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SITE SPECIFIC COMPARISONS OF MANGROVE DYNAMICS IN INDUS DELTA

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ABSTRACT

GIS and field studies of Indus delta were conducted during 2005-08 to determine the influence of frequent flooding by river Indus, rare / no flooding as well as frequent oceanic storms on dynamics of mangrove vegetation during 49 years period from 1953 to 2001. Integrated dense mangrove forests which proportionally incorporate dense, medium as well as poor/ sparse mangroves showed the net loss of 30.6% in site exposed to most river water flooding as compared to insignificant loss of 1% in the site with least river water flooding but with daily tidal inundations as well as gain of 18.4% in site exposed to daily high sea waves without any trace of river water flooding.

Key words: Mangrove Dynamics; Sea Surface Water Salinity; Indus Delta; GIS / Remote Sensing; Cyclonic Storms

INTRODUCTION

Mangroves largely occur in sheltered tropical / subtropical coasts having deep alluvium and a gently sloping interface (Ministry of Natural Resources, 1987). Walsh (1977) identified five basic elements of mangrove development as: (a) large tidal range (gentle slope), (b) tropical temperature, (c) fine grained alluvium, (d) shores free of strong waves and (e) regular inundation by salt water. There is no mention in particular that regular or irregular river water inundations is a prerequisite for good quality mangroves.

LITERATURE REVIEW

The active Indus delta region is a vast area of about 1,519 km^2 with approximately 75 km coastline and 15 to 50 km width. The area is highly variable / complex / hostile and being inaccessible is therefore mostly little known to researchers / scientists (Qamar and Quraishi, 2010).

Literature on mangroves is numerous and diverse. Most of the literature is of Japanese and Australian origin followed by South East Asian and South American contributions (Barkati and Solaha, 2005). Information on mangrove fauna and flora in Pakistan is generally of qualitative nature and is mostly limited to coastal areas of Karachi vicinity (Macnae, 1968).

Several studies have been conducted to estimate the extent of mangrove forest areas of Pakistan and their relevant preliminary information about Pakistan coasts with the help of satellite remote sensing technology. The GIS / Remote Sensing studies comprise of using various types of aerial photographs and different kinds of satellite imageries for studying nature and trends of vegetation etc.(Haines-Young, 1994).

The first indigenous study on the mangrove forest extent was conducted by Pakistan Space and Upper Atmospheric Commission (SUPARCO) in 1983. The study was based on Landsat Multiple Spectral Scanner (MSS) data of 1978 and reported the mangrove forest vegetation cover as 260,000 ha which form about 44% of the total Indus delta area. The vegetation cover consisted of 50.000 ha of dense forest and 210,000 ha of medium forest.

IUCN sponsored a major study of enhanced colour image of Karachi Harbour area. The study compared the Spot XS image of 2003 with Landsat TM data for 1990 and 1998 and reported the extent of mangrove forests along the coast of Sindh as 82,669 ha. The condition in western, middle and the eastern part of the Indus delta has been evaluated for the above periods. The middle part of the delta shows the reduction in mangrove forests and its disappearance at the mouth of the river Indus whereas western and eastern parts of the delta have shown an improvement in the mangrove forest areas and their condition.

In 2003, WWF-P studied mangrove cover over a period of eight years. This study compared Landsat satellite images of 1992 and of 2000 with each other and examined the entire coast of Sindh, Pakistan from Korangi Creek near Karachi to SarCreek near the Rann of Kutch. The overall extent of deltaic vegetation was reported to be 73,810 ha in 1992 and 73,000 ha in 2000. Although the study did not find significant variation in the overall extent of mangrove cover over this period, it detected a very significant shift in the mangrove distribution from the south eastern part to the north western part of the delta (WWF, 2005).

Studies of low – resolution satellite images of 1978 and 2001 (Government of Pakistan, 2005) supported by soil survey maps have studied the land use patterns of Indus Active Delta. The study shows that the area covered by barren mudflats with sparse salt shrub vegetation has slightly increased between 1978 and 2001. The other land use type was sediments which increased significantly within the 23 years study period. The area covered by sand was almost doubled by 2001. The mangrove cover decreased by 56.4% from 48,537 ha in 1978 to 21,182 ha in 2001.

