	10	24

Source: Household Survey

* This *Ndiwa* has also reduced its size.

5.2.4 Changes to Upland Farming Systems

Ndiwa structures are very important to sustain agriculture in the Usambaras, particularly during the dry season. In some areas like the Mlalo division, the *vuli* season is the most important rainfall season but this lasts for not more than two months, i.e. November and December and sometimes up to January. This means that for about eight months per year there is no rain and this is when *Ndiwa*s become useful.

Ndiwa structures have an important role to play in the upland farming systems of the West Usambara Mountains. With the limitations of rain-fed agriculture discussed earlier, the NIS has been an alternative source of income and food for upland communities. Often the scarce water is used for growing high value crops, most commonly, vegetables. The range of crops grown is enormous. Mowo, *et al,* (2002) suggest that over one hundred high value crops are grown in Lushoto. They range from herbs, vegetables, legumes, to flowers. Some of the most common crops are tomatoes, cabbages, green pepper, peas, onions, potatoes, etc. The availability of water through *Ndiwa* structures has enabled a high cropping frequency of up to four times per year.

5.2.5 Changes in the Organisation of Ndiwa Users

The organisational aspect of *Ndiwa* water resource management is an important element, as it influences the access to water by individual farmers. Basically, farmers themselves own and manage *Ndiwas.* However, there has been a change in the organisation of the users. The role of managing

the *Ndiwa* water resource traditionally with clan elders, who were often the founders of the *Ndiwa*. The traditional elders no longer have the power over the management of *Ndiwas*. In some villages, a great deal of power in the management of *Ndiwa* has been transferred to the local government leadership. Although the village leaders do not directly organise the day-to-day functioning of the *Ndiwa* system, they have a strong say in settling water use allocations and conflicts. It is very common that a local neighbourhood (Kitongoji) leader is also the chairperson of the *Ndiwa* users' group. Often village governments define by-laws that govern the use of *Ndiwa* water. In Magila and Shashui villages, for example, *Ndiwa* users are still organised on a clan / family basis. Also some *Ndiwa* structures are organised and managed on a private basis.

The decline of traditional *Ndiwa* water resource management by clan elders in favour of village government leaders is a necessary outcome of the changes in village authorities after villagisation. A *Ndiwa* is no longer identified with a family or clan. This implies that they are more open to all farmers irrespective of clans and, therefore, makes their composition more heterogeneous and open to more conflicts. Information from Shashui and Magila indicated that *Ndiwa* structures managed on clan basis had less conflict because members were related by blood. Also, *Ndiwa*s are becoming more privatised, which implies a decline in communal altitudes towards production. This is a ripe condition for greater social differentiation of the village community members.

The former power of elders to call for work on furrow construction and maintenance is no longer practiced. Membership to a *Ndiwa* users' group is determined by an individual farmer's participation in the maintenance of a *Ndiwa* infrastructure. The *Ndiwa* users are not formally organised. Since they are few in number they are able to handle allocation of water without having any formally designed timetable. No formal list of members was available. However, as more people become involved in *Ndiwa* irrigation and water scarcity worsens, it is likely that conflicts among *Ndiwa* users will occur. This is where the role of village government leaders becomes important as they are vested with power of setting and enforcing regulations pertaining to resource utilisation within their areas of jurisdiction.

5.2.6 Changes in Accessing Land

There is an apparent change in how land is accessed in the study area. Increasingly, fields under irrigation are becoming transferable through the local land market. Land transaction through buying and renting has enabled a greater access to land for richer farmers. Due to the growing importance of irrigated land in the area, the purchase of more land is an important means of alleviating one's poverty status. A quarter of an acre of land under irrigation was being rented for Tshs 15,000 per dry season. Farmers who sold or leased land were often poorer as they were not able to acquire the necessary inputs for growing vegetables or had some other social problems that required cash income. The outcome of the growing land market is that richer farmers have the opportunity to accumulate land while poorer farmers lose land and often turn to off-farm occupations or rely on income from their casual labour. Note that inadequate access to land is considered as an indicator of poverty in the study area.

