Assessment of Land use/cover Changes due to Traditional Irrigation Activities: A Case Study of Four Villages around Ruaha Mbuyuni, Iringa and Morogoro, Tanzania

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Abstract

Irrigated agriculture is considered as a panacea for food shortage problems facing many developing countries including Tanzania. Little though has been done to assess the impact of irrigation activities on the environment. The aim of this study was therefore to try and determine the extent of land use changes as a result of irrigation activities in sample villages around Ruaha Mbuyuni in Iringa and Morogoro regions, Tanzania. Aerial photographs of the study area taken at different times were interpreted and analysed for land use/cover changes. Results show that irrigated agriculture has been expanding steadily mainly along the river valleys replacing the riverine vegetation as a result. This is seen as a major threat to the stability of the river system as well as loss of biodiversity.

Introduction

The agricultural sector forms the basis of Tanzania's economy. The sector is estimated to employ 80% of the economically active population of the country. However, soil and climatic conditions and the use of the land beyond its limit result in decreased agricultural production (FAO, 1992). The development of agriculture, especially irrigated agriculture should therefore be approached cautiously since it is a natural resource dependant industry. Its survival can only be assured if the natural resource base on which it is heavily dependent is sustained. According to Vaughn, *et al.*, (1979), irrigation can be defined as the artificial method of applying water for supplementing rainfall, to improve crop yield and quality in areas where rainfall is insufficient or ill-timed. Irrigation also increases the extent of

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cultivated areas and increases the harvest frequencies to two or more per year. Various types of irrigation methods can be used depending on local conditions, cost, crop types, and the type of water resources that are being utilised. Rivers, dams, reservoirs and groundwater sources are relevant both for large and small-scale irrigation systems (NORAD, 1994).

Land use is any kind of permanent or cyclic human intervention to satisfy human needs, either materially or spiritually. It refers to man's utilitarian activities on the land (Khanna and Kondawar, 1991). Land is the most important natural resource, which embodies soil, water and associated flora and fauna involving the total ecosystem. Land as a natural resource is there to be used, and use takes place in specific areas at specific localities. Population growth and accompanied human activities are increasing the pressure on the limited land resources for food, energy and several other needs with the attendant danger of desertification. UNEP (1997) attributes two-thirds of the area already disertified in Africa to overgrazing and the remaining third to unsustainable agricultural and forestry practices.

Comprehensive information on the spatial distribution of land use/cover categories and the pattern of their change is a prerequisite for planning, utilisation and management of the land resources of the country. Land use/cover inventories are assuming increasing importance in various resources sectors like agricultural planning, settlement and cadastral surveys, environmental studies and operational planning based on agro-climatic zones. Information on land use/cover permits a better understanding of the land utilisation aspects on cropping patterns, fallow lands, forests, grazing lands, wastelands and surface water bodies, which is vital for developmental planning (Vink, 1963). Unfortunately, land cover classification in Tanzania is yet to be standardized. This situation makes it difficult to compare different studies and use previous studies as baseline for subsequent studies (Kikula, 1997).

Rural land use and the pattern of uses change in response to population growth, socio-economic developments and improved farming practices, as well as technology in the area. In the process, irrigation projects transform the land into two ways. First by direct modifications of the land surface that occur when canal networks are constructed and land is cleared, shaped and leveled for irrigation. Second by indirect in-depth transformations that take place when the water and salt balances in the region are changed following the import of additional quantities of water and salt into the

area. Irrigation can also change the land use by increasing productivity hence more farming activities which can lead to abandoning of some farms due to improper management of irrigation activities (Shanan, 1987).

