A profile of environmental change in the Lake Manyara Basin, Tanzania

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CONTENTS

INTRODUCTION

Popular environmental narratives often serve a political purpose by choosing to ignore or distort the complexity and principles of ecological processes. The study of environmental history is crucial for understanding contemporary processes of change in landscapes, land use and livelihoods. Such studies help better to recognize the complexity and non-linearity inherent in social and biophysical systems which shape the countryside, resulting in altered perspectives on the nature of environmental change as well as on its causes. Where previously, for example, farmers and pastoralists were perceived as the primary causes of environmental degradation, now political, institutional and structural factors are recognised as being equally important factors. Not only does an environmental history perspective create a more reliable basis for informed policy decisions but, at its best, it also illuminates the political ecology of policy and development.

This paper reports on a study of the Lake Manyara Basin in north-west Tanzania. It covers the northern and central parts of this area, focusing on eight villages and their landscapes in some detail.[1] We do not presume to describe the complex biophysical, socio-economic and historical factors which have helped to shape the cultural landscape of the Lake Manyara Basin as a whole, but we do provide detailed examples of processes which are representative of a more general dynamism. Our intention is to create a 'rough guide' to the Lake Manyara area and its environmental history, and identify significant social, economic and political processes which have occurred here over the last 100 years or so, in order to understand the relationship between land-use practices and environmental change.

The study area can be separated into several distinct agro-ecological zones in which soil fertility and rainfall are highly correlated with topography and elevation (see Map 1). These are the arid Maasai Plains abutting the Rift Wall (200-500mm per year), the semi-arid Maasai and Ardai Plains (500-700 mm) and the semi-arid to sub-humid Karatu, Mbulumbulu and Monduli Highlands (700 - 1000mm). Rainfall is bimodal, with very high coefficients of variation. Soils vary from fertile highly erodable volcanic material, to a variety of moderate to low fertility sedimentary and basement soils. Vegetation ranges from open, bushed and wooded grasslands on the plains to wooded grasslands,

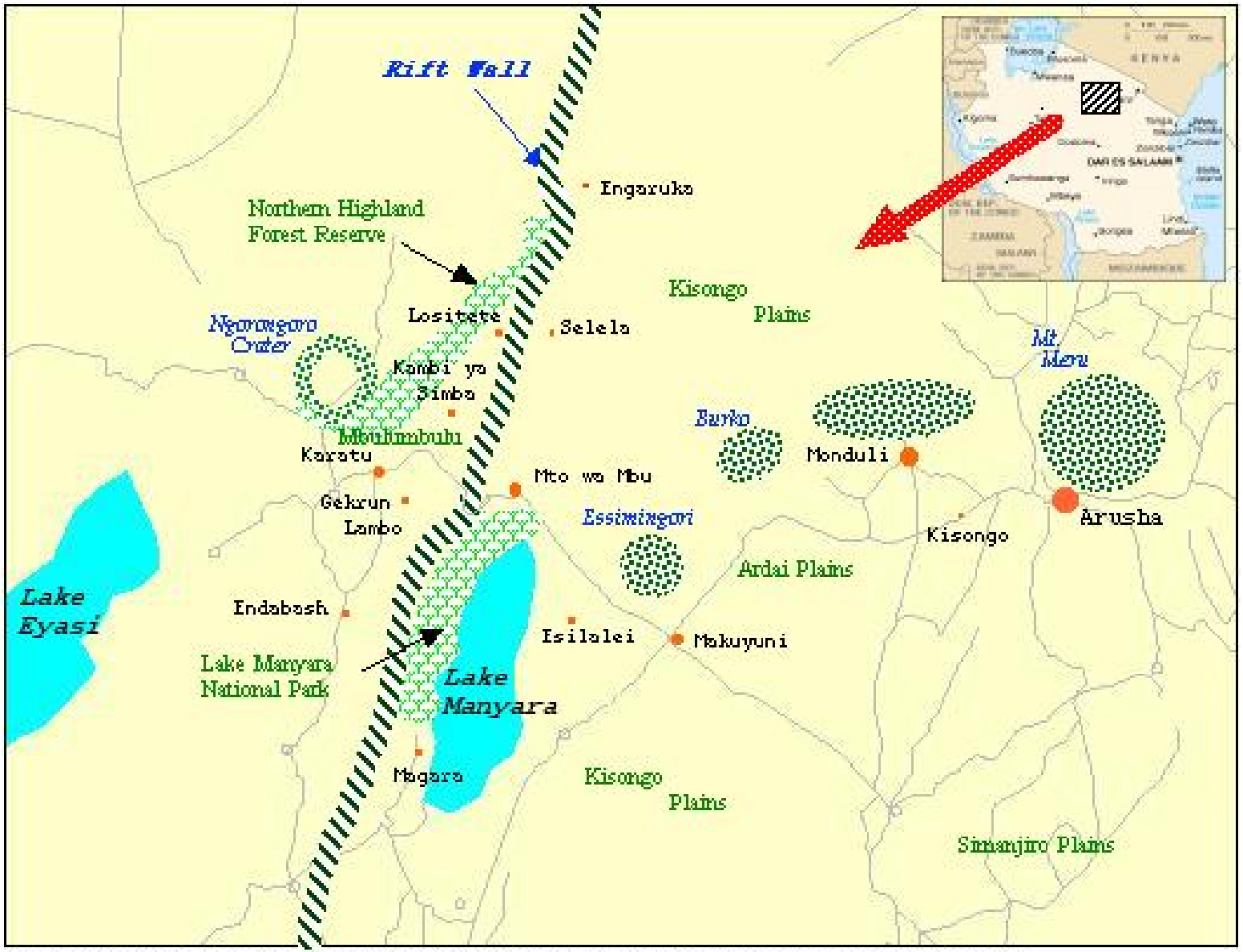
[1] This paper is derived from a more comprehensive and detailed project report (Rohde & Hilhorst, 2001).

woodlands, forests and extensive cultivated areas on the plateau (Meindertsma and Kessler, 1997a; 1997b).