5.2.7. Growth of Non-farm Occupations

During the dry season months those who do not have access to *Ndiwa* water engage in other non-farm activities like working as temporary casual labourers. Some people, especially women, engage themselves as middle-women and transfer vegetables and other crops to periodic markets in other wards / villages. A few are involved as cultivators in the plains (well known as *kitivo*) where an alternative source of water from rivers is available. A bigger proportion of women go to the lowlands to buy crops and commodities like rice, yams, cassava, etc. to sell at the periodic markets. A small number of men are engaged in lumbering, petty trade (for those who can afford it) carpentry, masonry, and other skilled trades. It is important to note that many of these non-farm occupations rely on produce and capital generated from *Ndiwa* irrigation.

5.2.8 Ndiwa Water Users' Conflicts

While there is growing population needs for *Ndiwa* irrigation water, the scarcity of water is also increasing. There are already some indications of growing competition for water that are likely to lead to conflicts. The study survey indicated an increasing trend of *Ndiwa* water users' conflicts. This is an important aspect that requires adequate attention and long-term strategies towards improving the rural livelihoods to focus on improving the availability of water for *Ndiwa* irrigation. Improving the social organisation of *Ndiwa* users may also minimise conflicts.

5.3 Factors Influencing Changes in the *Ndiwa* Irrigation System

This study identified factors that contribute to changes in the NIS. This is important, as it enables consideration of viable strategies of enhancing the beneficial contribution of *Ndiwa* system to poverty alleviation. Information drawn from current, previous and non-users of *Ndiwa* water is used to identify factors responsible for changes in NIS.

Table 5.5 below summarises factors responsible for changes in *Ndiwa* irrigation as drawn from *Ndiwa* users. The majority of *Ndiwa* users attributed changes in *Ndiwa* irrigation to environmental change. This includes changes in the weather pattern, especially the decrease in the amount of rainfall. This further relates to the decrease of water at sources. Other factors relate to the growing needs of *Ndiwa* water among the population. These include the growing production potential of *Ndiwas* and increasing numbers of users. External intervention does not feature strongly. However, where TIP has operated, its contribution to change in NIS is greatly acknowledged by *Ndiwa* users.

Table 5.5: Factors for Change in the *Ndiwa* Irrigation System

Factor Category	Factor Details	Frequency	% of N
Environmental Change	Drought, inadequate rainfall	20	61.7
	Environmental change	4	
	Decrease of quantity of water at sources	6	
	Drying of water sources	1	
	Destruction of water sources	3	
	Planting of eucalyptus trees at water sources	1	
	Declining soil fertility	1	
	Runoff	1	
	Total	37	
Production Potential	Greater and more reliable production	18	36.7
	Availability of seeds and planting materials	4	
	Total	22	
Population	Increase in number of users, returning migrants	10	21.2
	Lack of rural employment opportunities	3	
	Total	13	
Improvement	Support from TIP	3	10.0
	Greater farmers' awareness on the need for conser-	1	
	Use of pipes instead of furrows	1	
	Greater availability of water	1	
	Total	6	

N = 60

Source: Household survey

Both previous and non-users identified some reasons for the change in NIS. Previous users indicated that *Ndiwa* irrigation was declining due to several factors. Reduction of water at source was said to be partly due to shortage of rainfall and long dry seasons; planting of water draining eucalyptus tree species near water sources; cutting of water conserving tree species; and cultivation at water sources. At the same time there has been an increase of the number of water users. Also *Ndiwa* structures are still constructed using traditional methods and most of them cannot stand floods during the rain season. Destruction of the *Ndiwa* structures has often reduced their productive use. Due to structures of the furrows, much water is likely to be lost on the way to fields, with fields that are far away from *the Ndiwa* having little chance of receiving adequate water. Weaknesses in the organisation of *Ndiwa* users, such as selfishness and non-participatory allocation of water are also mentioned.

