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COASTAL MANAGEMENT : FOR WHOM ?

Abstract

The narrow coastal strip of Konkan (Maharashtra) was a region of rice cultivation coconut and arecanut orchards and traditional fishing. Moist deciduous and evergreen forests clothed the hills. With the policy of increasing industrialization and introduction of railway to better the condition of local people, new social, economic, and ecological conditions are being created.

An ornithological survey carried out in 1994-95 revealed that birds are the indicators of the changed environment. Increase in the number of scavenging birds and decline of habitat specific birds signify the changes in the landscape. On this background the question arises, "for whom we wish to change our coastline?" The authors conclude that the present scenario indicates that the coastal management will mainly benefit the rich.

The 500 Km long, narrow coastal strip of Maharashtra, well known as the Konkan (Lat. 16°-19° N. Long. 73°-74° E) is in the throes of rapid economic development. But the strange thing is, the development projects will neither utilize the biological resources nor the human resources of the region. The only advantage the Konkan offers to the developers is nearness to the sea which facilitates raw material imports. The region is neither rich in minerals nor in industrially utilizable biomass. Over the years the region has also proved to be a net exporter of unskilled labour. The development projects have therefore, to import not only raw material but skilled labour too. The benefits of development, it appears, will then be largely exported without in any way benefitting the local people. On the other hand these development projects will lead to large scale transformation of the landscape and the seascape bringing in its wake quality deterioration of air, water and biota.

On this background we undertook a survey of the coast in the winter of 1994-95. Though the main objective was ornithological, we had occasion to assess the general quality of

the coastal habitat. This article will sketch the habitat pattern of the coast to bring out what is likely to be lost in terms of biotic and human resources and cultural practices due to transformation of the landscape. This should provide background material for coastal management helping to clarify goals in terms of resource conservation and benefits to local communities.

The Konkan region is bounded to the east by the almost perpendicular escarpment of Western Ghats and to the west by the Arabian sea. The region is hilly due to a number of spurs radiating west from the escarpment. Numerous streams that originate in the ridges of the Ghat and debouch into the sea, dissect the undulating landscape. Some of the streams are navigable for a short distance due to the influence of the tides. The silt and nutrients that the streams bring in have given rise to mudflats and mangroves which are responsible in protecting the land from sea erosion and wave action. Nonetheless the sea has carved out bays and inlets, deposited sand on huge stretches while laying bare and moulding rocks in others. The coast exhibits alternately rock outcrops and sandy beaches

punctuated with promontories that jut into the sea and river mouths where fresh and sea water mingle.

Man has been modifying this landscape for over 3000 years now.

Historically the Konkan was a land of small fishing communities who settled along the coast. Later waves of immigrants started pouring in from the mainland as resident communities retreated before the onslaught of invaders from the north-west.

As the mainland developed agriculturally and commercially, and maritime commerce became possible, trading posts came to be established on the coast. Some of them developed into busy ports from where vessels plied to west Asia and even Africa right upto the arrival of Europeans in India.

Away from the sea, the interior of the Konkan was very little developed or settled. The hilly terrain dissected by many streams was neither conducive to agriculture nor to settlement as movement and communication were difficult. Most of the hills though privately owned, were little cultivated and given over to indigenous forests. These moist deciduous and semi-evergreen forests were not well known for commercially valuable species such as teak, but harboured a number of plants which were useful in traditional systems of medicine. In modern parlance they were rich in genetic resources and bio-diversity though not amenable to large-scale commercial exploitation.

The British encouraged settlement of the region offering land and stimulating plantations of coconut, arecanut and spices and improved varieties of mango. These resources were however, not sufficient to sustain the increasing population who resorted to migration in search of education and jobs.

It is to improve the economic condition of the local people and provide them with on the site jobs that industrialization and improvement in transport, especially railways, were thought of. Some other measures such as development of saline lands - lands subjected to tidal ingress -- to make them suitable for agriculture and restoration of mangrove patches were also instituted.

The large-scale transformation of the landscape began in the eighties with the arrival of chemical and petrochemical industry and introduction of the railway.

As we drove down the steep roads that penetrate the escarpment and lead one to the sea, we became witness to the changes in the landscape. As everywhere, deforestation of the hills was the first to strike one's vision. Shifting cultivation, cutting for fuel, lesser timber and making of charcoal were seen to be the main causes. Driving ahead as one entered the undulating land with its plateaus, ravines, stream basins and estuaries, one began to cross plateaus that were mere grasslands or just bare laterite where forest had been cleared recently. Some of them had juvenile plantations of mango or

cashew on plots devoid of any other vegetation while others exhibited fragmentary construction-- the beginning of a new industrial or commercial venture, or just barbed wire fencing where vegetation was cut in anticipation of a new project.

Nearer the sea we began to notice clustering of settlements: old villages supplemented by labour shanties, vehicle depots and shops smeared in oil and grease. Large tracts of land on sides of the road that were once rice farms now were seen to be reduced to unproductive marshes growing obnoxious weeds such as water hyacinth and *Ipomoea carnea*.