The Lake Manyara area is a frontier zone, reflecting a social dynamism which has existed in this part of East Africa for several centuries. Maasai pastoralists have inhabited the plains to the east of Lake Manyara and the Northern Highlands, since at least the 18th century. More recently, the Barabaig pastoralists have migrated into the area from the south due to increasing marginalisation and land alienation. Agro-pastoralism is the predominant mode of production among the Iraqw, Gorowa, and Mbugwe settlers of the Mbulu and Babati Districts to the south and west, while pockets of intensive irrigated crop production at the foot of the Rift Valley Escarpment have developed rapidly during the last 50 years, drawing immigrants from all parts of Tanzania. Recent increases in the region's population have resulted in a massive expansion of cultivation in the Highlands and large tracts of land previously used exclusively by pastoral Maasai have been appropriated by the state, and large and small scale farmers. Signs are that the land frontier is closing as land holdings, village boundaries and definitions of rights to natural resources are increasingly contested, consolidated and re-defined.

The next section gives an overview of the various methods which have been used to reconstruct the environmental history of the study area. It then goes on to discuss the implications of historical, socio-economic and environmental research findings for interpreting change in the Lake Manyara Basin and contrasts these findings with popular or dominant narratives of environmental change. This paper ends with a series of conclusions on what environmental history research can contribute to the understanding of the dynamics of the Lake Manyara Basin and highlights the applicability of such techniques to studying environmental change in other African situations.

Map 1: The Lake Manyara Area showing major geographical features, major roads, towns and case study villages.



METHODOLOGY

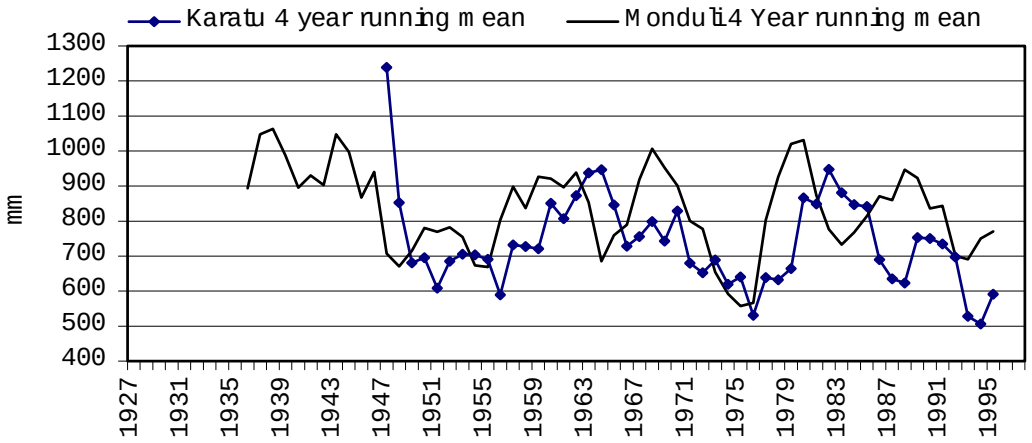
Methodological approaches to research on environmental history increasingly rely on inter-disciplinary collaboration between the social and natural sciences. Unfortunately, detailed botanical and geomorphological components are not included in this study. Instead, we relied on historical research using published literature, archival documents, including landscape and aerial photographs combined with social and political economy research at local level in an attempt to understand micro-processes of change. A series of 26 repeat landscape photographs were taken from across the study area. They provide important evidence of both stability and dynamic change in the vicinity of many of the case study sites. These repeat landscape photos were compared with aerial photos, oral and archival histories, contemporary publications and recent socio-economic research. Interviews were conducted in eight case study villages, and reconnaissance was carried out across an area of approximately 1,200 square kilometres, or less than 20% of the total Lake Manyara Catchment.

Climate and rainfall data

Monthly rainfall data were obtained for Lake Manyara National Park (1971-1999), Monduli (1934-1996), Karatu (1939-1995) and the Selian Airport west of Arusha (1925-1997). Average coefficients of variation (CV) for Lake Manyara Park (25%), Karatu (32%), Monduli (25%) and Arusha (26%) mask much larger inter-annual variations, which are more extreme in adjacent arid and semi-arid areas where the average CV is much higher (>35%).

The coincidence of deep drought followed by higher than average rainfall during the 1970s appears to be a common and significant feature in all the records of this area (Figure 1). The smoothing of trends using a four year running average shows a convergence in pattern between Monduli and Karatu with a slight lag in rainfall data from the west. The extreme climatic fluctuations during the 1970s coincided with Operation *Vijijini* - the implementation of *Ujamaa* throughout Tanzania.

Figure 1 : Rainfall – Karatu and Monduli 4 year running mean



Archaeological research

Archaeological research along the foot of the escarpment has focused on the remains of a series of late Iron Age villages which depended on crop irrigation systems, the most striking and well preserved of these being Engaruka which lies just to the north of the Lake Manyara catchment. Archaeological evidence suggests that previous episodes of in-migration, settlement and population increase have occurred spanning the 13th to 18th centuries (Sutton 1978; 1990). In its hey-day, Engaruka's fields were similar in design and scale to today's rapidly growing settlements of Selela and Mto wa Mbu, a comparison which raises important considerations regarding long term ecological processes and interactions between people and the environment.

Archival and contemporary vegetation and land-use maps

The British published a series of 1:300,000 maps covering all of Tanzania in 1941. These were based on German maps (OS 1914 - 1915) and include vegetation descriptions such as "Grass with trees and scattered bush", "Grassy plain", "Primeval forest", "Isolated trees", etc. These were made from observations during the German colonial period and document a landscape as seen by travellers just after the turn of the century, prior to the advance of agriculture in the Lake Manyara study area. These maps were referred to during fieldwork from which it could be seen that vegetation in those sites that had not been cultivated had remained more or less true to the colonial maps'

descriptions, due primarily to substrate and hydrological conditions. This was most obvious in the Maasai Plains areas, the Rift Wall and the protected highland areas. In study sites where cultivation has changed the natural vegetation, these maps helped to elicit oral history details from local informants.

Comparing these archival maps with contemporary land cover and land use maps of the area (United Republic of Tanzania 1966, scale 1:250,000) is somewhat problematic due to the difference in vegetation categories used in the two sets, but it tends to substantiate the hypothesis that the primary determinant of vegetation type is related to rainfall, substrate and hydrological conditions in uncultivated areas, while many of the natural characteristics of cultivated land correspond with land use categories such as "Woodland with scattered cropland", "Bushland with scattered cropland" etc.

