TITLE OF THE PAPER.

An Ecological Assessment of potential impacts of riverbed sand harvesting to riparian ecosystems in Kenya.

Ecological Assessment of potential impacts of river sand harvesting

- A paper to be present during Kabarak University's 4th International Conference on Addressing the Challenges facing Humanity through Research and Innovation to be held on 15th- 18th July 2014. at the main campus
- By Prof. Jackson J. Kitetu; Ph.D., Kabarak University. Kenya

INTRODUCTION

- River ecosystems are among those most damaged by human activities, and especially by sand and gravel harvesting.
- This paper deals with the assessment of environmental resources affected by sand harvesting from riverbed and riparian ecosystems in Kenya.

.

Introduction cont.

- The research involved a field survey of vegetation patterns comprising the riparian ecosystems
- To quantify the effects of sand harvesting and related operations in mined and unmined areas of rivers Thwake, Kaiti, Muooni and Iuuma in the study area of the larger Tana and Athi Rivers catchments.

Vegetation Research Methods used

- National Vegetation Classification (NVC) method- This technique is based on identification, mapping and sampling of homogeneous stands of Vegetation with assignment to plant communities and subcommunities (Rodwell, 1991)
- The technique was initially developed for vegetation mapping in the UK, but it is transferable to wider environments

Vegetation survey methods used cont.

- The NVC provides both mapping units by which the distribution of vegetation is recorded and a conceptual framework to facilitate interpretation of results.
- Data was collected from three seasonally dry rivers that were investigated, that is Thwake, Kaiti and Muooni ephemeral rivers located in Machakos and Makueni counties.

Research design and Sampling scheme.

- The three studied rivers were each divided in to mined reaches (sites) and un-mined reaches (sites) from which vegetation data was collected.
- The un-mined river sites represented the normal baseline condition.
- Twelve (12) cross-sections were marked
- The boundaries of the main vegetation strands were identified in the field.

Sampling and data collection Methods

- Quadrats of 10m x 50m were established on the high banks because of presence of trees and shrubs.
- Quadrats of 4m x 4m were used for herbaceous and short shrubs within the channel banks and bed.
- Vegetation data were collected for all vascular plants only

- The study parameters considered were cover / abundance and height.
- Others were vegetation structure, dominant species, stand size, zonation, to other vegetation types, moic relationships, management and biotic factors.
- Table below shows Vegetation data sampling sites

River	Mined sites quads	Mined sites quads	Un-mined sites quads	Un-mined sites quads	Totals
Thwake	T1 3- 6	T5 8-11	T2 12-16	T4 1,2,7,17, 18	18
Kaiti	K2	K4 19-22	K1 --	K3 23-26	8
Muooni	M1 27-34	M3 35, 36	M2 37,38,39, 40	M4 41, 42, 43	17
Total	12	10	9	12	43

Domin Scale of % cover used in vegetation analysis

Domin Scale	**% Cover**
10	91- 100
9	76- 90
8	51- 75
7	34- 50
6	26- 33
5	11- 25
4	4- 10
3	<4
2	< 4
1	< 4

Methodology cont.

- VESPAN III is an analytical computer package that was used to analyze the vegetation data.
- Domin values were used because of its ease of application with large quadrat units
- It is also a requirement of VESPAN III.
- Fieldwork was carried out during dry and wet seasons

Vegetation patterns and Phytogeo.

- A totalof 43 quadrats were colloceted within which a total of 101 species of plants were recorded and 27 families identified.
- The most common families were Solanaceae, Cyperaceae, Acanthaceae, Bigniaceae, Pailionaceae, Tiliacea, Umballiferae, Gramineae and Euphorbiaceae. The below shows the most common species.

Results - Species frequency

Species	Frequency %	Species	Frequency %
Acacia seyal	*78*	*Solanum incanum*	*69*
A. hockii	*56*	*Agave sisalana*	*65*
A.xanthophloea	*62*	*Grewia tembensis*	*53*
A.mellifera	*53*	*Cassia bicapularis*	*44*
A.perinata	*47*	*C.Occidentalis*	*38*
A. tortilis	*40*	*Croton megalocapus*	*40*
Lantana camara	*74*	*Compositeae helicrysum*	*42*
Lantana trifolia	*48*		

Results. Species frequency and distribution in riparian ecosystems

- The field observations indicated that some species have particular ecological site requirements.
- *A. sayel, A. tortilis, A. mellifera, Laranthus hiderbrandtii, Croton megalocarpus and Cassia occidentalis* were most abundant on the high river bank tops and on terraces above the flood level.

Plant species distribution

- Lower lying terraces supported shrubs and small trees including *Solanum incanum, Lantana camara, Acalypha fruiticosa, Agave sisalana, terminalia brownii, Aloe ukambensis, Sida cordifolia, and Commiphora schimperii.*
- Channel bars were occppied by herbaceous plants such as *cyperus rotundus, Cyperus papyrus, Bidens pilosa, Rhus vulgaris, Chloris virgata and Cenchrus ciliaris*

Mining impacts on Riparian ecosystem’s vegetation

- To investigate the impact of mining, a relatively simple test was carried out using diversity data from mined and un-mined reaches.
- The results showed that the un-mined reaches/ sites had over 18 plant species compared to 15 species within a mined site.
- The maximum diversity of species found in a single quadrat was 37 obtained from un-mined site on river Thwake compared to 9 species within a mined area on the Kaiti river

Vegetation Community Analysis

- VESPAN III computer package was the main method used for vegetation community classification.
- VESPAN III method was developed at Lancaster in U.K and is designed to process, store and display large quantities of vegetation data (Malloch, 1995).
- The programmes are built around the analytical techniques of TWINSPAN and DECORANA

VESPAN III Computer method

- TWINSPAN is a polythetic method of cluster analysis.
- DERONA is an ordination technique.
- TWINSPAN (two-way indicator Analysis
- Which is designed to perform a divisive cluster analysis on multivariate ecological data.