As one drew nearer the sea, amidst rows of coconut, one glimpsed spacious villas of the neo-rich, luxury hotels topping the hills overlooking the sea punctuated by howels of the fisher-men and orchards and farms of the small cultivator. Near and around the river mouths and estuaries we came across stunted mangroves, river flows choked with industrial debris and settlement waste through which oily water flowed down. Facing the sea were casurina plantations, a few temples, shacks of fishermen and garbage dumps. Even the beaches were littered with waste and garbage and were a place where men regularly came to defecate in the evening and cows acted as scavengers cleaning the human waste!

These are the most visible effects of industrialization and large-scale immigration of construction and other labour. The local people have not only lost their lands but the land itself has lost its *raison d'etre*. It is now being put to uses for which it is not suitable either physically or biologically.

Birds are supposed to be the indicators of the environmental quality. Is it true as far as the conditions of our own coast go?

In our ornithological survey the most numerous birds that we found on Konkan's sandy beaches were gulls: Brownheaded and Blackheaded (Table). These gulls are migratory. They breed either around the high altitude lakes of Ladakh and Tibet or on the beaches of Europe. At one time an arm of the sea extended right upto the region which we today call the Tibetan plateau. The descendants of the gulls who bred on the beaches surrounding the Tethys sea still migrate to their ancient breeding grounds though the sea has long disappeared. They now breed on islands in saline and freshwater lakes of Ladakh and Tibet. But what is of importance for us is the fact that the gull is essentially a scavenger. It frequents garbage dumps in Europe or in and around the sea coast picks up scraps of food (dead fish and other sea creatures) thrown overboard by the fishing vessels. There is no dearth of these vessels on our coast today. One can see scores of them fishing or trawling in the shallow seas adjoining the coast. Their big nets scour the sea bed and scoop up everything including many creatures that are not on demand in the market. They are just thrown back into the sea either dead or severely mauled -- a pre-digested meal for the scavenging gulls! The sight of huge flocks of gulls sequealing and dancing in the air as the trawlers come ashore is

really stunning. At other times these birds pick up scraps of garbage and other waste material just lying on our beaches or floating down the estuaries. With industrialization and rise in shanty settlements, the number of scavenging gulls must have increased too. In this sense these birds are indeed the indicators of the quality of the environment.

The other bird that we would like to mention here is the Blackcapped Kingfisher, a cousin of the familiar white-breasted Kingfisher that we see everywhere : near water as well as around fields and gardens. The Black-capped one is a denizen of Mangroves. While the number of gulls on our coast has increased the Kingfisher has become extremely rare. We had to search hard to find them and over the entire stretch of about 500 km of the coast we found just half a dozen of them. This shows that the kingfisher's habitat, i.e. mangrove swamps has declined both in extent and quality. Mangroves are under heavy exploitation for their fuel and timber value. No substantial mangrove patches now remain on the west coast. The coast is being exposed more and more to the erosive influences of the wind and waves. Their importance as breeding grounds for marine fish and other creatures has declined as well. Not only do they not offer any shelter and security of the breeding fish, the temperature regime of their waters has changed too. This was brought to our notice by the traditional fishermen who depend on their livelihood on fish who breed in mangrove swamps. They cannot fish in deep seas in their small vessels. In estuaries, according to them, not only the quantity of fresh water flowing down from the uplands is reduced, but the water that flows in shows marked temperature variations that kill the fish spawn. Barrages built for irrigation on streams and industries releasing effluents are both responsible for these conditions. Both have affected the local fishermen adversely. Moreover they have to face stiff competition from trawler owners who even demand that they should be allowed to fish during the monsoon season-- the breeding season of fish, when no traditional fisherman goes out to the sea.

But there is one bird that so far seems to remain unaffected by industrialization and urbanization. This is because its breeding habitat remains largely unaffected. This is the white-bellied Sea Eagle, a stately-looking magnificent avian that patrols thesea coast like a guardian of all things natural! The eagle builds his large nest on tall casurina trees. Casurina groves that provide an imposing backdrop to many a beach were planted by the Forest Department to protect the coast from sea erosion and to provide firewood and timber to the people. Landowners have also planted these trees in their backyards many of which are utilized by the eagle for nesting and perching. If these groves are re-moved to make way for beach resorts, hotels and their likes the eagle's breeding sites will be gone leading to the decline of another impressive bird.

Their disappearance in future does not seem to be far fetched. The offshoot of industrialization is commercial tourism. Politicians are openly dreaming of converting Konkan's beaches into tourist hot spots. Only a week ago (25th July

1996) newspapers carried a story of forcible acquisition of poor peoples land (fishermen's) near the sea for a five star hotel.

In a sense this looks inevitable. With large-scale investments, the old order of small-scale cultivators, orchard owners an those who depended on money orders from their kith and kin working in the metropolis, will be replaced by one consisting of the industrial and trading elite, a middle level of technocrats and white collar executives and a lower one of blue collar technicians and machine operators. The land, its characteristic produce, the bio-diversity its climate, soil and plant life are able to generate, will hardly matter in a value-added economy dependent largely on imports. The question then we want to pose is, for whom do we intend to manage our coast line?

