ARRESTING ENVIRONMENTAL DEGRADATION THROUGH ACCELERATED ON-SITE SOIL SEDIMENTATION AND REVEGETATION USING MICROCATCHMENTS AND RESEEDING*

W.N. Mnene[1], F.P. Wandera[2] and S.H. Lebbie[2]

1- National Range Research Centre-Kiboko, P.O. Box 12 Makindu, Kenya, 2- National Dryland Farming Research Centre-Katumani, P.O. Box 340, Machakos, Kenya, 3- International Livestock Research Institute, Nairobi, Kenya

SUMMARY

Degradation of arid and semi-arid lands (ASALs) through denudation has been found to result in lowered capacity to support livestock, particularly under extensive production systems. This would normally start as a loss of important forage species, which in effect may lower pasture nutritive quality and hence animal performance. After participatory rural appraisal (PRA) an opportunity was identified in the pastoral reserve grazing areas involving the combined use of micro-catchments (specifically pitting) and reseeding with adapted forage species in reserve grazing areas. Pitting was employed in order, hopefully, to increase success rates of emergent seedling establishment. Treatments were imposed before the 1996 short rainy season. Data were collected on soil sedimentation (mm depth) as well as herbaceous cover (%) and standing crop (kg ha^{-1}). Much of the soil deposit comprised of fine silt/clay in the pits and sand on the up-slope. No soil deposit was observed on the down-slope of the pits. This increased in subsequent rainfall seasons. Although seeding was done by hand, broadcasting to cover whole plots, establishment was only evident where it was pitted. Volunteer herbaceous vegetation expressed themselves and plant cover tendered to also increase in freshly deposited soil from one wet season to another. Herbage was particularly dense on the crescents of the pits. Respective effect of either pitting or seeding alone was not isolated in the trials thus requiring additional studies.

Keywords: Rangeland degradation, loss of important forages, soil loss, renegetation, pitting and reseedin

INTRODUCTION

Sheet erosion is a common feature on over-utilized soils of the basement system areas where surface sealing has occurred. Infiltration rates are low and surface run off is thus high.

In such circumstances, it is extremely difficult for seed to lodge, germinate and establish on such a surface. Further, where bare patches occur, the effective grazing area is reduced. This would also, in effect, lower the carrying capacity of the land. In a related scenario, removal of vegetation and exposure of bare soil to the forces of weather has an adverse effect through changes in soil temperature regime. The humus of the topsoil tends to disappear while the impact of the rain drops and treading of livestock is much greater on the bare soil surface (Thurrow, 1991). The result is a highly compacted concrete-like feature, also referred to as sealed soil surface. This is especially common on soils derived from the basement system rock (Thurrow 1991; Range Management Handbook, 1993).

Given that variability and thus unreliability of rainfall in ASALs is common, herbage/forage production becomes uncertain. In deed, the potential forage production is not achieved. Instead, degradation (denudation and loss of important forage species) may ensue. Therefore, to ensure an effective utilization of the scarce rains (one of the key resources needed to support pasture and hence livestock in dry areas in Africa), it is necessary to develop strategies that harvest any available rain water. In some areas there are possibilities of recovery through deferment. However, this may take 10-20 years, a very long period considering the opportunity cost of not utilizing the land. Other strategies would be necessary to accelerate recovery and thus increase the potential for higher livestock production required to support the ever-increasing human population. This paper discusses the combined effects of pitting and reseeding as an option for accelerating rangeland recovery as experienced in a case study in the pastoral areas of Kenya.

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* This paper is an improvement of an earlier version presented to the 6th KARI Scientific Conference in 1998 in Nairobi, Kenya.

MATERIALS AND METHODS

Problem identification and site selection

Participatory rural appraisal approach was used to identify constraints to ruminant production in Kajiado district (Wandera *et al.*, 1996; Table 1-3). Water and feed shortage ranked number one and two, respectively, as the major constraints to the farmers' efforts to improve livestock production. Apart from the vagaries of weather, over-utilization had led to land denudation. There was need to control grazing. To rehabilitate the degraded areas, reseeding with desired herbage species was chosen while pitting was selected to improve on-site infiltration. Fortunately, the Maasai communities traditionally practice the setting aside a reserve grazing are (*Olopololi*) near homesteads (manyattas) to cater for the young stock, breeding stock and sick cases. Three manyattas were selected to represent three rangeland ecological zones (Pratt and Gwynne, 1977): zone IV (Maparasha), V (Masimba) and VI (Maili 46). The entire *Olopololis* were characterized for slope, soil erosion type, herbaceous vegetation composition and standing crop, as well as woody plant density and canopy cover. Standard methods with slight modification were used (NRC, 1962).