Matched ground photography

Matched or repeat fixed-point photography was used extensively in this study and is a powerful tool in providing high quality comparative information directly through an image without having to resort to statistical analysis and specialized expert knowledge. It is a means of provoking relevant questions about environmental change in a specific location. When comparing images from two separate time periods one is immediately aware of significant changes in the density of vegetation and species composition. Questions arising from a comparison of matched photos can be related to histories of environmental variables, such as rainfall, fire, wildlife and human impacts, thus building a profile of likely causes of environmental change. This methodology is available to anyone with a basic knowledge of cameras and a modicum of common sense (see Box 1). Soil, vegetation and socio-economic site surveys should also be fed back into the repeat photo research process in order to revise and construct more reliable theories of ecological dynamism and environmental change.

A series of 26 repeat ground photographs was established during the SUNRISE project. These are discussed in more detail in the section "Evidence of environmental change" below.

Box 1. Methods of producing matched photographs

Locating the exact camera position from an archival photograph can be time consuming, but provided there are at least two identifiable landscape features such as rocks, hills, buildings or trees present, surprising site accuracy can be obtained through triangulation. It is useful to determine the time of day and season in which the archival photo was made in order to obtain a more accurate match. By determining the centre of the original photo it is possible to align the centre of the image in the camera view finder to correspond with the original; a zoom lens is useful in replicating the original frame. Standardized data sheets should be drawn up to record date, time, position, grid reference, location maps, source and date of original photo, field type and subject, soil types, geological features, landscape description and notes on major changes. It is prudent to 'bracket' exposures by taking several frames of the same image while varying the lens aperture: film is cheap compared to the expense and time required to revisit sites in case of mistakes in film development.

The process of replicating an exact match is finally accomplished in the dark room during the process of enlargement by superimposing the negative image of the match onto the archival photo until prominent features from both photos can be accurately aligned. The archival photo is then replaced by unexposed photo paper and a print made of the matched image. Alternatively, the matched photos can be scanned and imported into the software programme *Adobe PhotoShop* where they are cropped to match, sized and justified before being mounted in *PageMaker*. A number of other similar software programmes are now available for digitising and publishing images.

Repeat aerial photos

The use of matched aerial photography as a method for measuring vegetation change has several advantages over matched ground photography, because vertical aerial photos depict continuous ground cover which can be measured and compared. Case study sites were investigated using stereoscopic aerial photos to identify past conditions and recent changes in both vegetation and human impact. However, analysis is restricted by the interval between repeat photos, which in the case of the Manyara Basin is both narrow and recent. Scale and resolution can present further limitations to the use of matched aerial photographs. Three sets of aerial images (1958, 1972 and 1983) of Kambi ya Simba (one of the Mbulumbulu Highland study villages), were scanned and imported into a *Corel Draw* programme where they were matched and rectified. Field boundaries, streams, paths and gullies were traced on each image to build up a sequence of landscape change before and

after *Ujamaa*. The most graphic evidence of soil erosion can be seen in the gully formation which results from livestock tracks. The use of recent satellite imagery would add significantly to the interpretation of landscape and settlement changes before, during and after villagisation.

Archival records, ethnographies and historical accounts

The journals and reports produced by travellers, explorers, geographers, administrators and missionaries provide accounts of landscapes, settlements and human activities. These are invaluable in unravelling past environmental conditions and human-nature relations, even though they may be coloured by the political and social culture of their time.[2] In relation to the Lake Manyara area, the earliest documents are either German or British Missionary records and refer to the Maasai, the devastation of livestock herds by the rinderpest epizootic of the 1890s, tsetse infestations and Iraqw settlement in Mbulu. Both Protestant and Roman Catholic missions were established in the Kilimanjaro - Meru areas during the late 19th century but it was only many decades later during British colonial rule that outreach missions were established in the Manyara Basin area of the Maasai Plains.[3]

Ethnographies and anthropological studies of the major ethnic groups of the area are further sources of historical detail which deserve investigation in the study of the Lake Manyara Basin. However, most are focused on the geographical fringes of the study area, partly because many of these studies were conducted prior to Independence when the Lake Manyara area was a sparsely populated zone.

Authors of historical monographs and journal articles help piece together the history of the Iraqw (Diyamett, 1978; Thornton, 1980) and their northern expansion to Karatu (Raikes, 1971; Snyder, 1990; Tommasoli, 1986) the

[2]One of the best sources of documents of the Lake Manyara area is to be found in the East Africa Collection and the Fosbrooke Collection, both housed within the Library of the University of Dar es Salaam. Rhodes House Library in Oxford holds a collection of photographs, diaries and reports by the geographer Clement Gillman who worked in this area sporadically during the 1920s and 1930s. It also holds many similar documents by other authors who worked in Tanganyika before Independence.

[3] The Lutheran Northern Diocese archives in Moshi, the Lutheran Theological College at Makumira and the Holy Ghost Fathers headquarters in Moshi contain valuable records of these early mission activities.

growth of Mto wa Mbu (Arens, 1979; Raikes, 1990) the Maasai (Fosbrooke, 1954; Homewood & Rogers, 1991), the Barabaig (Lane, 1996), tsetse eradication at the southern edge of the Lake Manyara catchment (Kjaerby, 1979), the settlement of Mount Meru by Arusha and their expansion into the Kisongo plains (Spear, 1997) as well as more general studies of agricultural and economic development in Tanzania (Iliffe, 1977; Kjekshus, 1977; Koponen, 1988). These sources, among others, form the basis of the historical summary in the following section.

A SHORT HISTORY OF THE LAKE MANYARA AREA

The Lake Manyara area is not only highly diverse and dynamic from a bio-physical perspective, it is extremely complex socially and has a long history of occupation. The 'stone-bowl people' who inhabited the Mbulu highlands 2,000 years ago are the earliest known culture to inhabit the Manyara area.

The ancient irrigation systems of Engaruka

The remains of several sophisticated Late Iron Age villages can be found along the base of the Rift escarpment, such as the ruins of Engaruka (see the section on 'Archaeological research' above). The abandonment of Engaruka probably occurred as a result of a combination of factors including the arrival of pastoral invaders, a decrease in water supply possibly due to decreased rainfall in the highlands, faulting associated with volcanic activities, or deforestation of the escarpment during the life of the ancient settlement. Soil exhaustion is another possible reason for the settlement's decline - the fields close to the escarpment are now seriously denuded of soil. At its height, the irrigated lands of old Engaruka covered 2,000 hectares and were inhabited by 5,000 people.