According to a study by FAO (1981), Tanzania has enough land to produce food for her present and future population. Land with good agricultural potential in Tanzania is estimated at 10 million ha (FAO 1992). However, the precarious food situation experienced in the country indicates that the mere availability of land is not enough for self-sufficiency in food production. This is probably because in the past almost all agricultural research, and especially irrigation research, carried out in Tanzania has been largely confined to observation trials and has therefore failed to provide answers to the most pressing problems facing irrigation in the country (FAO, 1972). According to a research conducted by Wansink (1992) in Ruaha-Mbuyuni area, it was observed that some of the watershed areas were facing deforestation and hence causing serious sedimentation to the lowlands and crop yield reduction. The study indicated that agricultural land, especially the irrigated one, was deteriorating due to fertilizers and other chemical applications resulting in some farms being abandoned. Despite all these, there has not been much work done in Ruaha-Mbuyuni area to investigate the extent to which land use has been changed due to irrigation and related activities. It is against this background that this research was conducted between 1999 and 2001 in order to investigate and assess the extent of land use changes due to irrigation development in four villages around Ruaha Mbuyuni.

The Study Area

The study area comprises of four villages, which are Ruaha Mbuyuni and Mtandika along Lukosi river, Msosa along Msosa river and Malolo along Mwega river. Lukosi, Msosa and Mwega are tributaries of Great Ruaha river. The area is located between latitudes 7°34'S and 7°18'S and between longitudes 36°33'E and 36°20'E, on the leeward side of Udzungwa mountains. The altitude ranges from 520m to 1500m above sea level.

The climate of the study area is semi-arid. The annual rainfall ranges from 430mm to 500mm. The average air temperature ranges from 26°C to 30°C. Annual evaporation rates vary from 1450mm to 1500mm. Relative humidity is lowest during the day. It ranges from 22.5% in the dry season to 87.9 % in the rainy season. The three rivers namely Lukosi, Msosa and Mwega have a large catchment area, hence the discharge is considerable. The

maximum discharge of the Great Ruaha river is 180m^3/s with an estimated difference between the lowest and highest water levels of 1.5m (TIP, 1992). Inundation of the lowland areas due to floods is common and river bank erosion threatens the intakes for the various irrigation schemes in the area.

Methodology

Socio-economic data was collected through both discussion (formal and informal) with villagers and household interviews for which a structured questionnaire was used. In order to get a manageable sample size, 5% of the households in each village were randomly chosen and surveyed. The statistical computer package for social sciences (SPSS) was used for analysis of the socio-economic data. Secondary data such as background information of the study area was obtained from local officials. Census information and other demographic data between 1968 and 1988 were collected from the Bureau of Statistics, Dar es Salaam.

Three sets of panchromatic aerial photographs (1955, 1976 and 1999) at a scale of 1:30 000 were obtained from the Survey and Mapping Division of the Ministry of Lands and Settlement Development in Dar es Salaam. These aerial photographs were interpreted using a mirror stereoscope by looking at elements and characteristics such as shape, pattern, tone (or hue), texture, shadows and association of objects and features (Dent and Young, 1981 and Lillesand and Kiefer, 2000). From this interpretation, broad classes of land use/cover were established and maps prepared.

Following ground truthing (field verification), the broad classes of land use/cover established were digitized. The digitized data were then fed into the GIS ARC/VIEW software for spatial analyses and map production. The area of each land cover type was calculated for each data set and the difference in aerial coverage between the various land cover types over time determined. Class to class change detection was carried out using map overlays (1955/1976 and 1976/1999) (ESRI, 1995). The dissimilarities among the remotely sensed data (acquisition dates and spatial resolution or scale have an influence on the accuracy of classification.

Results and Discussion

Land use/cover types of the study area between 1955 and 1999

Broad classes of land use/cover established by interpretation of aerial photographs of the study area were forest, woodland, scrub bushland,

cultivated areas (irrigated and rainfed), abandoned fields, riverine vegetation, settlement and main river. Forest is vegetation consisting of large and dense trees with definite bole or trunk, can be natural or artificial, while woodland is vegetation consisting of trees and shrubs but not as dense as forest. Scrub bushland is vegetation consisting of stunted trees and shrubs.Shrubs are trees that do not have definite bole or trunk (Kiunsi, 1994). Cultivated area refers to land cultivated in the year of photography and abandoned field refers to land cultivated 1-3 years before the year of photography (regenerating). Riverine vegetation is the vegetation along the river, which may be forest, scrub bushland or woodland and settlement is the area consisting of buildings where people reside. The dissimilarities among the remotely sensed data (acquisition dates and spatial resolution or scale) influenced the accuracy of classification.