The slopes readings were taken every 5 m along permanent transects placed 10 m apart. Herbage was sampled along the transects using 0.25 m^2 quadrants every 5 m. in each quadrant, individual species were estimated visually and in one out of four quadrants. The plants were clipped and weighed to derive correction factors for the visual estimates. These clippings were oven-dried to obtain percentage dry matter (DM) and thus express the available herbage in kg $Dmha^{-1}$ Woody plant densities were count for all those rooted within a 1 x 50 m belt transects and expressed as number per hectare by species. The canopy cover was the sums of above ground canopy intercepts of the line transects converted into percentages by species. Subsequently, smaller experimental plots measuring 20 x 40 m were demarcated in the denuded area in each *Olopololi* and more detailed characterization done along five permanent line-transects.

Semi-circular range pits were made across the slope in bare ground using farm hand tools. The pits measured 1-2 m long and no more than 30 cm deep at the center. Soil was scooped downs-lope and the inside part of the formed crescent was firmed up using the back of shovels. The up-slope part was slanted gently so as to reduce the impact of the run-off on entry into the pits. Depending on the slope, between 20-30 pits were made in each 20 x 40 m treatment plot; more pits were necessary where the slope was steep because the pits had to be closer together than where the slope was more gentle. Seed broadcasting was done immediately thereafter. The whole exercise required four persons for per treatment plot 30 minutes.

A mixture of seed of perennial grass (*Cenchrus ciliaris, Chloris roxburghiana, and Eragrostis superba*) and a legume (*Stylosanthes scabra*) were broadcast by hand. Seeds were liberally applied all over the plot such that some fell on the undisturbed ground between pits, some on the pits' crescents and others in the pits themselves. The grass seeds were harvested from natural stands at Kiboko the previous season while the legume seed was purchased from Australia. Seed broadcasting lasted 15 minutes. Both pitting and seeding were done and completed 1-2 weeks before the expected on-set of the short rainy season in 1996. Subsequently, vegetation inventories were repeated in 1997 and 1998. Five pits were selected at random in which soil sedimentation was estimated by measuring the pit depths using a meter rule. Analysis of variance (SAS,1988) was done to estimate possible differences in plant ground cover and herbage standing crop and soil sedimentation between sampling dates as measures of site recovery.

RESULTS AND DISCUSSION

Sedimentation

Soil sedimentation was significant ($P< 0.05$) during each rainy season, but varied from site to site, probably due to variation in slope, soil type and the amount of rainfall received. On average about 80% soil sedimentation had occurred after three rainy seasons. Continued sedimentation was not expected, especially at Masimba (zone V) and Maparasha (zone IV) where vegetation cover had established well and the sites appeared to have stabilized.

Ground Cover

Percent ground cover by herbaceous vegetation increased steadily with each rainy season and on average bare ground was reduced by 50% across the sites (Figure 1). This would have been even higher if sod forming rather than bunch type of species were used. Regardless of ecological variation between sites, ground

Table 1. Problems of small ruminant production in Bissel and Maparasha sub locations of Kajiado ranked using 'pair-wise ranking' techniques of the PRA with a group of producers

Problem	WLM	LBS	CCPP	WOM	F/RT	FS	WS	TBD	P/MKT	ENT	CI	ORF	Points	**Rank**
Wildlife menace		LBS	CCPP	WLM	WLM	FS	WS	TBD	P/MKT	ENT	CI	WLM	3	9
Lack breed stock			CCPP	LBS	LBS	FS	WS	TBD	LBS	ENT	CI	BS	5	7
CCPP[1]				CCPP	CCPP	FS	WS	TBD	CCPP	ENT	CCPP	CCPP	7	5
Worms					WOM	FS	WS	TBD	P/MKT	ENT	CI	WOM	2	10
Foot Rot						FS	WS	TBD	P/MKT	ENT	CI	F/RT	1	11
Feed shortage							WS	FS	FS	FS	FS	FS	10	2
Water shortage								WS	WS	WS	WS	WS	11	1
TBD[2] esp. Anaplasmosis									TBD	ENT	TBD	TBD	8	4
Poor market										ENT	CL	P/MKT	4	8
Enterotoxaemia											ENT	ENT	9	3
Costly inputs												CL	6	6
ORF													0	12

1 Contagious Caprine PLeuro-Pneumonia
2 Tick-Borne Diseases

Table 2. Problems, causes, producers, current coping strategies and possible opportunities for small ruminant production in pastoral system of Kajiado

