Eco-Development of Riparian Ecosystems

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ABSTRACT

Ecologically the river banks that remain flooded for a few weeks and experience erosion, silting, agricultural operations, grazing and variety of human influences like defecating, bathing, and mass-scale cloth washing, sewage discharges, etc. represent a distinct ecosystem different from the mainland terrestrial and the river ecosystems. This habitat is in a state of rapid flux in all system functions such as in nutrient input, storage and outflows, soil dynamics, deposition of seeds and plantlets of far off places brought by flood waters, and a variety of allogenic forces. On the riparian ecosystems on the banks of R. Ganga (at Varanasi) and its tributares, R. Taruna (at Rajghat-Varanasi) and R. Gomti (at Jaunpur) have been under ecological investigations for ecosystem structure and functioning. A number of herbaceous species have been experimentally tested for their soil binding capacity, biomass accumulation, rate of net solar energy fixation, energy conserving efficiency, soil erosion, silt load, nutrient cycling etc. This paper gives an ecomodel of the riparian ecosystem dynamics and outlines the eco-development strategies for the proper and long range use and stability of the habitat.

It is found that the present condition is highly unsatisfactory on the banks of all three there rivers. There is a high rate of resource depletion with respect to soil nutrients, texture, structure, permanent vegetation, water quality, carrying capacity ot water, etc. These can be overcome by plantation of adapted trees on river curvatures, cultivation of agricultural crops intermixed with strips of perennial grasses with very high soil conservation values as estimated by us, control of sewer and industrial discharges in the rivers, etc.

INTRODUCTION

The UNO conference on 'Human Environment at stockholm in June 1972, has catalysed ecologists, environmentalists, politicians and public alike at inter-governmental levels on formulating the strategies of environmental management of degraded areas which remain under stresses throughout the year. It is in this context that a seminar such as this is an appropriate opportunity for discussing the development of riparian ecosystems in light of ecological principles.

The natural ecosystems along the banks of river those influenced by it due to close proximity to water ate called riparian ecosystems. As described by Odum (1979) "riparian ecosystems are well-defined landscape features that have many of the same values and land use problems as wet lands in general but are nevertheless distinct enough to warrant special consideration.....As functional ecosystems they are very open with large energy, nutrient and biotic interchanges with aquatic systems on the inner margin." Therefore we can say that the riverbank or riparian is a narrow typical ecotone or transitional zone in between river water and upland terrestrial system.

From time immemorial there has been an attachment and reverence of mankind to rivers. The river banks are thought to be the sacred lands for common good of everyone and belonged to the communjty as a whole. Most of the religious discourses, temples and learning places were located on the riverbanks. But due to technological progress, anthropogenic pressure and decline in religious outlook, riparian ecosystems got deteriorated and imbalanced at most of the places.

The study of riparian ecosystems of three different river banks have been made to understand their ecology and the role of the vegetation in water and soil conservation, and management of these delicate ecosystems, for perpetual use. Role of river in relation to silt load and aspects of river current for proper location of the outfall of sewage and site for washermen using detergents are discussed.

Recommendation on the proper management, best exploitation of the resources, practices fo the cultivation of different kind of plants etc. are being recommended backed upon our experimental studies.

MATERIAL AND METHODS

Site description

Field investigations have been initiated and carried out along the river banks of river Ganga and its tributory River Barna (or Varuna) at Varanasi (25°18' North latitude and 83°1' East longitude). Extensive and intensive studies have been conducted on the banks of River Gomti (a tributory of River Ganga) at Jaunpur (23°24', 26°12' North latitude and 82°7', 83°5' East longitude). The altitude of these sites are approximately 76.00 meters above the sea level.