IUCN (2010) studied the mangrove ecosystems of Pakistan which are an important natural resource, critical for fisheries and natural barrier to various disastrous threats. The study determines global warming, arid conditions, prolong drought spells, inadequate supply of fresh water from river Indus, industrial and thermal pollution, dumping of untreated effluents, overexploitation of mangroves for fuel wood / fodder and population pressure as main causes of degradation of Indus delta mangroves.

Bunt *et al*. (1982) reported that the species having the capability to grow in all salinity ranges from fresh water to sea water included *Avicennia marina*, *Bruguieragymnorrhiza*and*Xylocarpusgranatum.Although* salinity of Interstitial*water is important to growth rate, survival and zonation of mangroves (Macnae and Kalk, 1962; Mogg, 1963; Macnae, 1968; Teas, 1979 and Semeniuk, 1983) but the frequency of regular tidal as well as cyclonic inundationsis most common variable used to illustrate mangrove forests zonation (Waston 1928; Macnae 1968; Chapman 1975 and Hamilton &Snedaker 1984).

Saifullah *et al*. (1997) observed that mangrove forest cover is gradually decreasing day by day along the coast of Pakistan. Climatic factors have, played an important role in current distribution and structure of the mangroves in Pakistan which largely occur in Indus delta.

FAO (2007a) observed that Pakistan is largely arid, with low rain fall, mostly received during monsoon period. Climatic factors have, therefore played an important role in current distribution and structure of the mangroves which are monospecific*Avicennia marina* andlargely occur in Indus delta.

Indus delta mangroves are subject to heavy population pressure using the mangrove products for fuel wood, poles, fodder, and camel grazing. Industrial pollution, increasing salinities caused by fresh water abstraction projects and oil spillages from ships visiting Karachi have negatively affected the species distribution and extent of mangroves in Pakistan. Resultantly Pakistan is reflected in the list of countries where anthropogenic factors have caused the severe loss in mangrove areas during 1980s (FAO, 2007a).

METHODOLOGY

Plan of Work

Three isolated distinct sites significantly variably exposed to river / sea water inundations were proposed to be selected for the purpose of monitoring of mangrove forest cover dynamics during last 49 years.

Selection of sites

After thorough examination of aerial photographs, as well as satellite imageries and in consultation with hydrology, oceanography, soil and climatology experts, three specific sites in the Indus delta (Figure 1) were selected representing a) zone most exposed to river water flooding (21 ppt), b) zone least exposed to river water flooding but inundated by regular coastal water tides(27 ppt) and c) zone exposed to frequent cyclonic storms from open sea with no trace of river water flooding (35 ppt). The integrated dense mangrove forest areas were determined in the specific selected sites in 1953 as well as 2001 for monitoring mangrove vegetation changes.

GIS / Remote sensing studies

The land surface types and mangrove forest cover of Indus Delta and their changes were investigated on the basis of topographical maps, aerial photographs taken under Colombo Plan in 1953 by Survey of Pakistan, and multi-resolution digital satellite imageries of the area for 1978 and 2001. Spatial extents and changes in mangrove forests, delta land use, shrubs, sediments, sand and land cover classes were determined and analysed (Qamar and Quraishi, 2010). The results of the study were later confirmed by ground-truthing done in field traverse.The traverse covered the selected sites in talukasKetiBunder, KharoChaan and Shah Bunder.