Problems	Causes	Coping Strategy	Opportunities
Water	Nature	Shifting Reduced watering frequency (2-3 days)	Borehoels Dams
Feed Shortage	Nature	Shifting Supplementation through lopping/pods Supplementation with cow milk to kids/lambs Conservation/standing hay	Purchase Reseeding Conversation
Enterotoxaemia	Plant poisoning Ticks Atnees	Dipping Deworming	Acaricide Deworming Vaccination
TBD. (Anaplasmosis)	Tick	Terramycin (orrally administered) Dewormers (Nilzan) Herbal Medicine (Osokonoi - Maasai) CUSO[4] (Orally administered) Dipping	Acaricide (Maintenance of Proper dip strength) Consultation (Vet. personnel)
CCPP	Contagious (Introduced)	Injecting – Antibiotics	Vaccination
Lack of Breeding Stock	Too expensive Not adaptable Unavailable	Borrowing Hiring-pay by giving a kid/lamb	Introduce ram/buck camp Purchase from LMC.
Costly Inputs	Not known Do not buy inputs Use of traditional traditional knowledge Under-dose drugs	Sale animals to raise money Reduced quantity per package Improve the efficiency of ITK	Lowering of prices

1 Indigenous Technical Knowledge

cover was not significantly (P>0.05) different in late 1996. Two rainy seasons later, the Masimba site had not shown great improvement in ground cover. This was probably because of severe drought conditions that affected all these areas and lasted longer at Masimba. Reduction in percent bare ground was attributed to the treatment effects, especially for both Masimba and Maparasha sites. However, at Maili46 damage of the structures by excessive heavy rainstorms may have interfered with the treatments.

Table 3. Producers' ranking of opportunities for problem No. 2 - Feed shortage

Opportunity	Purchase	Reseeding	Conservation	Points	Rank
Purchase(P)		R	C	0	3
Reseeding(R)			R	2	1
Conservation(C)				1	2

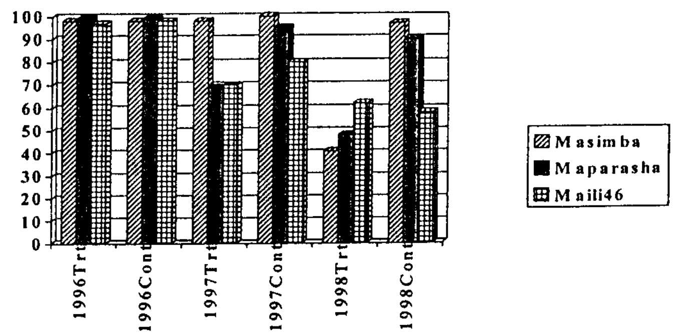

Figure 1. Effect on bare ground (%) changes at different sites from 1996-1998.

There was no seed establishment between the pits. This was attributed to the hard surface that inhibited penetration by roots of germinating seeds allowing loss through run-off. In any case, it was observed that most seeds were either blown by the wind and (or) washed down into the pits. Pearson et al. (1995) also observed that for fast vegetation establishment, site preparation was necessary. This was confirmed in this study.

Herbaceous standing crop

The initial standing crop was essentially negligible or non-existent altogether in all the three sites (Figure 2).

Below average rainfall early in the study period resulted in poor seed establishment. Maparasha site, which is hilly, had slightly better rains and a slightly significant increase in standing crop. Very significant increase had occurred by early 1998. This was probably due to heavy rainfall received throughout the study area although site variations still remained. Regardless of season, post-treatment herbage was only able to establish in the pits and not all over the plots. Pitting was a form of seed bed preparation that may have allowed easy seed germination an establishment which was not possible where the soil had capped (Pearson *et al.*, 1995). At Masimba, the treated area had more than 20-fold more herbage than the untreated. Herbage increase was least at Maili46. Improved on-site moisture retention, as a result of reduced run-off, probably enabled better herbage establishment. Suleiman *et al.* (1995) obtained similar results by using different forms of water harvesting catchments to produce livestock forage.

One livestock Unit (LU, 250 kg Live weight) requires approximately 7.5 kg dry matter (DM) of forage daily or 225 kg DM for a month. Assuming that all the feed would be derived from herbage, then one ha (1292 kg DM) would be able to support 173 LUs for one day or 6 LUs for one month. On the other hand, without treatment the same one-hectare would only support two LUs for one month. This added capacity would more than offset the cost of the rehabilitation.