The riparian or river banks can be distinguished into two broad categories, i. e. neglected natural lands and croplands. During the rainy season the lower sloping lands get flooded with river water which in occasional years even rises and inundates flat upland for weeks together: Keeping in view of the above to broad categories a strip (one hectare) of neglected fallow land and a cultivated cropland have been taken on the same side of the Gomti river bank for the present study. Riparian vegetation shows distinct features of zonatiens. It is mainly governed by edaphic complex. Du Rietz (1930) recognized four categories of such complex according to geographic arrangements of habitats and the degree of complexity. River bank reflects one of these complexity in the form of zonation. Maurya (1978), Bhatnagar (1982) and Prakash (1983) has recognized four to five vegetal zones on river banks. Dansereau (1957) is of the opinion that all zones in the riparian ecosystem can be placed along a physiographic gradients from the main stream to the mesic site of flood plain proper.

In the present study the banks of River Gomti have been categorised into three zonations by upper, middle and lower from top up land, slopping bank and lower region near water margin, keeping in view of slope, the number of days of innundations, moisture availability and soil texture. The zonation of vegetation is caused by differences in ecological amplitude of the plant species, but here the zonation of vegetation is mainry due to the edaphic complex.

Silt load

Water sampling for the silt load was done at three points (left side, middle and right side) which changed at every sampling with the volume of water in the river. Silt sampler was used to collect water samples (one litre) suspended with silt at the depth point representing 60% of the total depth of water. Coarse sediments are separated by 100 mesh size sieve (coarse sediment 0.2 mm). Filtrate is thoroughly stirred and left undisturbed for certain hours depending on the temperature chart. Then fine sediment is seperated by decantation from medium sediment which settled at the flask. The decanted water is dried in crucible and weighed for the fine sediment. Simultaneously the medium sediment settled at the bottom of the flask and coarse sediments on the sieve are dried and their weights were taken (Anonymous 1961).

Water velocity of the river was measured by current meter. The depth of the river was taken by marked wooden rods to find out the area of that section of the river. Discharge and runoff are calculateb by the formula given below.

Discharge (Q) = A X V

where A = area of that section in m^2

V = velocity of river water ($m.s^{-1}$)

Runoff = Q x 0.00864

Silt load = Runoff x g/l x 10 t day^{-1} (for hectametre)

Conservation

On the river banks of Ganga, Barna and Gomti different plant species were thoroughly examined and on the basis of highest IVI values certain dominant species were selected for the culture studies in the rainy season in the Botanical Garden, Banaras Hindu University. On each of the experimental sloping plots (13^0) the propagules of different species were planted at uniform density level but due to the vegetative propagation the aerial cover increased differently in different species in the course of study period. The foliage growth was sufficient to cover the ground fully after about 8 to 10 weeks. One bare plot was left as such. Then artificial showering from a multipore nozzle having 2 mm diameter perforations from 1 m height with a constant speed of 16 l min^{-1} was done for 30 minutes accounting a total input of 480 litres. The showering was done at the interval ef 15 days for three consecutive fortnights on all the plots i. e. vegetated and bare. The water and soil conservation value (CV) of each species was calculated using the formula given by Ambasht (1970)

$$CV = 100 - \left(\frac{Swp}{Swo} \times 100\right)$$

where CVS = Soil conservation value

Swp = Weight of soil washed from vegetated plots.

Swo = weight of soil washed from the bare plot under identitical erosional stresses.

Primary Productivity

Primary productivity studies were done for the period of one year from April 1981 to March 1982, specially on the Gomti river bank of dominant weeds and crops. Harvest method (Odum 1960) was followed at fortnightly for winter crops, dominant weeds and rest weeds, and montly in the neglected land for dominant and rest weede. Economic yield of agricultural crops were calculated after separating seeds from husks.

Results

Silt load cclculated from the three points of the River Gomti in different months of the year, shown highest values in rainy season i. e. in the month of August and September (Table 1), (See Page–53) The highest value of 132.90 t. day^{-1} hectameter^{-1} was recorded in the mid-stream. The silt load was maximum in the mid-stream and decreased on the two sides of the river to maximum level of 59.02. and 69.51 t. day^{-1} hectameter^{-1} in the month of August on toe right and left side of the river respectively. In winter and summer seasons the silt load was much lower.