Although the NIS experiences problems that threaten its contribution to rural livelihoods, the system is still increasing in importance among residents of Lushoto. Data from non-users of *Ndiwa* indicated that NIS was increasing in importance because many more people needed to irrigate their fields. This has increased the number of *Ndiwa* users. Also *Ndiwa* irrigation has been found to be profitable, which keeps attracting more people to use *Ndiwa* irrigation wherever possible. The key factors for change in NIS are discussed below.

5.3.1 Climate Change

Water availability in the catchment areas is essential for *Ndiwa* structures to perform their role in poverty alleviation. The apparent change in climate is likely to have contributed to the scarcity of water not only for rain-fed agriculture but also for *Ndiwa*s. However, there is no common agreement as to whether climatic change is responsible for the change in the surface drainage patterns on the Pangani Basin. Yet, drought conditions are likely to have influenced the relatively less water available for *Ndiwa*s. The TIP progress report for August / September 2001 notes the prevalence of long periods of drought that has led to scarcity of water for irrigation. Similarly, it is observed that over the years the amount of rainfall has been decreasing[36].

5.3.2 Land Use and Vegetation Cover Change

A change in vegetation cover has a great impact on the ability of a catchment to hold and supply water. There has been serious deforestation on the upland forests of the West Usambara Mountains[37]. This was partly the reason for SECAP's involvement in afforestation of the Usambara Mountains. Deforestation has occurred due to extension of agricultural land, forest harvests for fuel wood, timber, etc, and most of the natural tree species used to conserve water in the upland catchments have disappeared. The removal of vegetation cover, without adequately adopting soil and water conservation measures, as part of the clearance for cultivation on steep slopes means that rainwater is lost through runoffs.

In response to the problem of deforestation, SECAP spearheaded the planting of trees (and other soil and water conservation measures) in the region, which was very successful as it improved vegetation cover tremendously. However, massive planting of eucalyptus tree species that use a lot of water was not appropriate for water conservation in the catchment areas. As Whitehead and Readle's (2004) study suggests, eucalyptus trees are known for their high rates of productivity, that are often associated with high rates of water use that reduce yields from catchments. Most of the *Ndiwa* farmers were of the opinion that the eucalyptus trees have contributed to the decline in the volume of water in upland streams.

Increasingly crop cultivation has continued to encroach on marginal lands including steep slopes. In the 1970s no cultivation was done on water sources and drainage lines. But at present the lowlands that were used for pasture and the ridges that were considered unsuitable for cultivation have all been put under cultivation. Pressure on land is a reality that farmers have to live with in Lushoto.

[36] Mwihomeke & Huwe, 1990
[37] Mascarenhas, 2000

5.3.3 Population Growth

The population density in West Usambara Mountains (see Table 3.1) is one of the highest in rural Tanzania. The population is still growing thus, adding more pressure on the available resources. The NIS has been more affected by the returning migrants from urban areas especially youths who are eager to earn cash income. It was commonly acknowledged that many youths who had migrated to towns were coming back to their villages because life has become too tough to withstand in towns. Returning youths have increased competition for irrigation water and this has had serious implications for people's livelihoods. Population growth should be considered as a contribution to growth in labour force that sustains the labour-demanding NIS. Although this phenomenon of returning migrants was widely cited in focus group discussions and informal interviews, supporting quantitative data were not available. This calls for further study.

5.3.4 Rural-Urban Linkages

The growth in rural-urban linkages, especially the flow of agricultural products to urban markets is the engine for the development of irrigated agriculture in the West Usambara Mountains. Urban demand for high value crop products has encouraged the growth in vegetable production and growth of marketing networks. Trade has also become an important off-farm occupation for many villagers who have less access to land and water for irrigation.

5.3.5 External Intervention

The TIP programme in Lushoto accounts for some significant improvement in *Ndiwa* irrigation especially in the Soni ward. These include the improvement of structures and enhancing better management of *Ndiwa* water catchment areas. TIP programmes insist that *Ndiwa* users develop better social organisation and improve soil and water conservation practices. However, only a few areas have been reached by TIP, these include: Soni, Umba, Mtae and parts of Mlalo division.