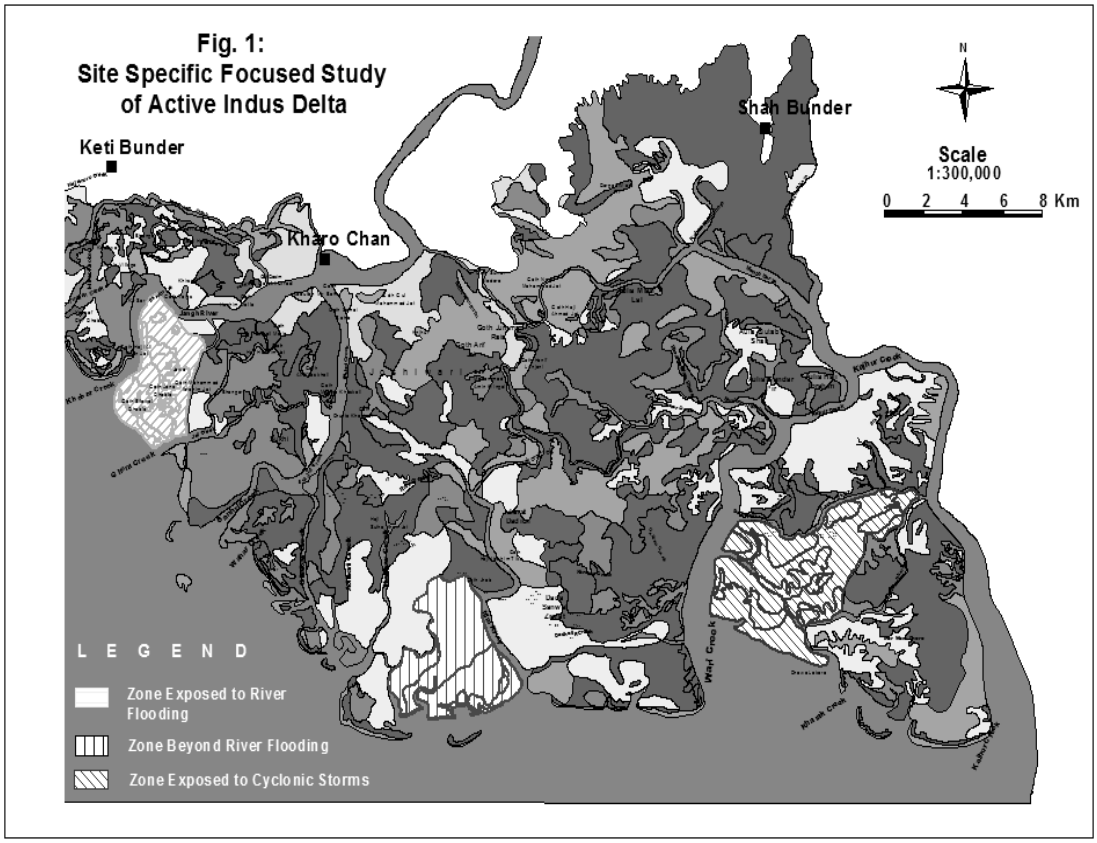
Forest Cover:

Forest cover was taken as percentage of the total area. The mangrove forests were divided into the following main categories (Ansari, 1987):

* *Interstitial water is the free soil water from 10 to 30 cm depth.*

Dense Mangroves having 100-75% cover

- Moderate Mangroves having 74-25 % cover.
- Poor / Sparse Mangroves having 24% or less cover.
- Total Integrated Dense Mangrove Forest ={(Dense Mangrove Forest) + (Moderate Mangrove Forest) × ½ + (Poor Mangrove Forest) × ¼}.



Sea surface water sampling

Site specific locations representing various zones were accessed with the help of GPS equipment. First set of 12 samples was collected in March / April 2006 at a time when previous year's river flooding effect was at a minimum level. The second set of samples was taken in September 2006 just after peak river flood season. This sampling was repeated in year 2007. The surface water samples were later analysed in the Water and Soil Lab of Agriculture Department Lahore for determining the Electric Conductivity (EC) which is a good measure of water salinity. The Electric Conductivity was used for estimating Total Dissolved Solids (TDS) with the help of following conversion factor:

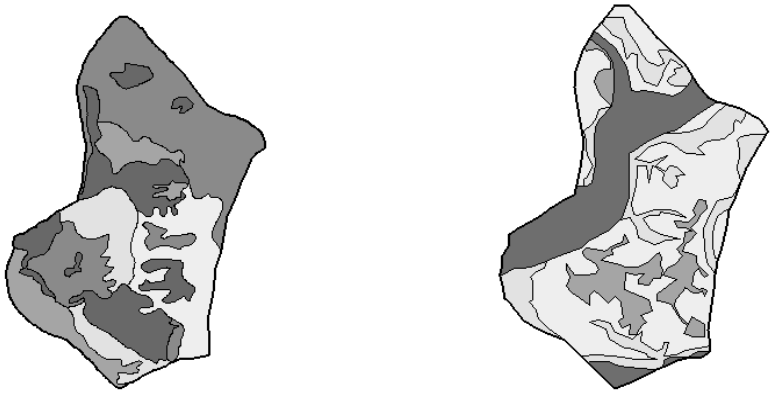
$$R = \frac{C(S,t,p)}{C(35,15,0)},$$

where C(35,15,0) is the conductivity of standard seawater of practical salinity 35, at 15^{o} C and atmospheric pressure.

