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AGRICULTURAL ADMINISTRATION UNIT

THE DESIGN AND MANAGEMENT OF PASTORAL DEVELOPMENT

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WATER HARVESTING IN TURKANA DISTRICT KENYA

by

Francis Hillmann*

Background to the area

1. Work started in January 1978, with a project based at Lokitaung in the north-east of Turkana district. Turkana district itself is an area of 60,824 square kilometres with a human population of 200,000, giving a population density of around three people per square kilometre. The majority of the people are of the nomadic Turkana tribe, with Somali traders in most of the permanent settlements, along with people from other parts of Kenya involved in business, or employed by the various government departments. Most of the district falls within zones 5 and 6 of the Pratt, Greenway and Gwynne (1966) classification of ecological potential - that is arid, and very arid, with semi arid areas (zone 4) around the tops of mountain ranges. The district has more water and population than is usual for such conditions. In spite of high livestock numbers, the average number of livestock per head of population is one large stock and five small stock. Dependence upon

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livestock and their products is supplemented to a certain extent by gathering pods, roots, fruits and by sorghum cultivation. Livestock consists of cattle, sheep and goats, camels and donkeys. All of the land area is County Council trust land. The absence of land titles provides little incentive to development or investment.

Facts relevant to water harvesting

2. Rainfall is bi-modal, with the main peak from February until May: often a lesser peak is experienced from October to December. The forty-year annual average for Lokitaung is 385mm. The annual mean maximum daily temperature is 30-34°C, and the minimum 22°C. The altitude around Lokitaung is 762 metres above sea level, dropping to 450 metres on the shores of Lake Turkana, and rising to 1,480 metres in the hills around Lokitaung. Due to elevation, temperature and winds, evaporation is high.

3. Natural vegetation is bushed grassland/wooded grassland with canopy cover ranging from 18 to 35%. There is woodland along the main water courses with canopy cover of up to 80% (Pratt, Greenway and Gwynne, 1966). The area consists of tertiary volcanic rock at higher elevations, and quaternary-sediments in lower areas. Resultant Boils are loamy sands along the shores of Lake Turkana, and shallow stony soils with rock outcrops, together with pockets of dark clay loam of varying depth. (National Atlas of Kenya, 1970)

4. The concept of water harvesting (seasonal or flood irrigation/run-off agriculture) is not new to the Turkana people. Firstly the whole district is a network of dry water courses which collect run-off from the hills around, which are at an advanced stage of erosion. The water courses converge into larger drainage systems which run northwards towards the Sudanese and Ethiopian borders, or eastwards towards Lake Turkana. Most domestic water supplies and water for stock are found in shallow hand dug wells along these water courses, or in rock depressions in the rocky gullies higher up in the hills Vegetation tends to be denser along these water courses, because they concentrate what rain actually falls, and becomes sparser in the catchment areas between. The water courses, therefore, provide grazing and browse along their length.

5. Secondly, owing to climatic conditions, the cultivation which has been traditionally carried out by the Turkana has to be based upon water harvesting principles. This is not to say that the people are actively involved in creating flood irrigation systems, but they make use of areas where flooding occurs naturally in order to grow sorghum. Such areas occur mainly along the lake shore where run-off collects in natural depressions and cannot escape to the lake, and along the banks of the larger water courses where alluvial soil has collected seasonally flooded.

Past work on water spreading in Turkana

6. Available information from articles (Kenya Farmer 1970) and Catholic priests who have been in the area for a long time, show that the only active work on water spreading in the past was that carried out on the Ministry of Agriculture schemes, starting in 1964 at Lorengipe in western Turkana, and subsequently at Lokichar and Lokorikippe along the Turkwell river valley and at Narangole north of Lodwar.