Is it for the small fisherman, for the poor cultivator or the small orchard owner? i.e. all those who are likely to disappear in the near future; or is it for the new industrial and commercial order that is fastening its grip on the land?

Social justice demands that the state should intervene on behalf of the poor. It should assist the poor to better their lot. But the state today appears to be under the mistaken belief that only by depriving people of their land and their way of life and converting them into wage labourers that their standard of living will be upgraded. Political leaders appear to steadfastly believe that poverty can only be wiped out by large scale industrialization, urbanisation and commercial agriculture and not by enhancing the quality and productivity of the soil, the water, or by enriching bio-diversity. If this belief continues coastal management will increasingly be in the interests of the new elite --- commercial tourism, intensive mechanical fishery, high input bio-technological fish and sea-creature breeding (e.g. prawn culture) and the like. The experience of industrial countries shows however, that these activities lead to heavy pollution, degradation of biological life, and accentuated social inequalities. Affluence breeds squalor!

But this is not the only way to manage our coast. There is an alternative and a benign one at that, thought it cannot promise fabulous wealth (& consequent high inequalities) and high profile consumerism. It is based on rejuvenation of the soil, invigoration of indigenous flora and fauna and restoration of the landscape, be it escarpments, hill slopes, river and stream basins, mangrove swamps, mud flats and the beaches. It will provide for not the greed of the few but the needs of everybody.

The techniques of restoration of nature are fast becoming sophisticated and immaculate in the developed countries who had experienced the ill-effects of intensive industrialization and commercialization. Societies who still remain enamoured of high profile consumerism which these two bring about, can hardly be expected to look seriously into the possibilities of restoration of nature. Today's political and social will frankly points to a coastal management that benefits the rich.

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Table

Total Birds Observed on Konkan Coast during field survey in 1994 by the authors.

Name of the Bird	No.on beaches	No. in creeks	Total Birds
Little cormorant	15	5	20
Cattle egret	1600	108	1708
Little egret	-	38	38
Large egret	-	3	3
Pond heron	37	49	8
Reef heron (Black)	48	25	73
Reef heron (White)	27	10	37
Reef heron (Eastern)	4	-	4
Pariakh kite	21	26	47
Brahminy kite	51	7	58
Whitebellied sea eagle	35	-	35
Osprey	2	-	2
Lesser sand plover	4290	20	4310
Greater sand plover	253	-	253
Kentish plover	496	-	496
Redshank	4	12	16
Greenshank	8	2	10
Common sandpiper	38	14	52
Marsh sandpiper	2	3	5
Terek sandpiper	7	30	37
Spotted sandpiper	-	2	2
Oystercatcher	-	8	8
Turnstone	3	1	4
Curlew	21	6	27
Whimbrel	9	9	18
E. Golden plover	-	25	25
Dunlin	-	22	22
Eastern knot	1	-	1
Blackheaded gull	4915	400	5315
Brownheaded gull	5245	500	5745
Herring gull	505	50	555
Lesser blackbacked gull	185	25	210
Great black gull	80	-	80
Gullbilled tern	170	420	590
Lesser blackbacked gull	785	30	815
Sandwich tern	490	-	490
Large crested tern	-	15	15
Brownwinged tern	-	11	11
Little tern	80	250	330
Caspian tern	3	1	4
Blackcapped kingfisher	1	1	2
Small blue kingfisher	10	4	14
Whitebreasted kingfisher	3	-	3
Grey heron	-	7	7
Blackwinged stilt	-	1	1

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Prakash Gole & Swati Gole

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Traditional systems of Water Harvesting, Supply & Irrigation

In most of India the duration of rainy season is between June & September every year. The average rainfall varies from region to region according to their geographical locations. As the dry season is long, provision of water supply is necessary for the lean season. It is green everywhere during the rains but every-thing progressively dries up ^{desi} ~~until~~ ^{until} it becomes dry & desiccated in summer.

A number of systems to store water during the rains for the supply in the dry season were developed in India since very ancient times. This enabled not only the ^{human} civilization but also a great variety of flora & fauna to survive for thousands of years. Evidence of this comes from all over India. Details of such water management systems, the rules governing them are found enshrined in many a stone inscription. ^{Archaeological} evidence ^{substantiates} them (Atharvaveda & Arthashastra by Kautilya).

An examination of this evidence suggests that these systems of water storage and distribution were well adapted to the variations in topography, soil conditions and environmental peculiarities of different regions.

Also arrangements to confront natural calamities such as flood & famine also seem to be incorporated in them. Regulations have been carefully designed to prevent contamination of water & maintain its quality. Systems, rules & division of labour ~~was~~ ^{were} designed to take care of catchment areas of streams.