RESULTS AND DISCUSSIONS

The results of the land cover classification of site specific studies of Indus Delta are represented in Table - 1.The data regarding total integrated dense mangrove forest areas which is a representative estimate of real forest cover shows a net loss of 30.6% in most river water flooded environment(Figure-2) as compared to a forest cover loss of 1.0% in least river water flooded but regular sea water tidal inundation environment (Figure-3)during 49 years of the study period. The site exposed to frequent high sea cyclones but receiving no trace of river water flooding environment (Figure-4), in contrast gained a net increase of 18.4% during the same study period.

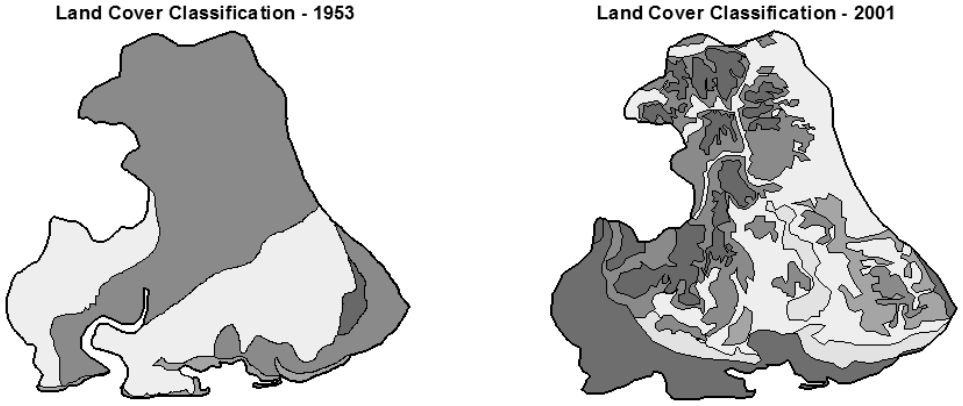
Fig. 2: Zone Most Exposed to River Flooding



L E G E N D	Area (percent) 1953	2001
Dense mangrove stand	23.0	-
Moderate mangrove stand	38.6	-
Sparse vegetation	15.1	61.6
Sediments	11.8	14.4
Sand	11.5	24.0
Erosion	-	24.2

Worked out from :
1953 : Colombo Plan aerial phtographs
2001 : Classified landsat digital satellite imagery

Fig. 3: Zone Exposed to Least River Water Flooding But Fully Exposed to Regular High Tide Inundation



L E G E N D	Area (percent) 1953	2001
Dense mangrove stand	1.3	14.7
Moderate mangrove stand	58.1	28.6
Sparse vegetation	37.9	39.2
Sediments	2.7	8.1
Sand	-	9.4
Erosion	-	17.4

Worked out from :
1953 : Colombo Plan aerial phtographs
2001 : Classified landsat digital satellite imagery

It indicates that inundation by normal sea water tides or flooding by oceanic cyclones is not specifically unwelcome / hostile to mangrove vegetation as against popular assumption.

The loss of mangrove forest in fresh water flooded environment appears not to be due to any physiological stress of salinity because this environment is the best possible and most favourable from sea surface water salinity view point but it is due to operation of various biological interventions such as excessive grazing / lopping/ felling as a result of mis-management and neglect by the authorities concerned.