7. The initial scheme at Lorengipe covered 25 acres (10 hectares), which were provided with run-off diverted by a weir from a nearby water course. Construction was carried out by using both machine and hand labour, the field being contoured to direct flood water in a series of 'S' bends. Results of planting with crops proved very poor, after which the scheme was handed over to Range Management department for grass seed production. Sowing with local grass varieties (Cenchrus ciliaris. Chloris roxburghiana and Eragrostis superha) proved more successful, increasing grass seed production by 2,000% since 1964 (yield of 140 lbs per acre in 1969). Local stock were allowed to graze for a fee on the site. Among other problems encountered was silting, which reduced grass growth and necessitated levelling every five years. The other three schemes aimed at producing grazing for stock, though information on their success has not been found, and apparently none of the schemes is currently in operation.

The Lokitaung project

8. The site of the Lokitaung project was not chosen particularly for its water harvesting potential, but because the request for a volunteer to start the work came from the Salvation Army, through whom funds are chanelled, and who were already based there. The initial objective of the project was to attempt to utilize run-off water from rainstorms to grow drought resistant food crops in small catchments of fertile deep soil to which this water had been diverted. It was hoped that, given favourable results, this method of utilizing small amounts of rainfall in order to gain some sort of food crop might be taken up by the Turkana people and adapted to their nomadic way of life. Once a catchment area was established it was envisaged that it could be left dormant until such time as suitable rain fell for it to be cultivated.

9. Over the past year or so, the original objective has been modified to include establishment of trees under the same conditions for various uses, and the inclusion of other activities in a more general 'rural development' project. The other activities include: trying out a number of species of trees along the shores of Lake Turkana in order to determine their resistance to the high sodium water table: beekeeping; and the making of cheap cement water storage jars to catch rooftop run-off for domestic use. Extension of these activities to an area 80 kms north of Lokitaung has been started.

It is envisaged that the work will be supported from outside for six years, during which time a local man is being trained. This support includes running a landrover pick-up, food for work, equipment and salaries for about five workers.

Water harvesting experience

10. To date six different sites have been established in the Lokitaung area (within 11 kms) of an average size of one acre, and one near the lake at Loarengak. One or two of the sites chosen had in the past been traditionally cultivated during years of especially abundant rainfall, serving as a good indication for water harvesting. The other sites were chosen for their soil characteristics and physical relief, enabling flood irrigation to bo attempted with relative ease... No objections were met from local people, who generally agree that the sites held potential for sorghum but had never themselves attempted to grow it there. All the work is done on a labour-intensive basis. The people concerned come from family groups currently living near the sites being worked on. This usually involves two or three members of each family group, coming together to make a work force of about ten people, men and women, whoever can be spared from the daily work of livestock herding/watering, water and firewood collection and from work around the homestead. These family groups have been semi-permanent within the work area for some time; the proximity to Lokitaung town enables them to obtain supplementary income from selling firewood, charcoal, hides, livestock and milk in the wet season. Payment, for the manual work of carrying stones, digging and cutting thorn enclosures, for the women, is maize - on a food-for-work basis, and for the men generally money. Simple surveying methods are used, employing a spirit level mounted on a 'T' stand, sighted onto a graduated staff, to determine where water should flow, contours, height of walls necessary and direction of diversion channels.

11. Work is supervised by a Turkana assistant, but after a year supervision on established sites has hardly been necessary. Once a site has been shown to produce a crop of sorghum successfully, subsequent planting has been left to individuals with no payment except for a small quantity of seed. The families agree amongst themselves who will plant where. In general it is those prepared to do the most work who are allocated larger areas, and who succeed in weeding and bird scaring thus obtaining more return. There is no formal system of land tenure. It is a case of first-come first-served. It is hoped that upkeep of soil/water conserving structures will in future also be taken over voluntarily - once their purpose is understood and shown to work.

12. It has been necessary recently to employ a watchman for the sites, to do a small amount of work, but mainly to try to persuade stock owners to keep out their stock, since even though no crop may be evident during the dry months, trees are being established in many places, and damage from stock was becoming excessive.