Water conservation values calculated only for the herbaceous species collected from River Gomti bank showed high values. *Cynodon dactylon* (Linn.) Pers., had 74, 23% watet conservation values whereas the lowest value of 27.29% was obtained for *Crotaria medicaginea* Lamk. Soil conservation values of herbeceous species collected from both River Gomti and Ganga banks had high values ranging from 52.8 in *Crotalaria medicaginia* to 97.5% In *Cynodon dactylone*. *Alhagi camelorum* Fisch., from Ganga river bank had lowest value of 35.0% only. Water and soil conservation value has direct relationship i. e. high soil conservation value of a species shows a high water conserving efficiency (Tables 2 & 3), (See Page–54)

Productivity of the Gomti River bank at Jaunpur for mixed crops in winter season had reasonably high values of 23.5 gm^{-2} day^{-1} in wheat (variety RR 21) and 23.17 gm-2 day^{-1} in mustard (variety Varuna; type 59) at 105 days inspite of various stresses and very little care. weed species had productivity rate of 260 gm^{-2} day^{-1} in *Cyanodou dactylon*, 0.82 gm^{-2} day^{-1} in rest weeds and 0.75 gm^{-2} day^{-1} in *Cyperus rotundus* Linn. Wheat grain yield was 2.64 t. ha^{-1} per cropping season where tiller density at maturity was 109.44 tillers m^{-2} and mustard grain yield was 0.26 t. ha^{-1} per cropping season with the plant density of 5.38 plants m^{-2}.

Discussion

The riparian and river ecosystems interact with each other. These ecosystems experience continuous anthropogenic and environmental stresses (Model 1). The main anthropogenic stresses are burning of dead bodies, use of pesticides, trampling, grazing urbanization, scraping, bathing and washing, whereas environmental stresses are nutrient depletion, excessive rainfall causing flood, drought, sediment in river water causing siltation, light, tempreture fluctuatioes ete. Most of the reparian ecosystems are delicate due to over exploitation of resources in the form of forage, thatching

TABLE-1.

Survey of the approximate silt load carried by River Gomti

MONTHS	RIGHT SIDE			MIDDLE			LEFT SIDE		
	Discharges $M^3 S^{-1}$	Runoff Hecta-meter DAY^{-1}	Silt Load Ton DAY^{-1}	Dis-charge M^3S^{-1}	Runoff Hecta-meter DAY^{-1}	ailt Load Ton DAY^{-1}	Dis-charge M^3S^{-1}	Runoff Hecta-meter DAY^{-1}	Silt Load Ton DAY^{-1}
Apr. 1981	24.95	0.22	0.16	90.62	0.78	0.60	107.16	0.93	0.16
May.	18.90	0.16	0.07	72.90	0.63	0.35	100.80	0.87	0.57
Jun.	25.92	0.22	1.14	216.00	1.87	6.83	187.20	1.62	4.84
Jul.	40.92	0.35	3.85	157.08	1.36	16.09	205.92	1.78	14.32
Aug.	680.00	5.88	76.55	1030.00	8.82	129.83	576.00	4.98	60.26
Sept.	595.00	5.14	59.02	1208.00	10.44	132.90	640.00	5.53	69.51
Oct.	62.5	0.54	6.16	343.00	2.96	33.72	302.40	2.61	29.74
Nov.	30.00	0.26	1.55	189.00	1.63	15.44	244.80	2.12	21.51
Dec.	48.00	2.42	3.26	220.50	1.91	15.54	336.60	2.91	26.85
Jan. 1982	13.28	0.12	0.24	46.80	0.40	0.91	241.92	2,09	7.34
Feb.	14.04	0.12	2.44	126.75	1.10	1.92	213.80	1.85	2.29
Mar.	9.45	0.08	0.06	70.09	0.61	0.58	239.90	2.07	0.83

TABLE-2

Water and soil conservation values of dominant herbs collected from Gomti river bank.