German and British colonial periods

From the end of the 19th century onwards, during the German and British colonial periods, histories of war, disease, famine and the spread of tsetse resulted in radical demographic change and social disruption. Maasai pastoralists had moved into the Lake Manyara area by the 18th century, but the 1890s were for them a decade of disaster. Rinderpest devastated Maasai herds and the remainder were subject to attack from ancient enemies. Maasai

fortunes turned after the World War I for a time, when they regained temporary dominance over their agricultural neighbours, such as the Iraqw, seizing the herds which the latter had built up under the Germans. Tsetse expanded into the Maasai plain in the early 1920s, probably as a result of the collapse of the pastoral economy and attendant rangeland management practices which in turn led to bush encroachment favourable to the spread of tsetse.

The Iraqw are an agro-pastoral people, who during the 19th and early 20th centuries inhabited the western rim of the Rift Valley in the Mbulu highlands where they had been prevented from expanding by surrounding pastoralists. In response, they developed an intensive system of agriculture involving manuring, contour ridging and large herds of cattle. In the aftermath of the rinderpest epidemic of the 1890's, the Iraqw displaced the Maasai and by the 1929 moved as far north as Karatu, even settling the plains at the foot of the Rift Wall. In the process, intensive agricultural practices were abandoned. The most fertile and productive lands in the Karatu District were settled by Europeans during the 1920s and 30s. This alienation of land served to develop the local economy with roads, marketing networks and improved health and education facilities.

The reduction in the cattle population in the highlands which followed the rinderpest attack led to vegetation changes which facilitated tsetse infestation, making large areas of prime pasture lands in the highlands useless, due to the threat of sleeping sickness. During the 1940s and 50s, the colonial tsetse eradication programme was undertaken, as a result of which large tracts of the area were cleared of bush and forest, facilitating agricultural and agro-pastoral expansion. This paved the way for widespread human settlement by immigrants with a most profound effect on the local environment. As the population and colonial economy grew, soil conservation initiatives such as the "bench terrace" schemes were introduced throughout Mbulu during the 1940s (Maack 1996), followed in the 1950s by wheat and coffee schemes on the plateau and in irrigated areas at the foot of the escarpment (Thornton 1980). The introduction of a 'wheat scheme' during World War II, transformed the Karatu area into a highly productive, capital intensive agricultural centre. When most European settlers left the area in the 1950s, Iraqw leaders played a major role in land re-allocations among their followers. Wheat cultivation continued, with some Iraqw commercial farmers being able to invest in tractors, combine harvesters, trucks and busses. Wheat is still an important cash crop for farmers in Mbulumbulu.

Ujamaa

Undoubtedly, the most significant political events since WW II were related to the nation-wide programme of villagisation (*Ujamaa*) which took place during the 1970s. *Ujamaa* aimed to move the entire Tanzanian rural population into co-operative villages and achieved this under "Operation Vijijini", when land was redistributed and several million peasants and pastoralists resettled in new more compact villages, often under duress. Operation Vijijini had a profound social and economic effect, especially on the Highlands of Karatu where wealthy commercial farmers were deprived of their land holdings. However, the pastoralists of the plains were left relatively unaffected by *Ujamaa* and a number of initiatives such as the Maasai Range Development Project proved ineffective and short-lived. Post-*Ujamaa* development projects in southern areas, such as the Kondoa Wheat Scheme, forced Barabaig pastoralists into pastures on the southern fringe of the study area.

On the eastern fringes of the Basin, Arusha, Meru and Chagga expansion around the slopes of Mount Meru and the alienation of land by colonial settlers during the late 19th and early 20th centuries are well documented. Less is known about the agro-pastoral expansion into the Maasai Plains (Kisongo) in the Lake Manyara Basin which began in earnest during the 1930s as Arusha and Meru entrepreneurs expanded cultivation along the highland spur to Monduli and continued west into Kisongo. This colonisation of the plains has always been in some way an extension of the mountain farming economies of Meru and Kilimanjaro. During the wheat boom of the 1940s, Arusha and Meru farmers expanded across the upper Makuyuni sub-catchment, engaging in large-scale wheat cultivation using tractors and combine harvesters, switching back to maize when prices fell in the 1950s. The availability of land in the plains was essential for the expansion of mixed farming and both Meru and Arusha were adept at employing a variety of agricultural strategies, both intensive and extensive, to increase productivity. Arusha cultural links with the Maasai enabled them to graze cattle on the plains and to gain access to land for expansion where they quickly learned how to plough with oxen and open up farms on the Monduli and Kisongo plains.

Liberalisation and multi-party democracy

Liberalisation in the economic aftermath of *Ujamaa* during the 1980s encouraged the expansion of agriculture in previously uncultivated areas to its

limits in the semi-arid Ardai Plains and the Kisongo Plains surrounding Makuyuni. This rapid expansion of pioneer settlement and cultivation accompanied by deforestation and increased livestock numbers, inevitably resulted in problems of soil erosion, declining fertility, and overgrazing. This recent surge in the region's population, due to high growth rates coupled with in-migration also resulted in a massive expansion of cultivation on the Rift plateau, spilling over into the Rift Valley itself where large tracts of land previously used exclusively by pastoral Maasai have been successively appropriated by plantation and peasant farmers, in addition to land already taken by the State for forest reserves, national parks, game controlled areas and the like. These processes of pastoral dispossession and agricultural colonisation have had negative impacts on Maasai pastoralists. In the plateau area of Mbulumbulu, population growth has resulted in large areas of land being cleared.

Pockets of intensive irrigated crop production at the foot of the Rift Valley escarpment have developed rapidly during the last 30 years, drawing immigrants from all parts of Tanzania. During the last decade a burgeoning land market has grown up around settlements such as Mto wa Mbu where an acre of irrigated land can now change hands for over one million shillings (£850). These irrigated lands are located at the interface between pastoral and agricultural societies and owe their existence to perennial springs and extensive wetlands. On the one hand, agricultural practices on the plateau have a direct bearing on soil fertility and the hydrological regime which supports this intensive irrigated agriculture at the escarpment foot. On the other, pastoralists in the plains are in conflict with village cultivators over these wetlands which comprise a key resource in their grazing system.