Methods

13. Suitable sites within the immediate area are few, since it is a rocky and hilly eroded region, areas of significant soil are limited to natural depressions and the flatter valley bottoms. Soils are of two main types; a) Sandy loam alkaline soils, deposited in depressions, dominated by Acacia nubica (Epetet - Turk.) as a primary coloniser; and b) darker clay/loam soils, dominated by the dwarf shrub Duoaperma (Epoo Turk.) mainly in valley bottoms. The hillsides around, through their natural drainage channels, provide the catchment area and concentrate the water for harvesting. This is then diverted to the chosen site by diverting a nearby water course, or by blocking off the exit as is the case with the valley bottoms. The diversion of a water course is done by building a wall of large rocks, filled in with sand and small stones. From this point the run-off water is led to the site by a diversion channel with a shallow gradient to avoid excessive erosion. The channel consists of a trench and a low earth bund, lined on the upper surface with stones to protect it from water flow, and to enable plants and grasses to establish themselves in the cracks.

14. Once water reaches a site it is necessary to contain it so that it floods to a depth of a foot or so, before the excess overflows, in order to give it time to soak right into the soil and to saturate it. To do this, a low terrace wall consisting of two lines of stones, in-filled with earth and small stones, is constructed across the valley bottom, or open side of the depression whichever the case may be. This wall must be provided with a spillway lined with stones, to take the overflow, which varies greatly with different storms. The' spillway must be big enough to take the most violent of the storms. There may be several of these low terrace walls, at thirty to forty metre intervals, one overflowing into another depending upon the size and layout of the site. They may be straight across, or contoured, depending upon how undulating or badly eroded a site is - contouring is more suitable where the area is undulating unless quite high walls are to be built.

15. Structures are temporary, requiring repair after heavy storms, until the soil becomes consolidated and plants become established or are planted on them. This also serves as a safety feature; in that in very violent storms, the storm water will break channel and bund before it reaches a site, thus saving the area from excess silting or erosion.

16. The above methods usually result in the water flooding an area of half an acre or more. Another method being tried is square micro-catchments of twelve by twelve-metres, with a low earth bund enclosing them. Each one is used to catch run-off from its area, and to concentrate this to em individual tree planted at the lowest point with a basin of four metres square dug around it in which the water collects and soaks into the root zone of the tree. These micro-catchment a have also been used successfully for sorghum cultivation In a good year such as 1979. Thirty of them are being tried out.

17. In several places there are permanent buildings with corrugated Iron roofs. These represent a considerable potential for run-off collection. They are being used successfully for the collection of drinking water in cement storage jars which are made by one trainee using a simple and cheap method. One further roof is being used to provide run-off for a variety of tree species, thus enabling them to survive long dry periods and to thrive where it would not otherwise be possible. A low semi-circular bund is constructed which contains the run-off and floods to a depth of up to a foot in heavy rain.

Climatic conditions experienced over two years

18. In 1978 the rainfall peak came just after commencing work, hence only a small site in Lokitaung was partially complete, and this was used for some Initial planting with a variety of crops to assess their performance under the local conditions. The rain consisted of four run-off-producing storms between February and April, three of which were over 40mm and one of 6mm. No October rainfall peak was experienced in 1978. However there was a single storm of 51mm In September, and another In December of three consecutive days totalling 90mm. Tree planting was started with seedlings from the government nursery in Lodwar, and later, towards the end of the year, from our own nursery. Other rainfall occurred which didn't produce run-off, giving an annual total of 407mm in 28 rainy days of average intensity 10.7mm/hour (range of 1.5 to 66mm/hr,).

19. In 1979 to date (November) a total of 578mm of rain has fallen, making it already an above average year. Run-off was experienced on four occasions in February, twice in March and on three occasions in April. Two storms of 26mm and 111mm were experienced In June, and recently another rain of *35mm* fell. In early November. There have been 33 rainy days so far, with an average intensity of 5.9mm/hour (a range of 1.1 to 24mm/hr.). This year (1979), mainly sorghum was planted, along with tree seedlings, in the early rains. Planting has again been done with the recent flood, but this has not yet been followed up by more much-needed rain.

Trees and crops being tried

20. Initially only drought resistant crops were being planted, but since October 1978 trees have also been planted. Crops which have been tried on a small scale to assess their performance under the conditions are:-

Food Crops

Sorghum - local Marille, Serena, Somali (goosenecked). Other varieties, presently planted out but only just germinated, require more rain.