5.4 Changes in the *Ndiwa* Irrigation System and Rural Poverty Alleviation

Changes in various components of NIS have some implications on alleviation of income poverty and food insecurity. Comparison of data from current, previous and non-*Ndiwa* users shows the various ways through which these changes relate to poverty alleviation. They relate to income generation, food production, and acquisition of capital for buying material assets.

5.4.1 Alleviation of Income Poverty and Food Insecurity

The findings of this study show that *Ndiwa* irrigation is an important alternative that can reduce the uncertainties of rain-fed agriculture. Since it enables production of high value crops that are of high demand in urban markets, it is a potential measure for alleviating income poverty of the local people. Income from *Ndiwa* irrigation is also valuable for reducing food insecurity, as households with sufficient incomes are able to purchase food; 84 per cent and 77 per cent of the *Ndiwa* water users acknowledged that access to cash income and food security, respectively, are key benefits of *Ndiwa* irrigation. Due to rain-fed agriculture constraints, households do greatly rely on purchasing food. Cash income from *Ndiwa* irrigation plays a great role in enabling households to access food. Table 5.6 below shows some examples of the cost-output for some vegetable production through *Ndiwa* irrigation. The gross margins are earned in a relatively shorter period. *Ndiwa* irrigation allows higher cropping frequency that enables farmers to change crops and benefit from production of high value crops.

Table 5.6: Typical Variable Costs and Outputs For *Ndiwa* Irrigation Crops

Crop / Production Cost Tshs	Output / Value Tshs	Gross Margin Tshs
Irish Potatoes (0.25 acre) Cultivation 3,000; Manure 8,000, Chemicals 15,000; Seed 10,000, Labour 2,000 Total 38,000	10 bags @ 8,000 Total: 80,000	42,000
Tomatoes (0.25 acre) Manure 20,000; Pesticides 70,000, Labour 20,000; Seed 3,000, Chemical fertilizer 20,000 Total 133,000	200 tins @ 3,000 Total 600,000	467,000
Cabbage (0.25 acre) Manure 8,000; Pesticides 15,000, Seed 3,000 Total 26,000	30 bags @ 6,000 Total 180,000	154,000
Green Peppers (0.25 acre) Seed 50gm 3,500; Pesticides 16,000, Manure 2,000; Chemical fertilizer 6,500 Total 28,000	100 tins @ Tshs 1,000 Total 100,000	72,000
Ngogwe (0.25 acre) Seed 600; Manure 800, Seedbed preparation 1,000 Total 2,400	20 tins @ 2,000 Total 40,000	37,000

Source: Household survey

5.4.2 Alleviation of Material Poverty

Data analysis has shown that NIS is a means to household poverty alleviation through acquisition of essential material for their existence. Income from the sale of high value crops has enabled households to purchase food and meet other basic needs. It has also enabled farmers to increase yields and diversify their farm activities. The household survey data of *Ndiwa* users shows that farmers have made some achievements by using *Ndiwa* irrigation. They have been able to improve their housing conditions, buy livestock, acquire durable assets, etc (Table 5.7). The acquisition of livestock is an

important aspect that improves crop livestock integration in the area. The benefits of such integration should enhance the livelihood and further reduce poverty. If this process of diversification into livestock keeping (zero-grazing) continues it will ease the pressure on resources, raise incomes and reduce environmental degradation in the area.

Table 5.7: Farmers' Achievements from Using *Ndiwa* Irrigation

Achievement	Number of Farmers	% of N
Constructed / improved housing	42	56.0
Bought livestock	24	32.0
Bought more fields	15	20.0
Bought durable household items	12	16.0
Paid for health services and children's education	15	20.0
Bought a bicycle	9	12.0
Invested in off-farm business	9	12.0
Improved standard of living	5	6.6
Better clothing	3	4.0
Bought durable farm implements (sprayer)	2	2.6
Able to pay development levy	1	1.3
Bought a motor vehicle / truck	1	1.3
Has savings in bank	1	1.3
Improved farming techniques	1	1.3

Source: Household Survey N = 75

The above data demonstrates that the NIS has provided an opportunity for poverty alleviation among the upland communities of the West Usambara Mountains. As noted in the discussion of poverty in West Usambara, possession of a good house, livestock and adequate land were important variables for a household to be considered better off. These three items feature much in the achievements made by farmers as a result of using *Ndiwa* irrigation. There is, furthermore, an indication that *Ndiwa* irrigation has been a gateway to diversification into non-farm activities including the establishment of shops, kiosk, etc. Being able to pay for education and health services is another poverty alleviation variable which the outcomes from *Ndiwa* irrigation have been able to support.