Cultivators from the plateau and pastoralists from the plains are becoming more interdependent within a rapidly expanding market economy arising out of highly productive irrigated settlements such as Mto wa Mbu, which can be seen as a microcosm of the more dynamic side of Tanzania's economy. The construction of a large scale irrigation, drainage and flood control system have made high production irrigated agriculture possible, boosting the local economy and drawing people from surrounding regions. Moreover, a burgeoning tourist industry is based around the area's world famous wildlife habitats spanning the Maasai plains and the Crater Highlands. The various National Parks, Forest Reserves, Game Controlled Areas, Migration Corridors and Wildlife Buffer Zones, restrict agro-pastoral access on the one hand while hotels, safari companies, tourist camps and souvenir markets provide some employment and income opportunities on the other.

EVIDENCE OF ENVIRONMENTAL CHANGE

'Received wisdom' of environmental narratives

Concern about environmental change and especially environmental degradation has played a significant part in both colonial and post-independence government policy in the Lake Manyara area. As far back as the 1920s, a colonial official commenting on gully erosion in the Mbulu District observed:

> *"[…] it is obvious to me that increasing cultivation and overstocking are rapidly destroying the value of what remains to the people. I know of no country in which forest conservation is more necessary than it is in Mbulu District where congested population, where grazing is overstocked, would if left without control, very speedily destroy all the mountain timber and with it their vital water supply" (quoted in Diyamett 1978:64-65).*

Seventy years later similar comments are still common currency: "*Considering the human population that can be supported by available agricultural land, the population is in excess of the [Lake Manyara] basin's carrying capacity by 228%"* (Kiwasila 1992:16). Similar claims are made regarding the grasslands of the Maasai plains which are purportedly overstocked by 177%, leading to "*ongoing overgrazing and mismanagement of rangelands*" (Mwalyosi 1992:19). Warnings about impending declines in wildlife populations, fuelwood supplies, agricultural productivity and water quality are other key environmental concerns which lie at the heart of government and donor development initiatives. Contemporary development plans assume adverse impacts of population growth and agricultural intensification, and propose technical interventions such as improved seed varieties, schemes to reduce grazing pressure and property titling. And yet the empirical evidence for a generalised process of environmental degradation is limited and conflicting.

Changes in the landscape

Hard evidence and vital clues to the environmental history of the Lake Manyara Basin were uncovered in a series of 26 repeat landscape photographs

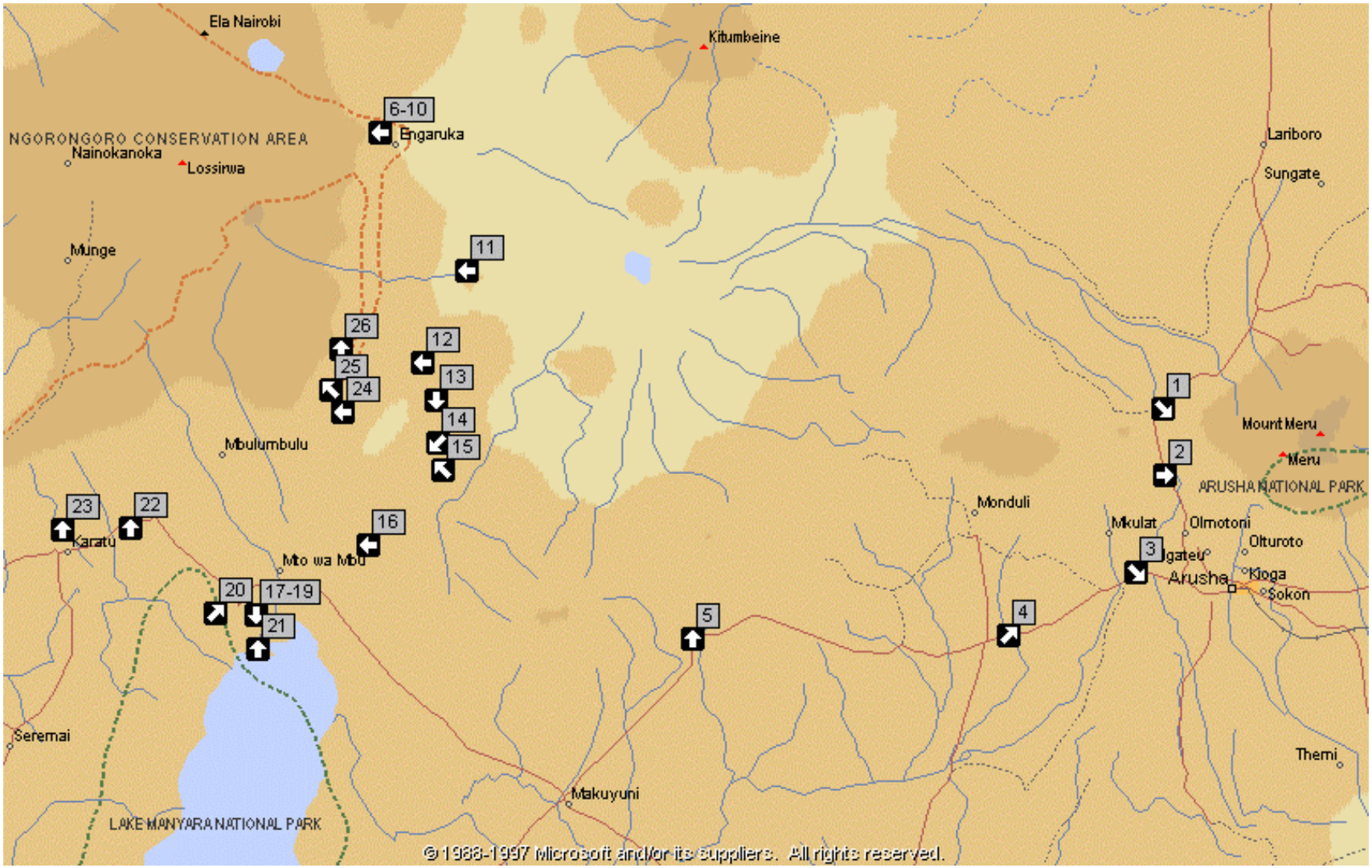
made in the study area a during field trip in October 2000[4]. The time spans of these matches vary from 90 to 15 years. However, most of the archival images were taken during the early 1960s. The analysis of these photos was made by dividing them into three transects (see map 2) reflecting the environmental gradients of (1) the Meru/ Monduli area, (2) the Rift Valley plains and escarpment and (3) the Karatu Highlands.