Bullrush millet, cowpeas, bonavist beans, pigeon peas, simsim, sunflower, buffalo gourd.

Plants for earth stabilisation and seed value

Castor, Sudan senna.

Trees

(i) Trees tried in micro-catchments:

Scientific name	Other name
Azadirachta indica	Neem.
Acacia albida	
Ceratonia siliqua	Carob.
Prosopis chilensis	Algaroba.
Erythrina	

(ii) Trees planted in generally flooded areas, along bunds, or in pits:

Azadirachta indica	Neem.
Acacia albida	
Acacia senegal	Gum arabic. (Ekonoit - Turkana)
Prosopis chilensis	Algaroba.
Prosopis cinerea	
Leucena leucocephala	Giant Haiwan
Tamarinus indica	Tamarind (Epeduru - Turkana.)
Zizyphus mauritana	(Ekalale - Turkana.)

(iii) Trees receiving roof run-off:

Leucena leucocephala	Giant Haiwan.
Tamarindus indica	Tamarind (Epeduru - Turkana.)
Parkinsonia aculeata	Jerusalem thorn.
Erythrina.	
Cassia spectabilis.	

21. Trees ore being planted with a view to their filling local needs for firewood, thorn enclosures, livestock browse fruit, building, charcoal, and general environmental improvement. While results of experience so far are discussed below, experience with many of these species consists of leas than *a* year with maybe one flood. Thus many are only just past seedling stage. Planting out is done after a good flood, and no subsequent watering is given, since the aim is to determine species which can survive under the conditions of natural rainfall, or flood irrigation.

Observations and conclusions

22. It has become apparent that the following points are of vital importance to the success or failure of water harvesting in this area.

i) Rainfall must be of an intensity of lOmm/hour or more to produce run-off in short storms of one to two hours, or rain must fall for several hours at lower intensity to produce run-off. Run-off is in the region of 30% initially, increasing to 90% or more once the 'soil' is saturated.

ii) February to April appears to be the only dependable peak, and in this period at least three floods are required, with adequate growth periods in between, to bring a crop of sorghum onto maturity. Total rainfall is immaterial, it is the frequency and spacing of floods in time, which must allow both for crop-growth and for a soil moisture deficit which can be recharged, which are important. Several floods in succession bring little more benefit than a single one, the extra rainfall *is* mostly wasted in excess run-off, and this is often the case in the rainy season here.

iii) As mentioned before, evaporation is high and no cold season is experienced following rain. Water-harvesting, carried out in many Mediterranean countries (with cold, wet winters) has led to a misconception that the phenomenon can be easily duplicated in other arid area3. Precipitation in the latter, however, needs to be higher to compensate for higher evaporation.

iv) Soil depth and structure la important. At least three feet of soil capable of water storage is necessary. The sandier loan soil mentioned 'caps' over well and thus appears more suited to crop production. The clay/loam tends to crack and dry out in its upper layers, making it more suited to the deep rooted drought resistant tree species.

23. Crops only have a fair chance of success once a year that is when planted in February and if the above mentioned climatic conditions are fulfilled. Bullrush millet has proved extremely drought resistant (surviving periods of three rainless months) but yields have been poor, and the work required to obtain this has made it unpopular with the Turkana when compared with sorghum which they know well. Sorghum is the most acceptable food crop to both social and climatic requirements. The locally available 'murille' variety, from the river Onto delta in Ethiopia, is well liked and successful. Improvements in yield, disease resistance (head smut), and resistance to bird damage have been made by using short improved varieties such as sarena, and by using seed dressings. The Somali (goosenecked) variety tried yields poorly with water stress, and suffers excessive bird damage. Local opinion la that 'we don't want it'. The yield of sorghum on one quarter-hectare catchment this year (1979) was in the region of fifty kilograms, with a small harvest later as a result of re-growth due to late rains. Spacing used is rows two feet apart, and one foot between plants, with three or four seeds per hole.