All such details can be found in Kautilya's Arthashastra. India was considered to be agricultural country & as the majority of people were dependent on agriculture, Kautilya considers this activity as the main source of income for the people. In order to get a satisfactory & regular income from agriculture he gave due importance to irrigation. Classified soils, graded them & formulated a land-use policy. Water tax was made dependent on the type of system used to irrigate the land. In this way the systems of water storage, use & irrigation were made a part of the economic system of the kingdom. This lent a continuity to these systems.

The Indus Valley Civilization which flourished around 3000 B.C. at ~~the~~ centres such as Mohenjodaro & Harappa and the recently excavated Dholavira in Gujarat are testimony to the ~~recently excavated~~ ^{high efficiency of} water management in ancient times.

Canals, well-built tanks have been excavated. The ruins of Harappa show evidence of 700 dug wells. These wells in residence ^{hial} areas were the main supply for drinking water. Archaeologists believe that wells also provided water for irrigation.

Indians have been using water from many sources such as springs, streams, rivers, rain-water, flood water, sub-soil water. Systems were cleverly designed to provide long-lasting supply from these. They were eco-friendly as needs of animals, birds, domesticated animals were also provided for. They were in tune with the functioning of natural eco-systems.

We will now look at the traditional water management systems prevalent in different parts of India. Let us begin with the Himalaya.

Trans-Himalayan Region

Ladakh & Kargil from the state of Jammu & Kashmir are included in this region. Ladakh is a cold desert so is Lahul-Spiti from Himachal Pradesh. Ladakh receives only 140 mm of precipitation per ~~annum~~ mostly in the form of snow in winter. Ladakh however, is a land of bright sunshine & fertile soil. But the high altitude & cold make agriculture difficult. Nothing grows above 5000 metres.

Around 4500 metres are grasslands & some agriculture is possible below 4000 m. altitude especially near streams & rivers. In summer melting snow feeds the streams which are diverted to bring water to the fields. People of Ladakh have evolved a good irrigation system on this water supply. The melt water reaches villages in the evening. The diversion channels are led to a pond called "Zing". From here smaller channels reach the fields. Generally a web of channels & ponds can be found around a village. People get irrigation on the basis of the area of the land-holding.

The Ladakh-Spiti region encompasses an area of 1.11 m. ha. Rainfall is only 27.1mm. Distribution of water is similar to Ladakh. This traditional system is still in use. Spiti is a cold desert. Still by diverting melt water agriculture has been made possible. The canal that brings melt water to the village is called "Kul". This feeds the pond especially at night. This system has been providing water to people for many centuries. Every year distribution of water was agreed upon on the basis of one's need. Dealings in one's share of water were prohibited. This system however, is now in shambles.

Western Himalaya

Kashmir & Uttarakhand provide Catchment area for the five rivers in Punjab & the Ganga. Terraced fields are common in the hills of Kashmir & Uttarakhand. All these fields are irrigated through traditional systems. The channels that provide water to terraces are known as "Kuhl". Water is circulated by building parallel channels. The channels may be 1 to 15 Km. long & carry water at the rate of 15 to 100 litres per second. Channels collect rain water. Melt-water is also collected. Longer Kuhls collect more water. One Kuhl can irrigate 80 to 400 ha. of land. Water mills are constructed on the flow at suitable places to grind grain. Building Kuhls involve an expenditure of 5000 to 5000 Rs. per Km. This efficient system is still in use at many places.

Kuhls are maintained by the beneficiaries. Smaller channels divert water from the Kuhl to individual terraces. A person is appointed who releases water into smaller channels from the Kuhl according to individual needs is called Kohli. This must be the genesis of the surname Kohli. Generally this is a family arrangement & is inherited by successive generations. For these services the Kohli is paid in terms of grain & his land is exempt from land tax. This is the oldest system of this region.

In Jammu tanks & reservoirs of various sizes stored water. They are built at the foot of slopes and on plateaus in hilly country. These tanks mainly provided drinking water. Springs from hills were the source of water for them. They are bounded on three sides with one side kept open for letting in the water. Water flowed in over a flat surface of specially placed rock slabs.

These tanks were managed by the village as a whole. The village as a whole participated in supervision, cleaning, desilting etc. of these tanks. Banyan & peepal trees were especially planted on the banks of some of these tanks. The ecological importance of these trees was generally recognised & so were also given religious importance. Silt that used to be removed from time to time from these tanks, was used to replenish soil in agricultural fields.

● Tehri-hadwari, the Himalayan region in Uttar Pradesh (now in Uttarakhand) has a system similar to Kuhl but known as kuhl. Most of the agriculture is rain-fed & not irrigated. Canals supply irrigation in Dehradun region.

Eastern Himalaya

From the plains of Bengal Darjeeling rises to a substantial altitude. Its steep hill-sides harbour a number of streams. These

are used for irrigation. Barrages are built on streams & rivers (Mechi, Barasun & Mahananda) & canals are constructed to provide irrigation in the hills. Lepcha, the people originally from Nepal practise terrace farming and take their cattle to high altitudes for grazing. Diver-sion channels on streams is the main source of irrigation.