SPECIES	CV FOR WATER (%)	CV FOR SOIL (%)	WATER RUNOFF (%)
COLLECTED FROM GOMTI RIVER BANK			
(1) *Cynodon dactylon*	74.23	95.4	21.04
(2) *Phyla nodiflora*	72.95	93.8	22.08
(3) *Cyperus rotundus*	70.91	91.1	23.75
(4) *Digiteria adscendens*	65.17	87.6	28.44
(5) *Croton bonplamdianum*	47.70	68.0	42.61
(6) *Crotolaria medicaginea*	27.29	52.8	59.38

TABLE-3

Soil conservation value of dominant herbs of Ganga River bank (Varanasi)

Species	CV For Soil (%)
COLLECTED FROM GANGA RIVER BANK	
(1) *Cynodon dactylon*	97.50
(2) *Saccharum munja*	96.40
(3) *Cyperus rotundus*	92.92
(4) *Scoparia dulcis*	83.12
(5) *Ruellia tuberasa*	87.90
(6) *Linaria ramosissima*	71.40
(7) *Alhagi camelorum*	35.00

material, fuel products and agricultural practices with little care of the system functioning. The over expoitation of resources leads to erosion, uprooting of trees, bushes etc. and disappearance of herbs and wild animals. Erosion with the other factors on sloping river banks directly affect the nutrient depletion and siltation at the riverbeds. In due course carrying capacity of the river gets reduced thus causing flood even though the rainfall and runoff are not too excessive.

The silt load of the river is one of the important factors which affects both riparian and river ecosystsms: The hill silt load in the rainy saason is due to erosion, as well as the lower infiltration rate on the river banks because of the removal of herbaceous species by free grazing, trampling and other forces. Silt deposition on the banks changes the soil texture and hutrient recharging (Ethrington 1975) or depletion is the effect. silt load on the concave side (left side) of the river is more due to more depth and continuous erosion on this side although the velocity of water is lower as compared to shallaw convex bank (right bank) with high velocity. Thus protection on the concave side from erosion by plantation is the best precaution. The convex side free from erosion can be used to extentive and intensive agricultural practices only in winter months as the most of the upland banks are inundated in rainy season. Certain patches of natural land should be left as such where there is more slope with the suggested herbeceous dominant species which increases the infiltation and minimises the surface runoff in rainy season.

The conservation of soil and water through herbaceous species on these river banks are indispensable. The culture experiment with artificial showering after full establishment of the species show high values of both water and soil conservation by grasses, sedges and other dicot herbs on these slopes and are the main soil binders and water retaining component in the system leading to reduced erosion. But due to excessive exploitation of the resources and least protection of these species, little role in soil and water conservation is harnessed from these species. The high soil and water conserving species, dominant depending on the sites should be preferred for revegetation of these banks for protection against erosion (Tables 2 & 3).

The convex side of the river which receives rainy seasons recharging of nutrients are most fertile for agricultural practice in winter on low slopes. The economic yield of the crops (wheat and mustard) for winter season is quite high in such neglected areas; thus the convex side with low slope can be used for agricultural practices in thousands of hectares all over the country to increase the national production to meet the increasing demand of population explosion.

RECOMMENDATION

Although there are social and religious restrictions or compulsions described in Sanskrit literature of ancient India for the adequate protection and proper management of natural systems particularly the rivers, yet there is absolutely a total disregard to

these guidlines and present day laws are rarely enforced to protect the riparian and river ecosystems. man takes full liberty in interferring with the natural landcapes and ruthless exploitation of the resources. As a consequence of these activities certain species are facing extinction. the soil is deteriorating and the carrying capacity of the river is decreasing and deteriorating with accelerated rate. This alarming situation calls for eco-development of riparian ecosystems. The environmental conscisouness about rivers and their banks, constituted and integral part of the Indian ethos in ancient times (Kaufman 1978). But later on, due to over exploitation of resourcess and decrease in religious outlooks these systemes has become more fragile and vulnerable, especially through the impact of human interference and other biotic stresses. Not only the riparian but original natural vegetation cover of India has been most profoundly modified by the human activitius (White 1974).