Further analysis shows some remarkable contrasts in asset ownership between current *Ndiwa*, previous and non-*Ndiwa* users (Table 5.1 above). A greater proportion of farmers who use *Ndiwa* irrigation

possess valuable household items such as livestock, bicycles and better housing. All of these assets are essential in enhancing the livelihood of household members; keeping livestock and possessing a means of transport can enhance agricultural productivity at household levels. Better housing reduces the health risks to household members.

The gender distribution of benefits from NIS is not clear. The survey indicated that women were barred from managing *Ndiwa* structures, including opening and closing outlets, maintenance of *Ndiwa* structures, etc. This may imply that women have no direct claim to the ownership of *Ndiwa* structures. However, this does not strictly deny them of the benefits from *Ndiwa* as they are involved in using the water and at household level they share the benefits of improving the general living standards of households, such as improvement to the housing.

Previous *Ndiwa* users indicated that they had lost much by ceasing to use *Ndiwa* (Table 5.8). This is another way of showing the importance of NIS in enhancing rural livelihoods. The majority of previous *Ndiwa* users associate stopping *Ndiwa* irrigation with reduction in their ability to produce adequate food for their households and reduction of their incomes. Also some farmers have sought alternative sources of water for irrigation that cost more labour and money compared to *Ndiwa* irrigation. Due to stopping using *Ndiwa*, the previous *Ndiwa* users are unable to cultivate during the dry season, to grow new high value crops; to maintain adequate food supply throughout the year; to construct better houses and to travel to town.

Table 5.8: Losses that Farmers Incurred from Ceasing to Use *Ndiwa* Irrigation

Item Loss	Frequency	% of N
Income reduction	13	54.2
Inability to produce adequate food	15	62.5
Loss of production, less of frequency of cultivation	9	37.5
Incurring greater costs in drawing water from alternative source *(vidau)*	4	16.7
Change occupation	2	8.3

Source: Household Survey N = 24

Non-*Ndiwa* users indicated various disadvantages of not using *Ndiwa*. It was not possible for them to undertake continuous cropping, they were not able to produce enough food (including vegetables); and had to sell their labour. This indicates that by lacking opportunity to use NIS, a household in Lushoto is deprived of a means to alleviate poverty and ensure food security unless a viable alternative is available. However, alternative sources of water for irrigation such as *vidau*, river valley bottom irrigation; etc are not easily accessible.

Ndiwa water has the potential for other beneficial use for the local community. *Ndiwa* structures provide water for domestic use and for construction works. However, access to *Ndiwa* water may be difficult as often homesteads are built on top of ridges while furrows do not necessarily pass through residential areas.

5.5. Potential for Improving the *Ndiwa* Irrigation System

The analysis of data shows the positive contribution of *Ndiwa* to poverty alleviation. However, the current changes in the system pose threats to its sustainability. The increasing scarcity of water, the emergence of competition and conflicts among water users; the growing social differentiation of the local population require to be taken into account and addressed. Some suggestions that

were identified for the improvement of the NIS include enhancing conservation of the *Ndiwa* water catchments; improving *Ndiwa* structures; improving *Ndiwa* users' organisation; and developing better organisation of the *Ndiwa* water management.