Table 1: Aerial Coverage of Land Use/Cover Types in the Study area in 1955, 1976 and 1999

Land use/cover	1955		1976		1999	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Forest	1422.7	2.6	1332.8	2.4	961.5	1.7
Irrigated fields	490.0	0.9	2234.5	4.0	4097.7	7.4
Rainfed fields	265.1	0.5	254.1	0.5	932.4	1.7
Abandoned fields	0.0	0.0	0.0	0.0	88.2	0.2
Riverine vegetation	4941.0	8.9	3640.1	6.6	1732.8	3.1
Scrub bushland	45301.6	81.8	45392.9	81.9	45157.4	81.5
Woodland	2178.1	3.9	1344.2	2.4	427.9	0.8
Settlement	362.1	0.6	762.4	1.4	1561.7	2.8
Main river	446.4	0.8	446.0	0.8	447.6	0.8
Total	55407.0	100.0	55407.0	100.0	55407.0	100.0

Table 1 shows that irrigated fields have steadily been increasing over time, while rainfed agriculture remained constant for much of the time with a slight increase during the temporal period of 1976-1999. Such an increase in cultivated area seems to have been at the expense of forest, woodland and riverine vegetation. Other causes of forest depletion, including woodland and riverine vegetation mentioned by farmers are cutting of trees for building materials, lumbering, firewood, charcoal production and destruction caused by forest fires.

Population statistics between 1968 and 1998 for the four villages indicate rather high growth rates (over 7% per annum) which is reflected in the gradual increase in the settlement area as shown in Table 1. Such increase in population inevitably exerts pressure on natural resources. It has been

documented for instance that firewood and charcoal provide approximately 70% of the energy used in Africa (FAO, 1999). Other land use/cover types such as scrub bushland, main river and abandoned fields appear to be unaffected with passage of time.

This would seem to suggest that suitable land for irrigated agriculture is scarce and very little if any is left fallow. Furthermore land cover types such as scrub bushland are known to occupy marginal land which is not suitable for irrigation as observed by Mohammed (1985).

Changes in land use/cover types between the two temporal periods (1955 -1976 and 1976 - 1999)

The temporal periods, 1955 to 1976 and 1976 to 1999 have experienced considerable land use/cover changes.

Table 2: Changes in Aerial Coverage of the Different Land Use/Cover Types in the Study Area between 1955 and 1999

Land use/cover	1955 - 1976		1976 - 1999	
	Area (ha)	Rate (ha/yr)	Area (ha)	Rate (ha/yr)
Forest	-89.9	-4.3	-371.3	-16.1
Irrigated fields	+1744.5	+83.1	+1863.0	+81.0
Rainfed fields	-11.0	-0.5	+678.3	+29.5
Abandoned fields	0.0	0.0	+88.2	+3.8
Riverine vegetation	-1300.9	-61.9	-1907.3	-82.9
Scrub bushland	+91.3	+4.3	-235.5	-10.2
Woodland	-833.9	-39.7	-916.3	-39.8
Settlement	+400.3	+19.1	+799.3	+34.8
Main river	-0.4	-0.02	+1.6	+0.07

NB: (+) Indicates increase and (-) indicates decrease.

Table 3: Change Detection Matrix Between 1955 and 1976

Land use/cover in 1955	Land use/cover in 1976								
	Forest	Irrigated fields	Rainfed fields	Riverine vegetation	Scrub bushland	Woodland	Settlement	Main river	Total
Forest	1332.8	0.0	11.0	25.0	24.0	29.9	0.0	0.0	1422.7
Irrigated fields	0.0	377.6	49.5	56.4	1.7	2.2	2.6	0.0	490.0
Rainfed fields	0.0	238.9	0.0	0.0	11.3	5.5	9.4	0.0	265.1
Riverine vegetation	0.0	1227.3	103.0	3100.9	392.0	0.8	117.0	0.0	4941.0
Scrub bushland	0.0	329.8	90.6	419.8	44280.8	11.0	169.6	0.0	45301.6
Woodland	0.0	48.4	0.0	38.0	663.7	1290.5	137.5	0.0	2178.1
Settlement	0.0	12.5	0.0	0.0	19.0	4.3	326.3	0.0	362.1
Main river	0.0	0.0	0.0	0.0	0.4	0.0	0.0	446.0	446.4
Total	1332.8	2234.5	254.1	3640.1	45392.9	1344.2	762.4	446.0	55407.0