2k. The main weeds are nut grass and sodom apple along with other annuals which establish themselves extremely fast after rain. These weeds are normally left until the crop is several inches high, and more rain falls or looks imminent. Otherwise the (weeding) activity is considered too tedious especially when success of the crop is in the balance.

25. Cowpeas and bonavist beans have been shown to do well under similar conditions to those suitable for sorghum. Both of these however, grown mainly for their leaves as a nutritious spinach, are unpopular, local opinion is that 'we don't eat goat food', although obviously they have a role around the towns. Pigeon peas, sunflower and sesame have been found to be too moisture-demanding, though a few sesame plants grew successfully (by accident) along a catchment wall, indicating possibilities for future planting. A few buffalo gourds recently planted appear to be doing well, though it is too early to judge their success at this stage- Castor beans and Sudan senna have both proved very successful for planting along bunds for soil stabilisation. Being goat resistant has proved an added benefit, and self seeding is now occurring.

26. Several kinds of trees have been raised from seed in a small nursery in Lokitaung. The seeds have been obtained locally and from people doing similar work in Kenya. The three exotic species proving most successful under rainfed conditions are the Prosopis species (chilensis and cinerca), the Neem (Azadirachta indica) and Leucena leucecophala. Growth rates of 15cm per month after a good flood have been noted with Neem and Leucena, and both have been shown to survive four rainless months. Carob is proving a very slow grower (being a Mediterranean species) and has poor survival rates; it is doubtful that it would develop into a mature tree. Similarly Jojoba (Simminondsia chinensis) germinates well, then tails off in growth and dies.

27. Acacia albida is not in its element here, but survives. In future it i» planned to try this and other riparian species along the banks of the larger water courses where fast growing species such as Neem and Leucena could also make a contribution.

The local true Zizyphus mauritiana (Ekalale - Turkana) is a reasonably fast growing tree for all round use (fruit, fodder, firewood, poles, thorns) and Has been planted out on moat of the sites. Tamarindus indica (Epeduru - Turkana) is a slow growing tree, known locally, requiring wetter conditions, being a riparian species, hut is growing well on a small site receiving run-off from a corrugated iron roof. The same may *be* said for the Erythrina, a bit more drought resistant; but a very slow grower. Another local species which has been planted is Acacia Senegal (Ekonoit - Turkana). Under run-off conditions it grows fairly fast (8cm per month) depending upon preceding rainfall. In future it is planned to plant the seeds of this tree at close 3pacing within a furrow along the inside of thorn enclosures so that it grows up into a living thorn fence. This tree has curved thorns in two directions, and the dry site variety grows in bush form near the ground, Potential for gum arable is limited by transport considerations (500km to the nearest large town - Kitale) and difficulty in getting a pure enough product.

Problems encountered

28. Whore no sorghum is growing at any one time, local stock, especially the untended stock (donkeys and camels) are the greatest problem, in spite of *thorn* enclosures. In addition, squirrels and hares have been fairly destructive to young trees. Timing the planting of nurseries and the availability of seed with rainfall is always a problem often resulting in seedlings having to be planted out when too small, or remaining in the nursery too long waiting for sufficient rain.

29. It would appear that the promotion and trials of tree growing in the area under rainfed conditions could make a valuable contribution. Trees can tap water and nutrients from a great depth in the ground, survive long periods of drought, and are already a dominant feature of the landscape - much used but not replanted with the future in mind. This leads us into the next sections which are by far the most Important when it conies to ensuring the success of any activity, and its relevance and integration into the social system.

Motivation

30. The presence of a project involved in water harvesting in the area is not the result of a direct request by the local people. It is an indirect response to continually stated feelings by local people of hunger, especially in dry years when forage for stock is scarce. The project aims to examine whether active work in soil and water conservation, including water harvesting, within the physical constraints of the environment, can contribute towards easing such situations on a local scale.