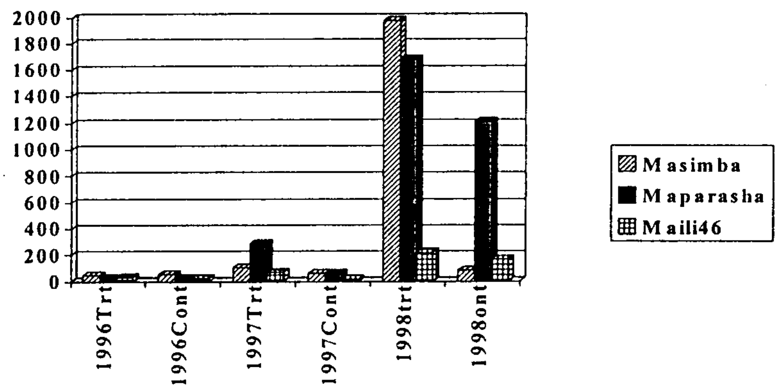

Figure 2. Effect on herbaceous standing crop (Kg DMHa^{-1}) changes across sites from 1996-1998.

Unlike Maparasha where herbage comprised of annual forbs (43%), the other sites had mostly perennial grasses. At Masimba, the three grass species planted contributed 94% of the herbage. These species constituted only 11 and 14 percent of the herbage at Maili46 and Maparasha, respectively. Their lower performance at these other sites was possibly due to lack of adaptation. Masimba is close to the site from where the seeds were obtained. *Eragrostis superba* performed better in terms of establishment and biomass production than the other two grass species. Where annual forbs mostly established as volunteers and invaders, the security of feed availability during the dry season would be uncertain since these plants die shortly after the rains. The litter on the ground disappears quickly due to consumption by termites and decomposition. This leaves the site bare and renders it vulnerable to further degradation. Perennial grasses on the other hand would protect the site as long as judicious utilization (as is always necessary for any other resource) is practiced after they have been re-established.

CONCLUSIONS

The treatments imposed were effective in reducing soil erosion and increasing ground cover as well as herbaceous standing crop. However, which of the two treatments contributed more to the observed responses could not be identified in this study. Since establishment of seeds was restricted to the pits, site preparation is necessary where soil surface has sealed. The potential gain from increased herbage coupled with reduced soil loss justifies serious consideration of this technology as an option for successful reseeding/ revegetation of denuded range. However, it is only possible where protection can be effected until the plants are fully established. The practical implementation of the technology, especially where *olopololis* are large, needs to be gradual.

ACKNOWLEDGEMENT

The authors thank the organizers of the 3rd All Africa Conference on Animal Agriculture and the Egyptian Society of Animal Production for the opportunity to share this paper with other stakeholders in the forum. The Director - KARI as well as Dr. H.K. Cheruiyot and Dr. A. Abate the Assistant Directors in-charge of Range and Animal Production Research Divisions, respectively supported this work. Colleagues in research and extension service contributed to the success of the project in different ways. Funding was from the KARI/ILRI SR-Net Collaborative Programme whose Steering Committee and those others not mentioned above are greatly thanked.

REFERENCES

Mnene, W.N. and D.S. Mbakaya, 1997. Pastoralist's problems, coping strategies and opportunities: a report on participatory rural appraisal of the Masimba sub-location in Kajiado district, Kenya.

NRC., (1962). National Academy of Sciences - National Research Council.. Range research - Basic problems and techniques. Washington, D.C., USA. Publ. No. 890.

Pearson, H.A., G.L. Wolters, R.E. Thill, A. Martin Jr and V.C. Baldwin (1995). Plant responses to soils, site preparation, and initial pine planting density. *J. Range Manage,* 48(6):511-516.

Pratt, D.J. and M.D. Gwynne, 1977. Range Management and Ecology in East Africa. Hodder and stoughton. London.

Range Management Handbook (Kenya), 1993. Vol. II 1. Marsabit District.

Suleiman, S, M.K. Wood, B.H. Shah, and L. Murray, 1995. Rainwater harveting for increasing livestock forage in arid rangelands of Pakistan. *J. Range Manage,* 48(6): 523-527.

Thurrow, T.L., 1991. Hydrology and erosion. In: Grazing Management - an ecological perspective. R.K. Heitschmidt and J.W. Stuth (eds). Timber Press, inc., Portland, Oregon, USA.

Wandera, F.P., J. Sitienei, W.N. Mnene, W. Audi, and C.O. Ahuya, 1996. PRA report for Kajiado and Baringo district.