Various ways of improving *Ndiwa* irrigation were suggested by both previous users and non-users of *Ndiwa* system. Previous *Ndiwa* users suggested that NIS had the potential to contribute more to rural livelihoods. This can be achieved through the reinforcement or reconstruction of *Ndiwa* structures; improved *Ndiwa* catchment management; protecting water sources by uprooting eucalyptus trees; planting water-conserving tree; replacing furrows with pipes and better organisation of *Ndiwa* usage. Similarly, non-users of *Ndiwa* suggested construction of more and bigger *Ndiwa* structures and use of expertise from extension workers as potential solutions to some of the problems facing the NIS.

Despite its potential contribution to poverty alleviation and livelihood strategies, the NIS is more demanding in resources from farmers. As Table 5.9 below shows, *Ndiwa* irrigation uses more manure, chemical fertilizer, and pesticides than rain-fed agriculture.

Table 5.9: Resources and Conservation Techniques Used in Rain-fed and *Ndiwa* Irrigation Farming Systems

Resource / SWC technique	Farming Systems	Level of Use (in frequencies)				
		None	Low	Average	High	Total
Manure	Rain-fed	24	14	15	7	**60**
	Ndiwa Irrigation	0	0	**23**	**52**	**75**
Chemical Fertilizer	Rain-fed	32	10	13	6	**61**
	Ndiwa Irrigation	7	4	**28**	**34**	**73**
Pesticides	Rain-fed	31	6	18	4	**59**
	Ndiwa Irrigation	4	5	**38**	**25**	**72**
Hired Labour	Rain-fed	35	11	13	4	**63**
	Ndiwa Irrigation	21	10	23	19	**73**
Labour Exchange	Rain-fed	42	9	12	4	**67**
	Ndiwa Irrigation	46	9	11	5	**71**
Distance to Fields	Rain-fed	4	16	36	12	**68**
	Ndiwa Irrigation	5	21	41	2	**69**
Field Transfer via Market	Rain-fed	32	17	14	0	**63**
	Ndiwa Irrigation	33	14	16	2	**65**
SWC - Tree Planting	Rain-fed	8	9	39	11	**67**
	Ndiwa irrigation	30	9	22	2	**63**
SWC – Terracing	Rain-fed	36	7	19	5	**67**
	Ndiwa Irrigation	28	6	16	22	**72**
SWC – Ridges	Rain-fed	45	4	2	2	**53**
	Ndiwa Irrigation	46	5	5	5	**59**
Grass Planting	Rain-fed	5	9	29	21	**64**
	Ndiwa Irrigation	13	4	26	24	**67**

N = 75
Source: Household Survey

There is also the potential for integrating livestock and *Ndiwa* irrigation. *Ndiwa* fields can provide livestock feeds, remains of vegetables, planted grass while livestock can provide manure and draft power. There is a growing interest in promoting group-extension as a means of generation, dissemination and uptake of agricultural technology in Tanzania. *Ndiwa* water users form potential groups for agricultural extension development in the uplands of the Usambara Mountains. They have common interest that makes their groups more stable and therefore suitable for group extension.

There is a potential for increasing water supply for *Ndiwa* irrigation through improvement of *Ndiwa* catchment management. This includes practising water-harvesting techniques that will increase infiltration of more water into the soil and ground water systems during the rain season. Such techniques include terracing, improving vegetation cover, planting of water conserving vegetation; uprooting of eucalyptus trees planted on water catchment areas and avoiding agricultural encroachment into areas of water sources.

Another area that is potential for *Ndiwa* development is the improvement of the *Ndiwa* infrastructure; including the pond and furrows. Reconstruction of these features using modern techniques (concrete and pipes) can reduce water loss, increase size of *Ndiwa*, and therefore raise the quantity of water available for irrigation. The TIP (Lushoto) programme has contributed significantly in these two areas of *Ndiwa* improvement (Photo 5.2). However, more resources are required to reach more farmers that practise *Ndiwa* irrigation on the Usambara Mountains.

Photo 5.2: An Improved *Ndiwa* Structure at Shashui Village

5.6. Constraints to *Ndiwa* Irrigation Development

Although the *Ndiwa* irrigation system has great potentials for alleviating poverty and enhancing rural livelihoods, these are not realised due to a number of constraints. Table 5.10 below summarises constraints to *the development of Ndiwa* irrigation, as identified by farmers themselves through the household questionnaire survey.