In Assam water is brought to fields through bamboo pipes. Apatani community is expert in diverting & channelling water by building earthen embankments. Every field has an inlet for water & an outlet to drain off excess water. The field is otherwise enclosed on all sides by a low bund. In terrace agriculture the outlet of the upper terrace serves as the inlet of the lower terrace. In this way water is provided to all fields. The source of the water in this system is the river Kele. As it comes out of the forest, channels divert its flow towards fields. Large boulders, trunks of trees are used to divert water.

In Nagaland a comprehensive water supply system in which needs of forest, cultivation, cattle are considered, has evolved. It is known as "Zabo". Forest is the catchment of water for this system & is protected. Below it

are excavated ponds to store water. Before water is released in ponds, it is first taken to a cistern for settling the silt. Below ponds are arrangements to water cattle. The dung & urine of cattle are disposed off by transporting them through bamboo pipes. The system appears to be eco-friendly.

Spring water is brought to villages for drinking through bamboo pipes. The system is still working well in Kikruma ^{Kikruma} village.

Bamboo drip irrigation is the speciality of Khasi & Jaintia communities. This 200-year old custom is still prevalent. This works on the principle of gravity. A variety of pipes are made from bamboo to take water from mountain springs to pepper & beetle cultivation. The input of water into bamboo pipe is 18 to 20 litre per minute & it travels without seepage several metres to reach the fields at the rate of 20 to 80 drops per minute.

Rain-water falling on the roofs of houses is collected & transported to a cistern in Mizoram. The cistern may also be built underground. As the average rainfall in Mizoram exceeds 2500 per year, there is scope for various water harvesting systems.

The Ganga Flood Plain Area Punjab - This is a densely populated region. The density is due to excellent water availability. Canals were constructed to divert river water to cultivation. The uplands between the rivers were provided irrigation by lifting water from the wells. Flood waters were utilised for irrigation in certain lands. Shallow wells were dug near the water channel of the rivers to store flood water & then used throughout the year to irrigate fields. Such wells were called "Zalas." In 1883 Sirhind canal was constructed in Malwa region. It had many distributaries to distribute irrigation water.

In addition, every village had a village fund. Water was transported from the pond to a well or a listern & then distributed from it to agricultural fields.

Haryana - It is a flat region. To the north lie Siwalik hills. Wells was the main source of water supply. Rohtak Canal was built in 1643. It supplied water till 1760, i.e. almost 120 years. It was repaired in 1821. In 1831 it was extended to Rohtak. In 1870 it was rebuilt & from then onwards was known as the West Yamuna Canal.

In the region watered by the Ghaggar & its tributary streams, an irrigation system called "Abi" was prevalent. Wells were dug up on the banks of the rivers. They were deeper than the river channel. They were supplied with ventilators to circulate the air. A diversion channel brought water to the well. In winter this channel was closed by a temporary bund. But as the river channels became deep, this system went out of use.

A part of Sanghar district is always flooded by the waters of Ghaggar and Choa rivers. A different system is used here to provide water for agriculture. In October and November flood waters are completely absorbed by the soil and they gradually become dry. They are then ploughed & wheat & pulses cultivated. They ripen even if there are no rains subsequently. They grow on soil moisture. If flood waters are retained at a shallower depth (< 30 cms.) rice is cultivated.

Before the dam was constructed on the Ghaggar, it was provided with mud embankments on both of its banks in Sissa district. This prevented the spread of flood waters into nearby fields. Whenever water was necessary, a hole was made

into the banks to let water in. Building of the dam made this system obsolete.

Delhi — The town of Delhi kept on shifting throughout its history. Mehrauli was 18 km from the Yamuna. As the site was higher, building of a canal was not possible. The Sultan of Delhi in those days (1210 to 1236 A.D.) constructed two large storages measuring 200 m. X 125 m. Rain water was collected in it. Channels distributed this water.

Later the catchment area of these two storages was encroached & water could not be stored into them. The sultans also constructed many wells with steps leading down to the water. They were called "Baradi." Some of them are still in use. For example, Gandhak Ki Baradi. Some of them are now dry. But their construction is still in good shape.

Allauddin Khilji built a large ~~storage~~ reservoir ^{at Siri} measuring 600 X 600 metres to store water running down from ^{the} Aravalli mountain. As population increased in Mehrauli & Siri, Mohammad Tughlaq shifted the capital at Tughlaqabad. The fort at this place contains ruins of three big Baradis & innumerable wells. The stream to its east was bounded & a diversion channel from the bank led

water into Naulakhi nullah & brought it to Tughlaqabad. The same nullah now carries water to the sewage of Delhi.

The present Delhi was founded by Shahjehan. He brought the Yamuna water to the capital. Seven flour mills worked on this water. The canal brought water to wells as well as the Dighi.

~~The~~ Dighi was a well with a round or rectangular mouth which could be capped. Steps were available to descend in it. Water from these was used only for drinking. These Dighis were available in many houses.