Transect 1: West of Meru

The first transect moves west from the high quality rainfed lands around Mt. Meru, into the densely populated marginal lands of Kisongo, and then into the semi-arid extensively managed pastoral lands south of Burko (photo sites 1 to 5 on Map 2). Across this 50 kilometre east-west transect we see the effects of a steep and declining rainfall gradient, and evidence of an increase in population pressure in all sites. There is evidence of agricultural intensification in the form of increased tree cover and the establishment of distinct field boundary markers, as the highly productive lands around Meru increase in value over time. The lower rainfall area was first permanently settled in the 1950s, when Arusha agro-pastoralists moved here from areas around the slopes of Mt. Meru as land shortages became more acute (see centre pages, Photos 1a & b). In Kisongo (site 3), a dam was constructed in 1960 as a watering point for livestock and this became the focal point for an extended village. Soon, however, gullies appeared which were the result of livestock paths to and from this watering point. This process proceeded rapidly until the end of the 1970s. Since then many gullies have stabilised along with livestock numbers. Local farmers have made some progress in checking these erosion processes as land scarcity changed this area from a frontier zone to a settlement area. Other evidence from repeat photos shows how this expansion along the main western highway has changed an unsettled acacia savannah in 1960 to a settled landscape of permanent houses and field boundaries.

[4] Due to publication costs, we are able to present only 3 of these repeat photo pairs in this report. The complete set of repeat photos can be obtained from the authors.

Map 2: Study area (Arusha Region) showing matched photo sites



Note: Map numbers correspond with site numbers referred to in main text of the Project Final Report (see Rohde & Hilhorst 2001). Arrows indicate location and approximate directional aspect of photographs.

Transect 2: the Rift Valley and Escarpment Wall

The second transect follows the Rift Wall from Engaruka in the north to Mto wa Mbu in the south (photo sites 6 to 21 on Map 2). The vegetation dynamics on the steep Rift wall and its foot-hills show a consistent pattern of patch dynamics probably due to recruitment and senescence events associated with climatic fluctuations. No doubt, the occurrence or cessation of periodic fires associated with grazing management also plays a part. Other sets of repeat photos show little change in the Rift Valley grasslands, apart from the dynamism associated with tree recruitment where ground water sources exist.

Photos 2a & b characterise the stability of the Rift Valley vegetation, the recruitment of woody vegetation due to human disturbance and the contrast between rainy season and drought conditions. Taken together, this set of transect photos indicates little change in a stable grassland environment while revealing the dynamic patchiness of woody vegetation on or near the Rift wall.

Transect 3: the Karatu and Mbulumbulu highlands

This transect (photo sites 22 to 26) is situated on the plateau between Karatu and Lositete. It tells a story similar to the first transect west of Meru and depicts a landscape where recent dramatic changes associated with agricultural intensification near Karatu are similar to those which have occurred closer to Arusha. The planting of trees and the defining of field boundaries have accompanied the expansion of Karatu town and the growing market in informal land transactions.

Photos 3a & b view the fireline separating the village of Upper Kitete from the Northern Highland Forest Reserve. In 1960, when the first photo was taken, Upper Kitete was sparsely inhabited. Since then there has been a massive increase in village settlement and cultivation, and a human population which uses illegally the adjacent forest resources. These photos show an extraordinary increase in forest vegetation on both sides of the Northern Highland Forest Reserve. Other photo matches in this highland area confirm that the forest cover is relatively stable.

AGRO-ECOLOGICAL ZONES AND ENVIRONMENTAL CHANGE

Land use can be categorised into *high quality rainfed lands* in the Highlands; *irrigated lands* - mainly at the escarpment foot; *pastoral lands* - the drier parts of the Maasai plains; and *extensively cultivated marginal lands* - in the Ardai plains, the last frontier zones of agro-pastoral activity. Population densities of about 10 people per square kilometre on the plains, over 60 in the Highlands, and even higher in irrigated areas, reflect the productive capacity differentials of these agro-ecological zones.

High quality rainfed lands in the Karatu Highlands

Land-use in this zone is highly diverse, reflecting the variety of soils, slopes and natural micro-environments which are used for village settlement areas, rainfed and irrigated fields, wood lots and grazing areas. Gully erosion began with bush clearing programmes to eradicate tsetse in the late 1940s and 1950s, and the expansion of Iraqw agro-pastoralists into the area. Many of the worst examples of gully formation can be traced back to early stock routes and human tracks, as soils in this area are highly erodable. There is also evidence to suggest that in many instances, erosion control measures carried out over the last decade have been effective in reversing gully formation. Some gullies treated with stones and strengthened with sisal are now filling up.

The social upheaval of villagisation during the 1970s, coincided with a period of extreme climatic events and environmental change. People were resettled in new, more compact villages which were often further away from grazing areas and family fields. In the Lake Manyara area, Operation *Vijijini* coupled with extreme drought followed by very high rainfall events resulted in increased gully formation, especially along livestock tracks in areas with fine volcanic soils which were more intensively used. Several dams in the study area rapidly filled with sediment during and subsequent to this period. The construction of new villages also led to localised deforestation. As the population grew over the succeeding decades, families were forced to use less fertile soils and erosion occurred as a result of the confinement of livestock to reduced grazing lands.

Commercial wheat production has resulted in more sheet erosion associated with extensive tractor cultivation. The frequency of sharecropping arrangements and the practice of hiring tractors often makes soil conservation

through contour ploughing and maintaining bunds a secondary consideration for poor farming families. Approximately 50% of the cultivable land in Kambi ya Simba, for example, is hired out to contract cultivators. Sheet erosion has resulted in the rapid siltation of dams and increased run-off affecting the irrigated lands below the escarpment. Farmers also report declining soil fertility and crop yields.

The recent settlement of marginal ravine areas has come about due to land shortages and the need of teenagers and young married couples to establish their own homesteads. Small stony hillside plots are cultivated by these subsistence farmers in spite of the fact that village by-laws often prohibit such settlement. This expansionary process is impossible to curtail because it presents the only option to the young and marginalised who must survive primarily on seasonal agricultural waged labour. Coping strategies of other families include selling livestock or migration to commercial plantations and urban areas in search of work.

Some aspects of village social structure and political organisation have helped villagers to reverse degradation and conserve communal resources. The village council of Kambi ya Simba, for example, is involved in land conservation and the prevention of erosion with each sub-village playing a role in enforcing bylaws restricting grazing and tree cutting. Villagers in Gekrun-Lambo, however, draw a correlation between the creation of a multi-party political system in 1992 with the relaxation of grazing regulations and village bylaws aimed at curtailing tree cutting, uncontrolled grazing and the cultivation of marginal, erosion-prone land. This flux in political power creates some uncertainty in the way natural resources are controlled within the village.