Table 5.10: Major Constraints to *Ndiwa* Irrigation Development

Constraint	Constraint Details	Frequency	% of N
Quantity of Water	Decrease in the quantity of water	38	56.7
	Total	**38**	
***Ndiwa* Structures**	Poorly constructed pond and furrow	2	17.9
	Blockage of ndiwa outlet	1	
	Weak ndiwa structures	3	
	Too long furrows	1	
	Small size of ndiwas	1	
	Silting of ndiwa	1	
	Poor maintenance of furrows	2	
	Water seepage	1	
	Multiple of ndiwas in one catchment	1	
	Total	**12**	
Damage of Structures	*Ndiwa* structure destruction by run-off	11	16.4
	Total	**11**	
Agronomic	Crop diseases	4	16.4
	Soil erosion – improper irrigation	2	
	Farmers lack agronomic skills	2	
	Lack of appropriate crop recommendations	1	
	Carrying manure is laborious	1	
	Old / outdated methods of farming	1	
	Total	**11**	
Input and Produce Markets	Farmers' low ability to buy inputs	1	14.9
	High cost / lack of inputs	7	
	Inadequate produce markets	2	
	Total	**10**	
Water Use Conflicts	Water use conflicts	9	13.4
	Total	**9**	
Water Allocation	Non-adherence to water allocation timetable	5	14.9
	Poor timing – too long intervals	2	
	High increase in number of water users	3	
	Total	**10**	
Weather	Drought	3	8.9
	Drying of water sources	1	
	Decrease / shortage of irrigation water	2	
	Total	**6**	
Catchment Management	Fields encroach ndiwa water sources	2	7.5
	Ownership of ndiwa water source areas	1	
	Degradation of ndiwa catchment area	1	
	Rapid increase in run-off	1	
	Total	**5**	

N = 67

Source: Household Survey, 2003

A major constraint is the decrease in the quantity of water; poor construction of *Ndiwa* structures; destruction of the structures during the rain season; inappropriate agronomic practices and poor social organisation of *Ndiwa* users. These constraints had also identified by previous *Ndiwa* users and were the reasons many previous *Ndiwa* users gave for stopping using *Ndiwa* irrigation.

As discussed above there are possibilities of minimising these constraints. Table 5.11 gives some of the potential solutions as provided by farmers. These strategies aim at increasing the quantity of water, improving catchment management; improving *Ndiwa* structures and social organisation of the users.

Table 5.11: Solutions to *Ndiwa* Irrigation Development Constraints

Solution	Detailed Solutions	Frequency	% of N
Increase Quantity of Water	Repair structures	2	50.8
	Increase size of dams	1	
	Strengthen ndiwa structures	7	
	Use pipes instead of furrows	4	
	Built larger and durable water harvesting structures	7	
	Scoop deposited materials in dams	1	
	Maintain furrows	1	
	Tap forest + other water sources	7	
	Total	**30**	
Catchment Management	Introduce catchment management measures	15	49.1
	Uproot eucalyptus trees	4	
	Use mulching	3	
	Crop diversification	3	
	Protect / conserve water sources	1	
	Avoid encroaching spring sources	1	
	Keep livestock	2	
	Total	**29**	
External Support	Technical assistance in strengthening ndiwa	10	37.2
	Provide financial credit	1	
	Provide government assistance	10	
	Bring input supply source closer to farmers	1	
	Total	**22**	
Farmers' Organisation	Introduction better water allocation systems	11	20.3
	Change water users group leadership	1	
	Total	**12**	

N = 59

Source: Household survey

5.7 Alternative Livelihood Strategies

To appreciate the contribution of NIS, one needs to consider the potential alternative livelihood strategies. Other irrigation systems, such as river valley irrigation, and valley bottom cultivation (*vidau*) are equally important. Irrigated agriculture has enabled growth of trade especially marketing of vegetables. Migration to urban areas appears less important, with many returning migrants seeking to engage in irrigated agriculture. School leavers find no immediate employment other than vegetable production through irrigation. Other activities done at small scale include: carpentry, masonry, small businesses, pottery, etc. A significant proportion of the population engage in trading activities, but this also relies on *Ndiwa* irrigation.