Table 4: Change Detection Matrix Between 1976 and 1999

Land use/cover in 1976	Land use/cover in 1999									
	Forest	Irrigated fields	Rainfed fields	Abandoned fields	Riverine vegetation	Scrub bushland	Woodland	Settlement	Main river	Total
Forest	958.08	0.0	0.0	0.0	0.0	0.0	374.8	0.0	0.0	1332.8
Irrigated fields	0.0	1900.8	0.0	56.0	44.0	74.2	0.0	159.5	0.0	2234.5
Rainfed fields	0.0	148.0	35.0	32.2	10.4	21.3	7.2	0.0	0.0	254.1
Abandoned fields	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riverine vegetation	0.0	1372.5	207.7	0.0	1506.7	460.0	28.0	63.6	1.6	3640.1
Scrub bushland	3.5	374.0	177.7	0.0	162.9	44145.0	11.4	518.4	0.0	45392.9
Woodland	0.0	298.9	506.0	0.0	8.8	452.3	6.5	71.7	0.0	1344.2
Settlement	0.0	3.3	6.0	0.0	0.0	4.6	0.0	748.5	0.0	762.4
Main river	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	446.0	446.0
Total	961.5	4097.5	932.4	88.2	1732.8	45157.4	427.9	1561.7	447.6	55407.0

Table 2 shows the rate of change of the various land use/cover types over the two temporal periods (1955-1976 and 1976-1999). The highest rate recorded during the period 1955-1976 was for irrigated agriculture which increased at the rate of 83 ha/yr. This was followed by riverine vegetation and woodland which decreased at the rate of 62 ha/yr and 40 ha/yr respectively during the same period. This would seem to suggest that much of the expansion in irrigated area was at the expense of the two land cover types. However, according to Table 3, only riverine vegetation contributed significantly to expansion in irrigated area (55%) followed by scrub bushland (15%). Much of the woodland reverted to scrub bushland. A similar trend was observed during the period 1976-1999 but with absolute rates for irrigated land and riverine vegetation being more or less the same (Table 2). However, contribution of riverine vegetation to expansion of irrigated area dropped to 33% with scrub bushland, woodland and rainfed fields contributing another 20% (Table 4).

Looking at the land use/cover evolution, the most significant change is in irrigated agriculture which rose from a mere 0.9% of the total land coverage in 1955 to 7.4% in 1999. Riverine vegetation on the other hand declined from 8.9% coverage to 3.1% during the same period. The greatest impact of irrigated agriculture thus seems to be on riverine vegetation (Figs. 1-3). The proximity of the latter to the water source makes it a target for traditional irrigation development. The rich alluvial soils along the river valleys and use of small portable water pumps clearly favour development of such land for irrigation purposes. However as suitable land gets depleted further, more and more of the scrub bushland which covers over

80% of the total area will be exploited for irrigation purposes. Alternatively, farmers may be forced further afield along the river valleys in search of suitable land for irrigation, something which already seems to be happening (Figs. 1-3).