Overall, evidence of conservation measures including renewed contour ploughing, wood-lot production, protection of vulnerable areas and gully reclamation suggest that farmers and village councils are capable of addressing environmental degradation in the high quality rainfed land in the plateau and highland regions.

Irrigated lands

The irrigated lands below the escarpment owe their existence to landscape processes which largely originate in upper catchments where land-use practices and environmental change have a direct impact on the hydrological regime. Irrigated fields are productive due to a steady supply of fertile

sediments through run-off. These floods however, have become more damaging, increasingly depositing sand and stones on the fields at the escarpment foot (see Box 2). This is caused by increased run-off from the plateau due to several factors: the clearing of vegetation, poor land husbandry practices and overgrazing in the upper catchments, and climatic change. In Mto wa Mbu, competition over poorly managed water supplies, salinisation of low lying areas due to poor soil husbandry practices and health problems, associated with water pollution and waste disposal, were identified as some of the most pressing problems. All irrigated areas are experiencing growing competition with Maasai pastoralists over access to dry season grazing and conflicts between farmers and conservationists over wildlife (see Box 3).

The transformation of Mto wa Mbu from a small irrigated settlement to today's 1,600 hectares of highly productive irrigated land was made possible by the ILO infrastructure project of the 1970s and 80s which built drains and large irrigation canals. However, it also left a large number of unresolved problems. There was a lack of appreciation for the extent of knowledge associated with small-scale irrigated agriculture and the environmental dynamics of the area.

Extensively managed pastoral lands - the Maasai Plains

Transhumant Maasai pastoralists inhabit the arid and semi-arid plains which lie to the east of the Rift Wall. Our study suggests that from the perspective of environmental change, this area is affected least by population growth, overgrazing or inappropriate development. Repeat ground and aerial photos show that there has been little change associated with pastoral activity in the agro-ecological zone during the last 50 to 100 years, but further detailed vegetation studies are necessary to confirm this.

Rainfed maize cultivation is probably the most obvious land-use change to have affected the plains but this is insignificant as a factor causing wide-spread soil and vegetation change. The high incidence of poverty and marginalisation are less a consequence of environmental degradation and more closely related to villagisation, misguided development initiatives and the alienation of large grazing areas from Maasai control. Inadequate provision of social services include water supplies, health and educational facilities, although the latter are in the process of improvement.

Box 2. Protecting the irrigated lands

The waters coming down from the escarpment are a source of silt, and some fields in Mto wa Mbu have a deposit of more than 2 meters of fertile brown soil. However, when the speed and volume of the water is too high, this results in the destruction of fields which are covered in stones, gravel and sand. Irrigation channels may fill up and rivers sometimes change their course. Major floods occurred in the late 1970s after a long period of drought and have become increasingly destructive during the 1990s. In the view of the Mto wa Mbu village council, this is caused by overgrazing and an increase in run-off and clearing of forests in the Mbulumbulu area by a growing population. Members of the council claim that there are fewer problems in areas where the forests of Ngorongoro conservation area stretch to the rim of the escarpment.

The council has tried to enforce bylaws aimed at conserving a buffer zone at the top of the escarpment where cultivation should be prohibited. Together with land-use planning officers, villagers from Mto wa Mbu tried to erect marker beacons to separate farmland on the upper escarpment from conserved areas above Mto wa Mbu in March 1999. However, they were turned away by a group of local farmers and elected officials from Mbulumbulu. Since there is a boundary dispute between Mbulumbulu and Mto wa Mbu Districts, the people from the upper plateau feared that the protected area was a pretext to set new boundaries. In spite of their best efforts, Mto wa Mbu councillors feel that their attempts to discuss conservation measures with farmers in Mbulumbulu have failed. They believe such issues can only be resolved at the District political level, a process that may take a long time.

The village council has tried to involve the Tanzania National Parks Authority (TANAPA) and the African Wildlife Foundation (AWF) as mediators, both of whom expressed concern about lake sedimentation caused by what they claim are unsustainable farming practices in the Highland area. However, these organisations also lack crucial data on changing water quality and the rates of siltation.

In the absence of a mechanism to solve such inter-village conflicts, village officials are becoming apathetic. They observed that the government is only dealing with the immediate consequences of the problem, such as clearing boulders from the road after flood events and are not trying to tackle the cause.

The village council has been far more successful when making bylaws for areas within their own boundaries. In 1998, the Mto wa Mbu council proclaimed a protected area at the foot of the escarpment where the cutting of trees is forbidden. Beacons have been constructed to mark the boundary in an unambiguous way. The hope is that the resulting forest will reduce the impact of the floods on the fields. Surrounding farmers have been asked to police the law and so far, at least six people have been fined.

Box 3. The struggle over wetlands

Selela is located at the foot of the escarpment north of Mto wa Mbu and is similar in that it has a permanent source of water for irrigated agriculture and benefits from relatively fertile soils. These attract many outsiders for both irrigated and rainfed farming. A special feature is the wildlife corridor which passes through Selela.

Selela developed as an *Ujamaa* village in 1973. During the early years, cultivators were in control of village politics as the Maasai population did not engage with the village council. As a result, they were slowly marginalised through decisions relating to land use and land allocation. At the end of the 1980s they were encouraged by a Maasai MP to get involved in local politics and as a result have now gained control over the village council as a result of their greater numbers.

After *Ujamaa*, irrigated cultivation expanded into the wetlands used by Maasai for dry season grazing. In 1993 the village council approved a change of land use to allow intensive cultivation in this wetland area which was also important for wildlife and livestock. The council allocated land to those people who were officially residing in the village, many of whom were Maasai. Cultivation was very successful with excellent harvests. Many outsiders were also attracted and started to lease land from the Maasai or entered in a sharecropping arrangement. After a few seasons some started to buy the land even though this contravened village bylaws. It was said that incoming cultivators took advantage of Maasai ignorance of land values.