6 IMPLICATIONS OF THE RESEARCH FINDINGS AND RECOMMENDATIONS

6.1 Implications of the Research Findings

The research findings show that some significant changes have taken place in the NIS in the West Usambara Mountains. These changes have some implications to rural poverty alleviation in the study area. This chapter discusses some policy and planning implications of the findings. Furthermore, the chapter gives general policy and research recommendations that aim at enhancing the contribution of *Ndiwa* irrigation to rural poverty alleviation.

6.2 Policy Implications

Poverty in the West Usambara Mountains is a problem that is aggravated by inadequate and unreliable rainfall that has constrained rain-fed agriculture. Traditional irrigation systems, especially NIS, have a great potential for enhancing rural livelihoods and reducing rural poverty. *Ndiwa*s are important to the livelihoods of the farmers; however, the NIS is facing a lot of constraints, including a crisis of water scarcity amidst growing demands. The likely outcome of this, unless addressed, will be increasing conflicts among *Ndiwa* water users, declining production and worsening poverty situations. There is the need to promote and support NIS, as this implies that intervention through policy guidelines and external support is important for poverty reduction. Evidence from Soni division, where TIP has contributed towards improvement of NIS, shows that there is a great potential for improvement. Addressing *Ndiwa* constraints is essential for poverty alleviation and enhancing rural livelihood.

Whereas at the national level, the importance of protection of all water catchment areas is encouraged, in practice there is little enforcement of conservation of the water catchments at local levels. There is need to develop mechanisms at the local level that will ensure that local population understands the need and participates in the conservation of water sources. The agricultural policy needs to link agricultural production enhancement with improvement in water harvesting for irrigation.

6.3. Recommendations

6.3.1. Policy and Planning Recommendations

The agricultural policy of Tanzania recognises the importance of traditional irrigation systems in general. This study has established the contribution of NIS to poverty alleviation among upland farmers of West Usambara Mountains. The agricultural policy and planning should give adequate support to NIS for enhancing rural livelihood. Agricultural development in the uplands of West Usambara Mountains is not possible without addressing the problem of water scarcity. It is important, therefore, for agricultural policy and planning to integrate crop production strategies with conservation of water sources for *Ndiwa* irrigation. This can be achieved through the promotion and facilitation of training of farmers on conservation of water sources. The planting of trees that conserve water catchments and the harvesting of rainwater for *Ndiwa* irrigation must be emphasised. Agricultural extension services should assist villages to develop action plans for the improvement of *Ndiwa* water management.

6.3.2. Research Recommendations

This study identified some key components of change in NIS and factors that have contributed to change. It also underscored the potentials for *Ndiwa* irrigation development. However, there are areas that require further research for enhancing our understanding of dynamics of NIS. These include: marketing improvement; the effectiveness of prevailing *Ndiwa* water users' organisations; and *Ndiwa* related non-farm sources of income and their potential for poverty alleviation. Research on how to improve the quantity and steady flow of water for *Ndiwa* irrigation, including identification of local area specific infiltration enhancement measures, is greatly needed. Further research is required on

efficient means of using *Ndiwa* water to reduce water loss.

There is a potential for crop-livestock integration in the NIS, however, more research is required to identify local area specific ways of integrating crop and livestock for enhancing agricultural productivity.

6.3.3. General Recommendations

A more reliable measure to reduce the problem would be to promote conservation of the water catchment area by planting water conserving natural tree species and improving the soil and water conservation practices on steep slopes. The TIP approach of combining water storage improvement with better soil and water conservation practices is highly commended. Effort is required to improve catchment management through terracing, tree planting for conservation of water sources; avoiding field encroachment into furrows and *Ndiwa* water sources; and the control of bush fires. Better organization of farmers will enable resources to be pooled together, and a better water distribution system will reduce conflicts.

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