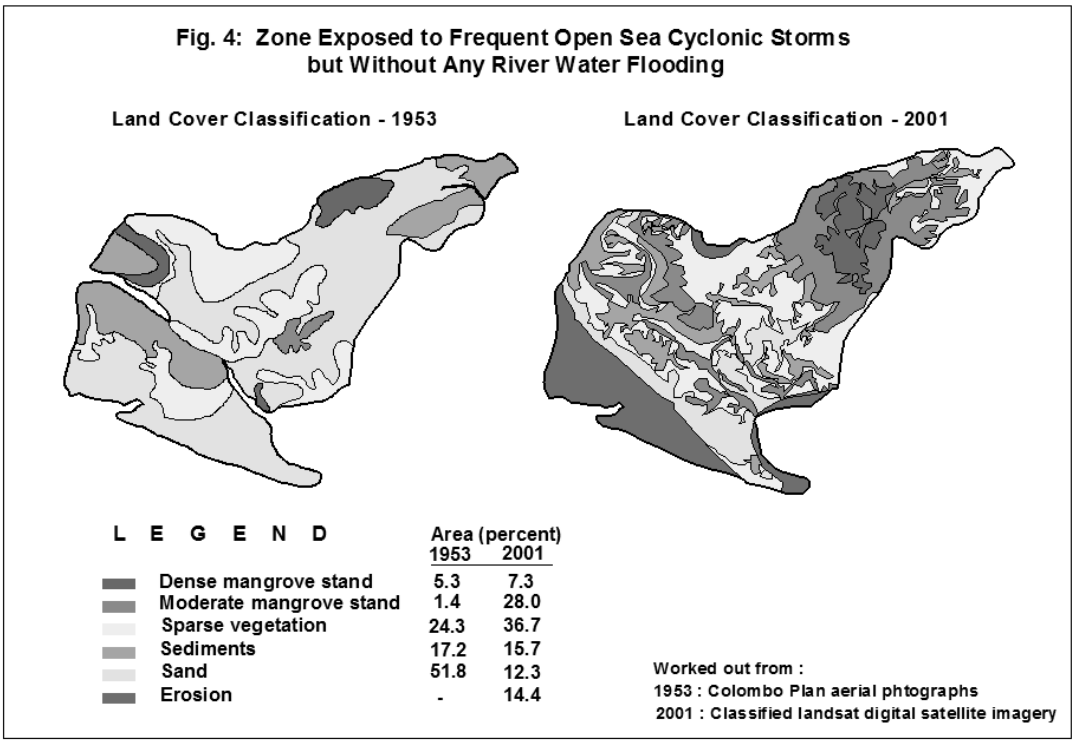


Table 1. Land Cover Classification of Specific Sites of Indus Delta.

(1953 and 2001)

Land Cover	Area (%)								
	Zone Most Exposed to River Water Flooding			Zone Least Exposed to River Water Flooding but with Daily Tidal Inundation			Zone Without River Water Flooding but Exposed to Frequent Cyclonic Storms		
	1953*	2001	Diffe-rence	1953*	2001	Diffe-rence	1953*	2001	Diffe-rence
Total Forest	76.7	61.6	-15.1	97.4	82.6	-14.9	31.0	72.0	35.0
▪ *Dense Mangroves*	*23.0*	*0.0*	*-23.0*	*1.3*	*14.7*	*13.4*	*5.3*	*7.3*	*2.0*
▪ *Moderate Mangroves*	*38.6*	*0.0*	*-38.6*	*58.1*	*28.6*	*-29.6*	*1.4*	*28.0*	*26.6*
▪ *Poor Mangroves*	*15.1*	*61.6*	*46.5*	*37.9*	*39.2*	*1.3*	*24.3*	*36.7*	*6.4*
Integrated Dense Mangrove Forest	46.0	15.4	-30.6	39.8	38.8	-1.0	12.1	30.5	18.4

**Bench Mark*

Conclusions

The study concludes that Integrated dense mangrove forests which proportionally incorporate dense, medium as well as poor/ sparse mangroves and are thus a genuine estimate of mangrove forest cover showed the net loss of 30.6% in specific sites exposed to maximum river water flooding as compared to an insignificant loss of 1% in the sites with least river water flooding but exposed to daily sea water tides as well as a highly significant net increase of 18.4 % mangrove forest cover in site exposed to frequent oceanic cyclones but experiencing no trace of river water flooding during 49 years of study period.

It indicates the negative correlation between regular inundations by regular sea water tides in the absence of river water flooding and the loss of mangrove forests. This study concludes that the above noted loss of 30.6% mangrove forest loss in river water flooded site is not due to any physiological stress of increased sea surface water

salinity because of reduced Indus flow but is due to various socio-economic pressures coupled with mis-management and neglect by concerned authorities.