Gradually the area expanded beyond the agreed boundaries into the swamp and the protected forests, but the village council was unable to stop these 'wandering' fields which were now located within the wildlife corridor. Farmers started to treat the wild animals that entered their fields as vermin, and began to kill them. Others used this a pretext for poaching. These events raised concern within the Tanzania National Parks Authority (TANAPA). When some farmers proceeded with formal complaints against marauding wild animals, TANAPA reacted by requesting the District to declare the area a designated wildlife corridor but which does not forbid the grazing of livestock. When both District and village council accepted this proposal, farmers were forced to abandon the area and at least 100 farmers lost land. The village council used the event to reclaim land illegally sold to outsiders, who were not compensated for their loss. Only inhabitants from Selela received another plot of rainfed land in compensation.

The creation of the wildlife corridor is still disputed by farmers in Selela, including younger Maasai who lost an important source of food and income. Selela's Maasai elders seem to have seized the opportunity to regain control over this major resource and at the same time they were able to halt the alienation of land from Maasai villagers. Opinions differ over the extent to which some Maasai actively encouraged TANAPA to get involved. Many believe that the village council was coerced by TANAPA with the inducement of consolidated control over pastoral resources by the Maasai.

The lack of development opportunities is associated with the centralised control of tourist, game and wildlife resources by the state. These adverse conditions have resulted in increased sedentarisation, gender inequality, and conflict with neighbouring land users. Evidence from recent studies suggests that a significant number of Maasai are leaving the pastoral system.

Extensively cultivated marginal lands - the Ardai and Makuyuni Plains

During the last 50 years the Ardai and Makuyuni Plains, where low rainfall and high annual variation makes cropping risk-prone, have been colonised by highly capitalised commercial plantations and by land-hungry peasant farmers. The extensive gully erosion in the upper reaches of the Makuyuni River sub-catchment have cut into the deep volcanic soils along stock paths to watering points, but are also the result of increased run-off from cultivated fields during extreme storm events. Perhaps the most significant (and under-researched) factor affecting environmental change in the marginal semi-arid portions of the Ardai and Makuyuni Plains is the extensive mechanised commercial farming which has come to dominate the landscape around Makuyuni in the recent past. Here, a series of large farms have ploughed vast tracts of grazing land, mined the soil for a number of years and moved on, leaving large numbers of unemployed labourers who must then turn to small-scale subsistence crop production. The long term effects of cultivation and population pressure in these marginal lands is likely to result in falling soil fertility, bush encroachment, decreased food security and depressed economic development.

CONCLUSION

One of the perspectives to emerge from this study is that the natural, social, cultural and economic landscapes of the Lake Manyara area are highly diverse and patterns of environmental change highly complex and localised. The area has a long history as a frontier zone, stretching back millennia. The rise and fall of Engaruka between the 13th and 18th centuries was a precursor to the population growth and development of irrigated settlements in the Rift valley today. The ebb and flow of hunter-gatherer, pastoral and cultivation activities within this environment over centuries have to a large extent modified and created the landscape which the pioneers and colonialists of the 20th century inherited. It was not a pristine wilderness or untouched 'garden of Eden' as some would like to believe.

The history of frontier expansion by various groups of agro-pastoralists and cultivators over the last 100 years encompasses several phases of agrarian change associated with population growth, agricultural extensification and latterly, intensification associated with expanded markets and a more diversified economy. Similarly, the political economy of colonisation, independence, *Ujamaa*, market liberalisation and multi-party politics provoked unique and local responses which in turn can be traced in the environmental landscape. As a result, the Lake Manyara Basin has become ever more of a human landscape, side-by-side with its increasingly protected wildlife enclaves.

To generalise about basin level environmental processes is inevitably to simplify and misrepresent. The impact which humans have had upon the environment is determined by complex factors including natural cyclic climatic events, combined with socio-economic conditions affecting land-use practices and marketing strategies. Evolving political circumstances that influence property and power relations between individuals and groups have also left their mark. Without a localised and historic perspective, landscape processes can all to easily be misinterpreted by researchers and planners.

Repeat ground photos, aerial photos and a comparison with colonial vegetation maps show that there has been very little change in the uncultivated parts of the arid and semi-arid plains lying to the east of the Rift Wall, which are associated with extensively managed pastoral activity. Also, evidence of changes in woody vegetation on the escarpment wall and its foothills demonstrates the rapid pace of natural patch dynamics in association with pastoral burning. Contrary to popular beliefs, this area appears to be least affected by increasing population pressures probably due to low and uncertain rainfall coupled with substrate and hydrological conditions.

Undoubtedly, there are important problems elsewhere in the Lake Manyara area related to land degradation that are in urgent need of attention. Sheet and wind erosion, gullies and loss of soil fertility are a consequence of unsustainable land use practices but they can also be seen as an inevitable stage in the process of change from a predominantly pastoral/ pioneer zone to a populated agricultural landscape.

There is also evidence of land use intensification where farmers and herders adapt to changing circumstances in a variety of ways. Most village councils that we met have developed bylaws to protect forests and other commonly

used areas, although enforcement is often difficult. Those with a social and cultural connection to the land attempt to conserve natural resources sustainably, in spite of the many problems they face in surviving within an impoverished agricultural economy.

While we have demonstrated that historical research methods can reveal important information about dynamic landscape processes, we must also admit their limitations. One of the many questions we have been unable to answer relates to massive gully formation, such as in the upper Makuyuni River catchment, near Kisongo. We were told that the El Niño rains of 1997-8 were responsible for the sudden appearance of this deep scar. One can see from Photo 4 (see centre pages) that soils here are very deep and seem to lack a structural matrix which would retard such gullying. Is this a delayed result of the rapid colonisation of the area by agro-pastoralists during the 1960s and 1970s? Was this gully created as a direct result of the funnelling action of a recently constructed culvert under the main trunk road west of Arusha? Was this a rare erosional event caused by unusually high rainfall following a drought? Or, are dramatic erosion gullies a natural characteristic of this landscape? Are such gullies a sign of the beginnings of a long process of inevitable landscape degradation, or are the time-scales inherent in such landscape processes long enough to allow humans to adapt sustainable land-use practices in vulnerable areas? What should be done to curtail such massive degradation? These and many other questions arise in the context of this photo. However, our analysis suggests that such radical degradation is limited to a small proportion of the Lake Manyara Basin and is confined to more recently settled marginal areas on fragile soils.

Questions about the causes and extent of ecological degradation inevitably lead to queries concerning the importance of political and macro-economic conditions, as well as issues of social justice. The complexity inherent in disentangling the diverse factors contributing to landscape change is daunting. With this study, we hope to have demonstrated why looking into the environmental history of an area is important for understanding processes of change and what methodologies could be usefully applied.

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