31. Why then do local people participate? The food for work, or casual payment offered for labour, la considered by participants as a form of supplementary income. Thin is an immediate and directly felt effect of the work. The basic aims of the project on the other hand are not directly obvious to or shared by the participants. It is hoped however that in the long run the basic aims and objectives of the work will indirectly benefit the participants. The response of the people to the methods being tried are generally enthusiastic, but their motives for this enthusiasm seem to be simply to obtain food-for-work and employment. Again it is hoped that given some significant results this enthusiasm will he for other reasons. An opinion often voiced is that rainfall is erratic and unreliable, thus boreholes and irrigation would be more useful and beneficial. This is no doubt true from their point of view and on a very local scale, but not a popular idea from funding bodies[1] point of view and when looking at the overall long-term effectiveness find environmental, social and economic implications. Owing to the conflict between the views held by project personnel and by local participants, considerable misunderstanding results, making public relations a difficult but interesting task.

Labour management

32. Putting aside such motivational issues, the availability of labour was not often a serious problem. Once it was known and understood what was going on, a work force could bo assembled with little prior notice. Employment and payment was on a daily basis, selection of individuals being done by familiarity with the family groups. An average of ten people per site was considered as the maximum, larger or smaller numbers resulting in a decline of productivity. Work was usually done on the sites in the morning only for five or six hours, the afternoons being very hot, and difficulty was experienced in getting people to return in the evenings. The availability of work was very erratic, but this was considered as desirable in that it avoided any possibility of family groups becoming too dependent upon the food given for work and it ensured that they lived as they always had clone for the majority of their time. Invariably more women than men would be present for work, this being socially acceptable, whereby in their daily lives women play a more active role than the men in the running of a homestead. Fluctuations in the availability of labour would be directly related to environmental conditions. In general, during more favourable times when stock forage and water were readily available, family groups were closer together, less effort was required in stock minding and watering; thus labour could be released. This would coincide with the small amount of cultivation carried out. In drier tiroes, family groups would be worn dispersed, more time had to be devoted to stock minding and watering, thus labour would be scarce. However demand for food in dry times would be greater owing to a reduction in milk yields, and work would be sought for this reason. Day to day life would always

be centred around the livestock and running the homestead, activities such as cultivation or involvement in project work would follow as a very distant secondary activity. This casual attitude of the people towards work, and its relative unimportance in their daily lives meant that no serious quarrels arose concerning jobs or cultivation and management of sites.

Social considerations

33. The attitude of this project all along has been one of working alongside the Turkana people with a view to finding out whether organised water-harvesting, combined with the other project activities mentioned, has a place in their life style, and at their level of operation. As mentioned earl: land is County Council trust land, and so no titles are held and, as a result, there is very little incentive for development. Mobility is essential for these people if they are to exploit all the potential of the area, and to survive in their present numbers of people and livestock. These two points make it very difficult to promote the idea of 'environmental improvement' including water harvesting, soil and water conservation; and this difficulty is aggravated by the fatalistic attitude of the majority of the population. Pride of traditional lifestyle is ever evident, and any significant voluntary change will take several decades to come about.

34. Thus one might conclude at this point that water harvesting activity only has a place nearer to the more permanent settlements, where environmental degradation tends to be greatest, and the demand for tree products and supplementary food (if only for beer making!) is also greatest. Here suitable sites might be developed, and individuals take a responsibility in their operation if and when the idea catches on. It remains however to do a lot more work and research into the whole 'idea' in order to find out and show how it can be made more predictable, and which species of trees and crops may be used successfully under the prevailing conditions.

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AGRICULTURAL ADMINISTRATION UNIT

THE DESIGN AND MANAGEMENT OF PASTORAL DEVELOPMENT

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ORGANIZATION, STRUCTURES AND RANCHES IN KENYA[1/]

by

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I INTRODUCTION

LIVESTOCK MANAGEMENT SYSTEMS

1.01 Livestock management systems in range areas of Kenya can be grouped under two broad headings: pastoral, which is subsistence oriented, and commercial, which is cash economy oriented. The grouping, however, is dependent to a large extent on land tenure and social custom.

1/ This paper was first presented at a workshop convened in February 1980 by the International Livestock Centre for Africa. The subject of the workshop was the design and implementation of pastoral development projects for Tropical Africa.

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