In countryside around Delhi wells, canals & bunds were the sources of irrigation. According to Delhi Gazetteer 57% of agriculture was irrigated. Water streaming down the hills was impounded with a bund which had spillways for excess water to flow on. The reservoir water was used for irrigation in the post-monsoon period. This system was quite widespread. Records of a number of bunds & the lands they irrigated could be found. Canals ~~which~~ could not provide flood waters to ^{some} lands where Jowar & Bajra were cultivated as rained crops. Rabi crops were taken whenever canal water was available.

Wells provided important services. They had three types of water quality. In some the water was potable, in others it was brackish or saline. Brackish water was used in agriculture to produce good crops.

Uttar Pradesh - The land watered by the Ganga Yamuna river system. Except the middle portion, all parts were served by canal irrigation. A number of wells provided water to Avadh, Kanpur, Jatehpur & Allahabad. The water table was quite high due to the perennially flowing Ganga. A number of tanks were built in the flat region of U.P. The water supply to them came from a well constructed within the tank. It had high walls & 2-3 openings to send water into the tank. Tanks supplied water for irrigation. There's natural wetlands, streams & brooks were also important sources of water. They were diverted by bunds & channels at many places to provide water for cultivation.

Bihar: The Ganga enters Bihar from the west & flows east. Tributaries such as the Ghagra, Gandak & Kosi join the Ganga. The Kosi is a river of sorrow in Bihar. Bihar itself is divided into three parts: the northern plain, the southern plain & the uplands. Rivers originating on the Chhota Nagpur plateau

Such as the Shon, the Pun Pun, the Morhar, the Mohani & the Gumari meet the Ganga from the south.

The southern plain of Bihar is deficient in subsoil water. Wells do not become sustainable. The southern plain slopes down towards the north. In this situation the traditional systems of 'Ahar & Pine' was widespread. It was prevalent since the time of the Tortakas. This irrigation system finds a reference in Mega the travels of Megasthenes. In south Bihar the ground slopes at the rate of 1 mm. per metre. Taking advantage of this slope, a metre-high bund was put in place. On its sides were built 2 more bunds in the direction of the high ground. This made for an impoundment-closed on 3 sides. The ground within the rectangular space was not excavated & was called 'Ahar'. The side bunds may reach a length of over a kilometre each. This impoundment irrigated about 400 ha. of land. Their sizes varied. This impounded water could be used throughout the year. The rivers could flow only during the monsoon. This system provided water during the dry period.

shallow rivers with sandy basins were treated in the system which was known as the "Pine". Pine means shallow canals or distributaries. The canal was of the length of 20 to 30 kms with a number of distributaries providing water to about 100 villages. To carry water from Ahar also Pines or canals were constructed. This Ahar-Pine system was useful in areas of low rainfall. It was simple, easy to work & effective.

This water was used to grow rice even in winter. In years of drought rice was grown in the Ahar basin itself. Ahar basin was also used sometime to grow rabbi crops for this system to work well co-operation of all farmers & their co-ordinated working was essential. To achieve this each task in agriculture was assigned 14 days & this limit was well enforced.

A dam built in Bihar near Khatipur in 1877 was also important. It provided water to 729 ha. Bunds constructed on mountain streams were known as "Dhar Bundh". In addition a number of canals were built by the states & even by private landlords. In Champaran district the Tiar canal was 11 kms long & irrigated 2629 ha. It was taken over by the government in

1886. Dhaka & Triveni canals of this region provided irrigation to 51,619 ha.

West Bengal

The Ganga flood plain occupies a large part of Bengal. It also includes delta regions of Damodar, Barak, Ajay, Ghaghara, Bhagirathi, Vidyadhar & Atharvanka. A large area is also marshland due to this. The land is evenly flat and without any undulations.

From ancient times flood waters were utilised for irrigation in an ingenious way. When rivers were flooded during the monsoon, water was diverted to fields through channels. Flood water would then enter canals & taken to different fields through distributaries. When floods receded water was not allowed to flow back into river basin but was retained into canals. This water was then used for post-monsoon crops. This system had many advantages: 1) Flood control 2) Floods brought sediment & biomass into fields which increased their fertility. 3) Rain water mixed with brackish flood water provided lot of nutrients to crops. 4) Flood waters brought ~~an~~ abundant supply of fish eggs which when deposited in fields & produced fish stocks later.

Rice & fish both were produced in the fields. 5) Monsoon showers saturated fields with water in early monsoon. When additional flood water entered fields, marshy conditions was the result which bred mosquitoes. But the growing fish fed on mosquito eggs & larvae & prevented spread of malaria and other diseases. The system of canals and distributaries for irrigation was thus an ideal one for the landscape of Bengal.

These canals ran parallel to each other. They were spaced at regular intervals & this distance was well-maintained. This system irrigated 7 million acres of land. It was destroyed after the battle of Plassey and with the establishment of British rule.

The Thar Desert

The area of Thar desert within Indian limits is 27.8 million hectares. It is bounded to east by the Aravalli range, to the west by the Indus plain, to the south by the Rann of Kutch and to the north by the fertile plains of Haryana & Punjab. The rainfall averages 500 mm. per annum & storms carrying dust and sand are common. Yet this region has a good diversity of vegetation. There are 700

species of plants including 107^{of} grasses. Also some of the domestic animals have excellent breeds here. The plants are famous for their nutrients, minerals & medicinal value.