Vegetation removal, grazing and cultivation are very common practices of such degrading areas which have greatly modified the floral constituents in the system (Dudgeon 1920, Singh 1972, Pathak 1970, and Ambasht 1978). In fact, a proper ecosystem management is a matter of ethics and value of judgement (Southwick 1972). As pointed out by Lepold (1949) and Odum (1971), understanding and proper management of ecosystems must be recognized by mankind as a moral responsibility. In order to achieve the ideal system there are certain objectives to fulfil and then maintenance of the ideal system for perpetual utilzation is the main aim of the following recommendations.

(1) Better understanding of such ecosystems through extensive and intensive research in the natural conditions.

(2) Water should be considered as a cyclic commodity within the whole ecosystem and should be given prime importance for its proper cycling. People who think that all our floods and erosion can be solved by building big dams or any other mechanical device may have a good appreciation of engineering but they need brush up on their ecology [Odum 1971]. Yet, 'dry reservoirs,' dikes and groynes, can often be justified for long-term use but flood control structures must occupy a niche.

(3) Keeping in view of the various environmental forces, especially the anthropogenic ones the immediate steps should be taken for the protection and proper management of watershed or catchement basin. It must be considered as the management unit (Odum 1971). It is further advocated that the river banks are retained as natural areas, free from multifarious developmental activities.

(4) Preservation of flora and fauna as gene pools.

(5) Selective plantation of certain species of doninant nature in the degrading areas which have high soil binding capacity. The riparian or river banks shoujd be stabilized by grass belts or others plants like *Cynodon dactylon, Phyla nodiflora*

(Linn.), *Saccharum munja* Roxb., *Cyperus rotundus*, *Digitaria adscendens* (HB & K) Henr. etc. which are very effective soil binders and colonize naturally eroded river banks, propagate vegetatively by virtu of quick growing rhizomes, tubers etc. These plants apart from soil binding capacity have high conservation effiency of water and nutrients for the whole system.

(6) Extensive plantation and agroforestry should be taken into consideration by certain fuel wood species preferably fast growing legumes on the bank of the river to check the erosin and meet the fuel wood demand. The recommended species for plantation are *Aeacia arabica* willd., *Prosopis Spicigera* Linn., *Leucaena leucocephala*, *Eucalyptus* Labill., *Anogeisses latifola* Waell. and *Zizyphus nummularia* W. & A.

(7) The shelter belts of the above trees on the bank can solve the wind erosion and heavy summer sand storm.

(8) The riparian ecosystem (convex bank) which can be highly productive for winter crops should not be kept as waste or neglected land. Seasonal submergence and expoure also help in recharging fertility status of these zones. If managed properly it can be an important source of additional production of crops to supplement the increasing demand of population.

(9) Government must set good examples by undertaking to project water quality, and stream-banks along selected segments of streams through the wild and scenic river programme. It should be treated as, 'critical environmental areas'

(10) The river banks are key to the life cycles of many living things, it must be treated as biosphere reserve for survival of birds and other animals, parks etc. for human recreation.

(11) Housing should be banned by the government in flood prone regions (Arnold 1981). It should not be financed, or guarantee af financing for housrng or business that are hazardously located in the flood plain.

(12) The bathing and washing of bulks of clothes must be concentrated at certain points of covnex side of river banks where water current is more.

(13) The sewers of the town should be treated first and then it can be passed through pipes in the mid-streams of river.

(14) Riparian and flood control policies are to be framed for long term and best protection with maximum utilization of resources.

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