REFERENCES

Ansari, T.A. (1987). Country Report of Pakistan. In: *Mangroves of Asia and the Pacific: Status and Management.* Technical Report of the UNDP / UNESCO Research and Training Pilot Programme on Mangrove Ecosystems in Asia and Pacific (RAS/79/002), Ministry of Natural Resources, Philippines, 151-174.

Barkati, S. and R. Solaha (2005). Species Composition and Faunal Diversity at Three Sites of Mangroves. *Pakistan. J. Zool.*, 37(1): 17-31.

Bunt, J.S., W.T. Williams and H.J. Clay (1982). River Water Salinity and Distribution of Mangrove Species along Several Rivers in North Queensland. *Aust. J. Bot.*, 30: 401-412.

Chapman, V.J. (1975). Mangrove Biography. In: *Proc. Int. Symp. Mangr. Mangr,* (Walsh, G.E., Snedakar, S.C. and Teas, H.J. (eds.).8-11 October 1974, East-West Center, Honolulu, 3-22.

FAO (2007a). *Mangroves of Asia 1980-2005: Country reports.* Food and Agriculture Organization,Working Paper 136, Room.

Government of Pakistan (2005). *Study on Water Escapages Downstream of the Kotri Barrage to Address Environmental Concerns (Study-II),* Federal Flood Commission, Ministry of Water and Power, Vol-I, 221pp and Vol-II, 273pp.

Haines-Young (1994). Remote Sensing of Environmental Change. In: *The Changing Global Environment* (Roberts N. eds). Blackwell Publishers, Oxford, UK, 2-45.

Hamilton, L.S. and Snedaker (eds). (1984). *Handbook of Mangrove Area Management.* United Nations Environment Programme, and East West Center Environment and Policy Institute. COE/IUCN, Gland-Switzerland, 396pp.

IUCN (2010). *Pakistan: National Strategy and Action Plan for Mangroves for the Future.* IUCN-Pakistan, Karachi.

Jayatissa, L.P., W.A.A.D.L. Wickramasinghe, F. Dahdouh-Guebas and M. Huxham (2008). Interspecific variations in responses of mangrove seedlings to two contrasting salinities. *International Review of Hydrobiology*, 93(6): 700-710.

Macane, W. and Kalk (1962). The Ecology of the Mangrove Swamps of Inhaca Island. *Mozambique. J. Eco.*, 50, 19-34.

Macnae, W. (1968). A general Account of Fauna and Flora of Mangrove Swamps and Forests in the Indo-West Pacific Region. *Advance Marine Biology*, 6, 73-270.

Ministry of Natural Resources (1987). *Mangroves of Asia and the Pacific: Status and Management.* Technical Report of the UNDP / UNESCO Research and Training Pilot Programme on Mangrove Ecosystems in Asia and Pacific (RAS/79/002), Ministry of Natural Resources, Philippines.

Mogg, A.O.D. (1963). A Primary Investigation of the Significance of Salinity in the Zonation of Species of Salt Marshes and Mangrove Swamp Associations. *S. Afr. J. Sci.,* 59: 81-86.

Qamar, M.K. and M.A.A. Quraishi (2010). *Mangroves of the Active Indus Delta- Changes and Their Causes*, Lambert Academic Publishing, AG & Co. KG, Germany.

Saifullah, S.M., F. Chughtai and S. Akhtar (1997). Dispersal and Establishment of Mangrove Propagules in the Exposed Coastal Habitat of Indus Delta. *Pak. J. Bot.*, 39(2): 577-582.

Semeniuk, V. (1983). Mangrove Distribution in North Western Australia in Relationship to Regional and Local Fresh water Seepages. *Vegetation*, 53: 11-31.

Teas, H.J. (1979). Silviculture with Saline Water: The Biosaline Concept. Edited By A. Hollaender. *New York Plenum*, 117-161.

Walsh, G.E. (1977). *Exploration of Mangal*. Chapman (ed). 347-362.

Watson, J.G. (1928). *Mangrove Forests of Malaysian Peninsula.* Malay. For rec. Singapore. Faster and Neave, Ltd. 275pp.

WWF (2005). *GIS Remote Sensing Based Assessment of Mangrove Resources of Selected Project Sites of Indus Delta and Makran Coast.* World Wildlife Fund for Nature and Natural Resources, Pakistan, Lahore, 55pp.

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