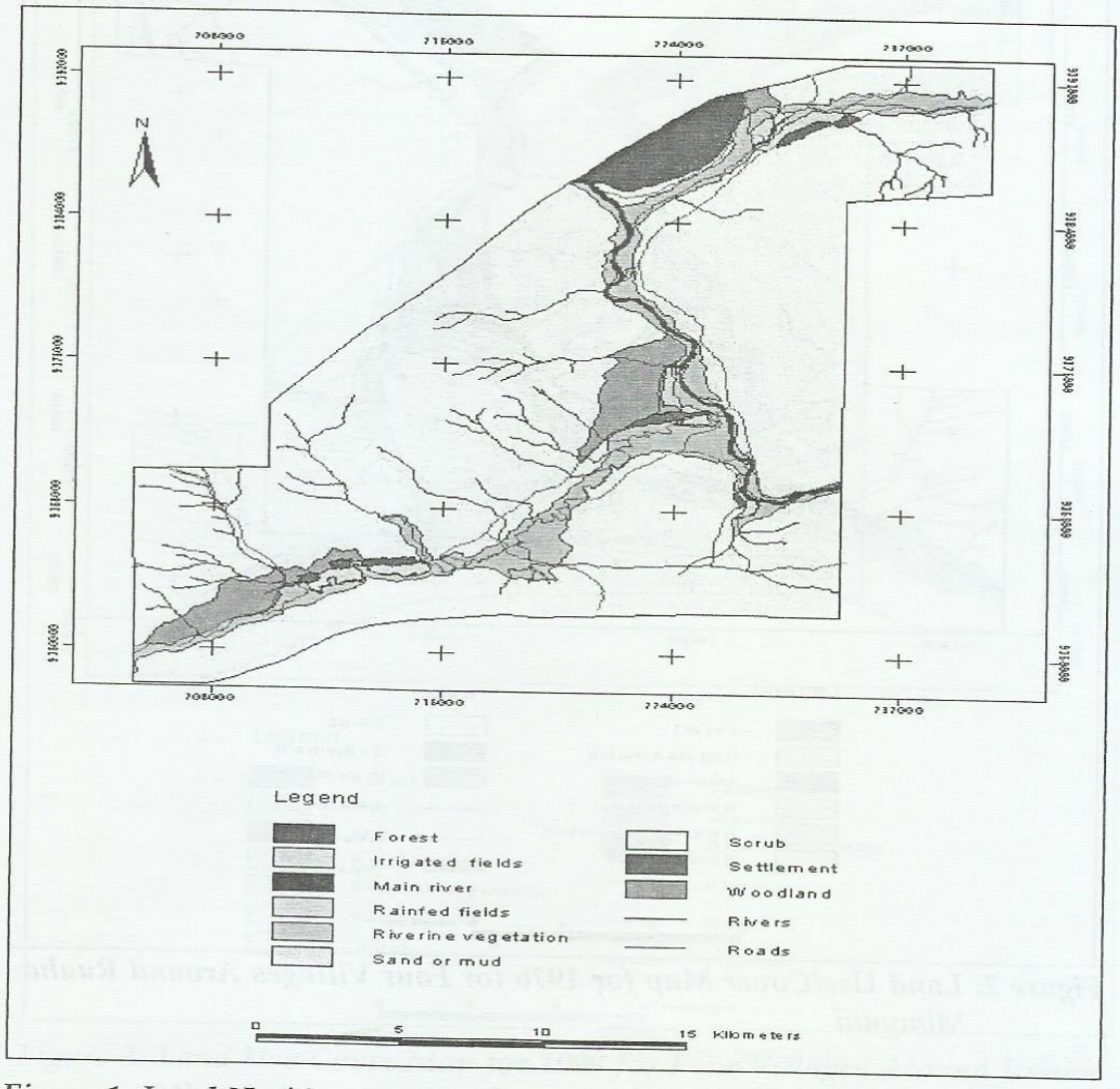

Figure 1: Land Use/Cover Map for 1955 for Four Villages Around Ruaha Mbuyuni

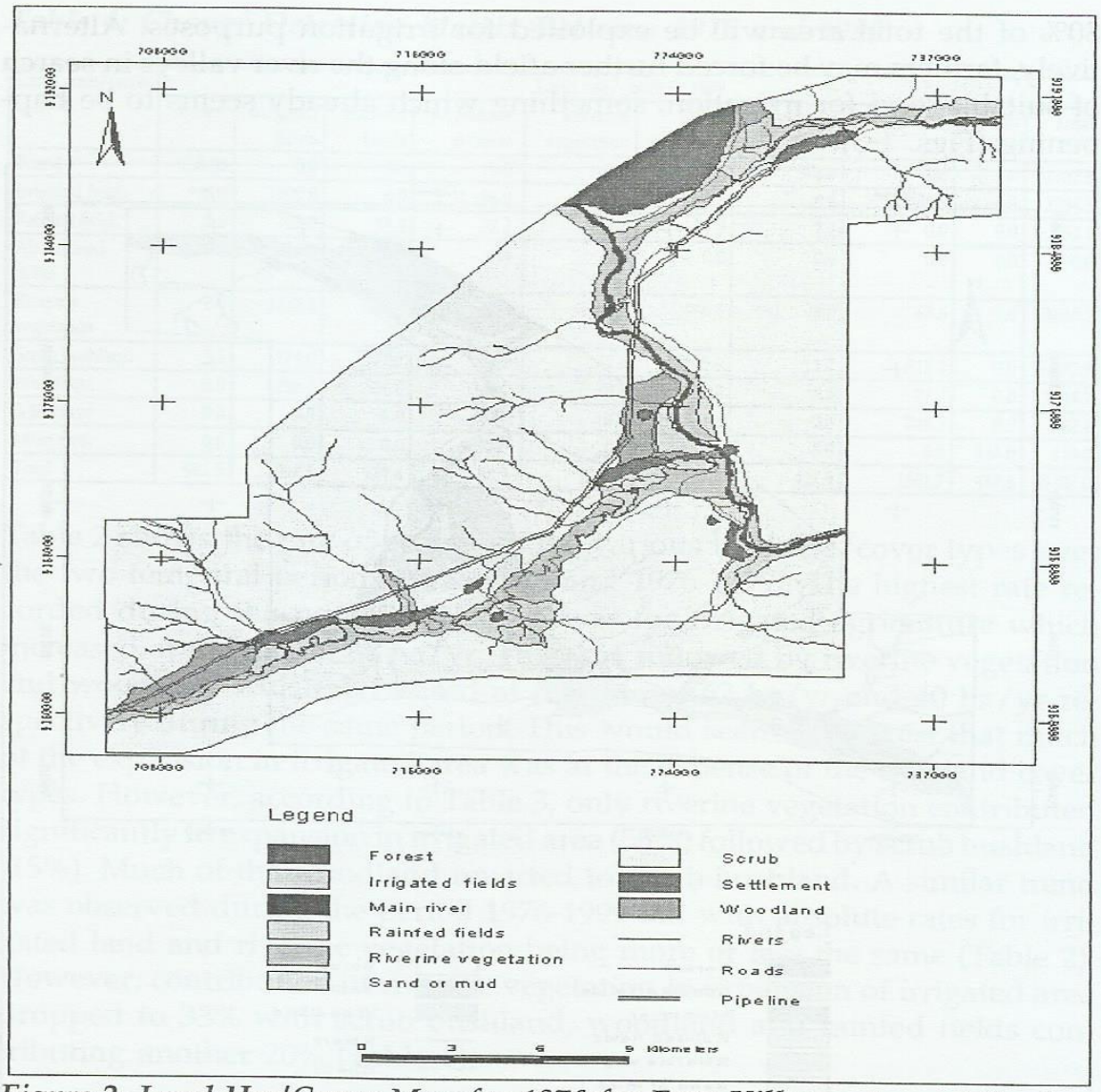

Figure 2: Land Use/Cover Map for 1976 for Four Villages Around Ruaha Mbuyuni

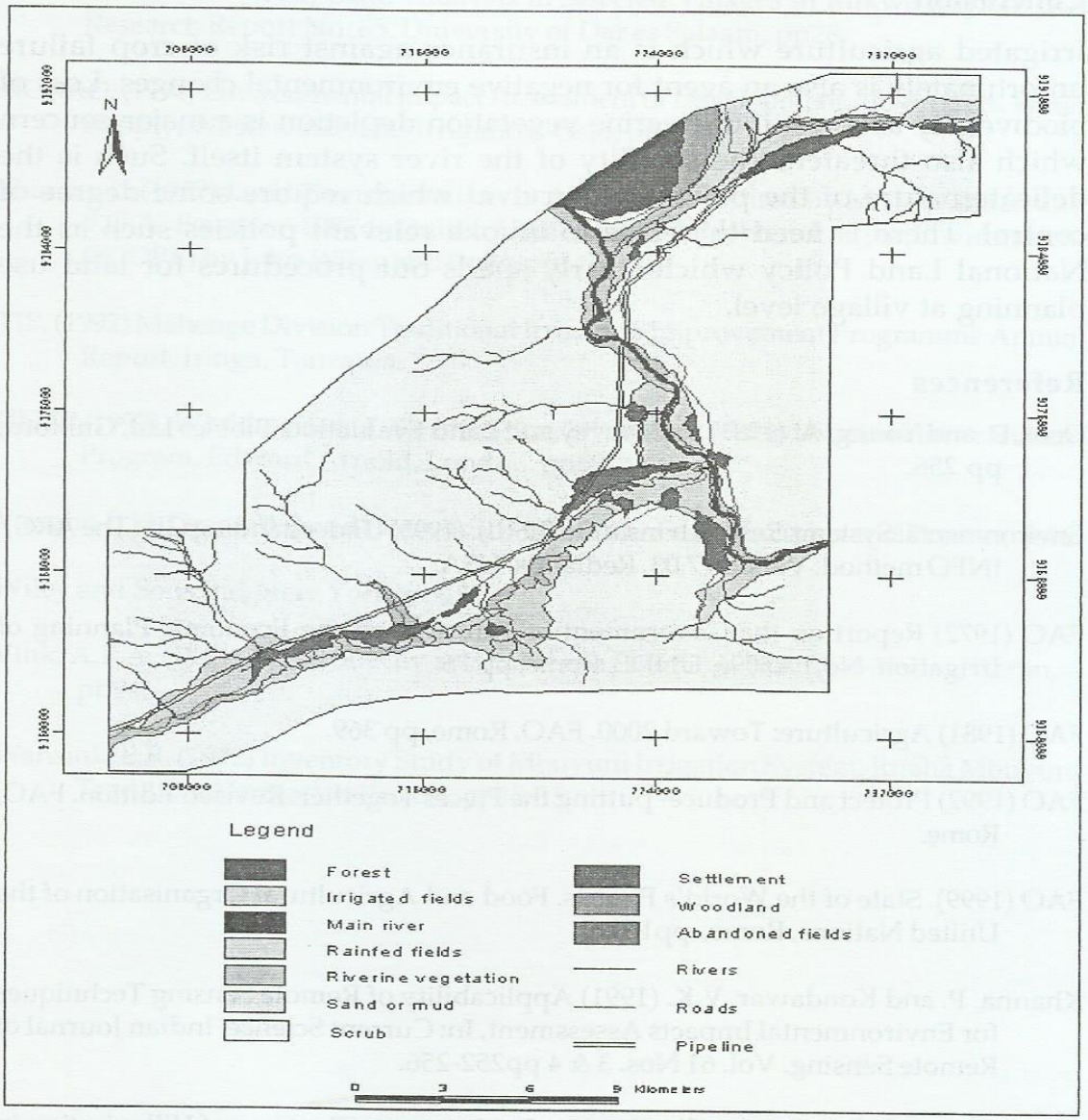

Figure 3: Land Use/Cover Map for 1999 for Four Villages Around Ruaha Mbuyuni

Conclusion

Irrigated agriculture which is an insurance against risk of crop failure unfortunately is also an agent for negative environmental changes. Loss of biodiversity as a result of riverine vegetation depletion is a major concern which also threatens the stability of the river system itself. Such is the delicate nature of the politics of survival which require some degree of control. There is need therefore to invoke relevant policies such as the National Land Policy which clearly spells out procedures for land use planning at village level.

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