If, in a particular year, rainfall is good, a number of crops can be grown & grass becomes available in plenty. This is stored for later use. Rain water is also stored in ponds and in underground cisterns.

The river Luni in Rajasthan flows from Ajmer to the Kutch through the Thar desert. A number of villages are located on its banks. It flows whenever there is good rainfall.

The states of Jaisalmer, Bikaner, Jodhpur though situated in the desert, were quite prosperous. This was because water was very well harvested & distributed through traditional systems and deep wells. Some of the wells were over 150 metres deep. They provided water for drinking.

At Jodhpur cultivation became possible in the flood plain of the Luni whenever there was water in it. Otherwise water melons was the usual crop.

At Jodhpur two large reservoirs were made by impounding the Luni & the Kishu rivers. They were named as Jawantsagar

and Sardarsamand respectively. In addition there were 35 small tanks ^{where} in ~~which~~ wheat was cultivated in their basins. Agricultural fields were banded also to impound water during the rainy months. Crops were cultivated on this water after the rainy season. It was nurtured on soil moisture even though there was no rain.

A number of tanks were built in Jaipur -mer & Bikaner towns & even in surrounding villages. Gadisar tank near Jaipurmer had water throughout the year. The catchment area of this tank was well maintained to retain good quality water in it. Grazing was prohibited in it. No one was allowed to enter the precincts of the tank. A canal carried water to the tank from the catchment area. Before it went into the tank it was filtered so that sediment, sand and suspended solids did not go into the tank. Similar devices were used in other tanks to maintain the water quality. Thick vegetation was maintained around Kolayat, Gangasarovar, Gajner etc. This prevented evaporation & even with scarcity of rainfall a number of villages, towns could be serviced on the basis of these systems.

An excellent system served Jodhpur city.

Water flowing down the central hill was channelled into a canal which carried it to Ravisar tank. From here it was led to Padamsar tank & through gravity percolated to five wells in settlements at the foot of the hill. A number of old wells & tanks were maintained in good condition for centuries.

In addition Toba & Kund were the other efficient systems prevalent in west Rajasthan. Toba provided both pastures and water to domestic animals whose numbers were very high in Rajasthan. In natural watersheds water was stored in depressions where animals could quench their thirst. The stored water could also increase the moisture holding capacity of surrounding soil & led to grass growth useful to animals.

Kund was a system to provide drinking water. The Kunds were ~~of~~ 1 to $1\frac{1}{2}$ metre diameter holes in the ground & were 20-25 feet deep. They were covered by a dome-like roof made of wood or earth. They were filled by water led to them from roofs where rain-water was harvested. This water was then used the whole year.

In the Gujarat wells were built of enormous sizes. They were deep & large

stairs, steps were built to go into them. They were used for both harnessing & distribution of rain water. In addition another system called Virda was prevalent. This was developed by the nomadic Maladhari tribe. In the basin of a river or a stream, a trench was dug which was called Virda. This was used only for drinking water.

East Rajasthan & Madhya Pradesh was a plateau area. The annual rainfall was 350 to 450 mm. The mean altitude of this region is 500 to 600 metres & the ground slopes towards the Gangetic plain. The supply of water in this region was mainly through wells. The basins of rivers are deep & the region being full of hills, canal construction was difficult. But hills provided excellent sites for building dams & bunds across streams & resulted in water storages.

In MP a novel method of cultivation is still practised around Jabalpur. The field is enclosed on all four sides by a 1-metre high walls to store water. Water is stored in the field till the time of sowing. As soon as the surface dries up, seeds are sown. No watering was necessary after this. The local name of this system is Haveli. In this system no water is retained in the

field for a considerable time, weeds are destroyed & do not compete with the crop.

If rains are good, the fields become saturated by August. Water is retained till October. If, at the time of sowing, water is still inside, it is slowly released through a cut in the wall. This prevents soil being washed away. Then sowing is done according to soil quality.

In MP a novel system of storing water was prevalent on the hill of Sanchi. The water falling on the hill was stored in a reservoir built below the slopes. This reservoir used to provide 2.27 million litres. In Jabua district streams coming down the hills were diverted & channelled to bring water even to fields which were at a higher altitude.

Maharashtra - Andhra Pradesh - Karnataka
(The Deccan Plateau).

In these regions also wells & canals provided irrigation since ancient times. Streams were banded temporarily or permanently to store and divert water. This technology was well-developed. These bands were either made up of stones/boulders, of earth or of piles of cement bags.

At some places wells were dug up at some distance from the river basin. They were connected to the river by an underground pipe line. Wells were also inter connected with pipes to maintain water level.

In Nasik, Dhule & Khandesh Phad System was prevalent. This was managed by all stakeholders. A number of bunds were built to provide irrigation ^{from} fields at upper reaches of the stream to fields lower down, all could get water through this system according to the agreed plan.