VESPAN III METHOD CONT.

- Aggregation of quadrats into clusters was initially based on two-way indicator species analysis using the default parameter settings provided by VESPAN III.
- Pseudospecies cut-levels were set at 0.1, 2.1, 4.1, and 7.1
  All species and pseudospecies were made available, with all the latter carrying equal weight up to seven indicator.

Classification of samples and species

- The TWINSPAN indicated that seven end groups which represented distinct vegetation communities named A-G with each group composed of several samples.
- Group A- Acacia-Croton- Lantana- community.
- Group B- Lantana- cassia – Acacia community.

Groups of plant communities defined by TWINSPAN and DECORANA

- Group C- Acacia- Cassia – Croton- Crotolaria community.
- Group D- Acacia- Terminalia- Euphobia Community.
- Group E- Acacia – commiphora - Markhamia
- Group F- Euphobia- Acacia- Tephrozia
- Group G- Acacia – Commiphora- Albizia community

Importance of using VESPAN III multivariate analysis method

- It is beneficial for formal description of riparian vegetation communities.
- It is used to characterize the riparian vegetation of Athi basin to determine whether the effects/ impacts of sand mining could be quantified or not.
- It is also used for vegetation classification, ordination, and evaluation of multivariate analysis

Secondary impacts resulting from vegetation damage by sand mining

- Damage is caused to some plants found in semi-arid riparian ecosystems such as bacteria, algae, phytoplankton, fungi, bryophytes and pteridophytes, which survive the dry periods.
- Sand mining from the river bed results in a loss of genetic materials and biodiversity within the river bed.

Impacts of sand mining on fauna

- Sand mining destroys habitats of animals within the riparian ecosystem.
- SH causes very high levels of suspended materials which can suffocate the fishes by clogging the gill filaments.
- SH destroys high quantity of bottom fauna especially, insects and molluscs populations
- Breeding sites for many organisms which need dry river beds such as locusts which lay their eggs in the sandy substrate is destroyed

Impacts of SH on biodiversity

- Dredging during SH operations during SH causes removal of organisms by suffocation, with gross reduction in animal biomass, number of species and number of specimens.
- SH increases water turbidity which inturn impairs light penetration, limits primary production, reduces photosynthesis and respiration.
- SH changes aquatic habitat quality by lowering it.

Impact of SH on biodiversity & ecosystem

- SH activities reduces the abundance of small mammals, reptiles, birds and amphibians significantly by > 75%
- Lowered water tables due to SH detrimentally affect vegetation by causing moisture depletion in the root zones.
- During dry season the soil structure and herbaceous plants such as grass is damaged through trampling on the earth roads by heavy lorries and as result a lot of dust is generated.

Ecological impacts of SH

- The vegetation changes induced by sand harvesting had negative implication for livestock production especially in Ndithini area of Machakos County.
- Damaged pastures lowered the lands carrying capacity significantly while the stocking rates where typically maintained, resulting in greater environmental degradation

Conclusion(s)

- Vegetation distribution patterns within the study rivers were mapped in the field and analyzed using a powerful multivariate statistical method called VESPAN III especially (TWINSPAN & DECORANA), enabling designations of distinctive plant communities. The method can be used in other ecosystems in Kenya to analyze vegetation.
- Through qualitative analysis, it has also been established that there widespread damage done to riparian fauna in mined than un-mined areas

Conclusions

- The results of the analysis indicated that mined areas/ sites evidenced lower plant diversity, poorer plant structural definition and lower ground plant cover compared to un-mined sites.
- These differences were caused by a range of impacts including direct physical loss through substrate / sand harvesting as well as, unintentional consequences from bad environmental practices (such as chopping vegetation, burning, traffic damage) which together have accelerated degradation of the overall riverine ecology

Conclunsions

- Sand mining/ harvesting operations have caused widespread environmental degradation on dry river and riparian ecosystems, and will continue to do so because of its importance to developing the national infrastructure and construction / building industry, unless SH activities are well legally controlled, and managed

Recommendations

- The riparian zones need to be aggressively replanted with appropriate indigenous plant material and carefully protected from further damage caused by removal of sand trampling caused on channel bed and river banks.
- While it is not possible to completely protect channel bed vegetation, it is important to consider issues of how quickly and successfully can vegetation be re-established after a period of sand mining

Recommendations cont.

- Every river is a complex ecological entity and predictions of possible effects and impacts of sand ming need to be based on knowledge of the area involved.
- Further National Vegetation Classifications (NVC) surveys are needed to evaluate the representativeness of the data of this study and to extend than appraisal to the whole of Kenya

THANK YOU

FOR YOUR ATTENTION AND PARTICIPATION