On the sea coast, in Goa & Konkan, the delta regions of streams & estuaries where sweet & salt water could mix, rice cultivation & fishing were blended to earn a sizeable income. This system was eco-friendly & sustainable. The perfect example is provided by Khajana type of cultivation.

Thus all over India, ^{several} systems to store water, recharge ground water & distribute water to distant areas were prevalent & operative till recent times. They are still working at some places. Then the question is these excellent systems were abandoned or went out of use?

The reasons are several:

1) Systems that provided for needs of villagers, which were in tune with geography and co-ordinated private & public purposes were destroyed by British rulers. They nationalised the sources of water. They also destroyed forests. They replant indigenous forests with commercial plantations, e.g. Sal & Teak ones. This disturbed food chains. Loss of forests destroyed water sources.

2) The water systems like they for public purpose or for cultivation, were managed by rural people & hence ^{worked} well. Water sources were owned by villages. After independence they were taken over by the government & rights of villages were not taken into account. The villagers showed little interest in their operation. People began to believe that management of ponds, canals & wells is the duty of the government. The old systems were neglected.

3) When a water system is evolved, it has to be improved as time passes. But pressures such as increasing populations, new agricultural techniques & other new demands & improvements in agriculture made the traditional systems obsolete & people lost interest in them.

4) The concept of agriculture changed as industrialisation, urbanisation & modernism came to be emphasized after Independence. ~~With increasing population, agriculture had to change in methods and parameters. But its potentialities could not be increased, new technologies were not properly utilised while traditional systems came to be neglected.~~ →

5) ~~Industries were concentrated in cities. People from villages migrated to cities in search of jobs. Agriculture was a part of Indian life-style. It was increasingly commercialised, with large-scale monocultures for which traditional water harnessing and distribution systems proved inadequate.~~

6) Industries were concentrated in cities. People from villages migrated to cities in search of jobs. To meet the needs of ever-expanding cities, to feed industries with water & power, large dams were built. This resulted in the destruction of stream and river eco-systems & systems dependent on their flows were destroyed. Benefits of dams & canals went to cities and people living away from impounded streams & rivers. On the other hand local people were displaced & migrated to cities and lost interest in maintaining local systems.

7) With green revolution, intensive farming of cash crops, foreign crops like Soyabean were emphasized. The small farmer was neglected & was further deprived of credit, marketing and inputs like water and power. The maintenance of local systems was replaced by costly canal water.

8) The government by its policy indicated that people would be spoon-fed. They became less & less interested in working for the village and standing on their own feet. This resulted in destruction of old devices such as Kunds, wells, rivers, canals, cisterns & bunds which villagers had constructed.

9) Catchment areas of several villages were encroached upon by industries, settlements etc. & destroyed natural storages of water.

10) Small farmers were forced to work as labourers elsewhere which increased the rate of removal of vegetation. Grasslands & forests were encroached upon resulting in drying up of

Springs & streams. Systems dependent on them collapsed
also

- 10) Water distribution system was imposed by the government. Formerly the cost of maintenance of systems was met largely by leading families of the village. This was now unnecessary resulting in neglect of traditional systems.
- 11) The city-dwellers received their water supply from large tanks. They became disinterested in natural sources of water like rivers and streams. The artificial life made possible by technology made a large section of the society uninterested in nature and traditions based on use of natural resources.

POPULATION CHANGE AND WILD LIFE : Prakash Gole.

India's population has now crossed the 800 million mark and is still growing exponentially. Before considering how this change affects wildlife and nature, let us take stock of the situation of the natural heritage that has come down to us over the millenia.

In the realm of plants about 15000 species of angiosperms and an equal or more number of species of gymnosperms and lower plants are to be found in India. We have almost double the number of known insects, some of them extremely colourful and about 1200 species of birds. There are about 150 mammals and marine animals besides a number of reptiles and amphibians. The exact number of invertebrates, molluscs and crustaceans is difficult to ascertain.

Human population influences these in two ways:

1. directly through hunting, killing, trapping, snaring, felling & otherwise exterminating them and
2. indirectly by interfering with their habitats.

Traditionally some of our tribes specialized in capturing, snaring and killing particular species of birds, animals, reptiles etc. The technique was primitive and this division of labour in a way maintained a balance and did not lead to complete extermination of any species. Under the guise of sport large-scale hunting of mammals, birds, reptiles and marine creatures was prevalent during British times. Serious population decline of wildlife began with British rule. Yet no large mammal became extinct except the Cheetah which was last reported in the thirties. Among birds the Pinkheaded duck and the Mountain quail could not be found.

Several mammal species however, became endangered. These are: Primates such as apes, lemurs, and macaques; Cats such as snow

leopard, clouded leopard, Asiatic lion and some lesser cats; the wolf; brown bear and red panda; the ratel; the painted bat; flying and giant squirrels; the elephant; the rhino; the wild ass; the yak; the high altitude sheep, goats and goat-antelopes; the Tibetan gazelle; deer such as the Hangul, the Thamin, the Barasingha and the Musk and the Hog deer; the river dolphin, dugong and the whales.

About 500 species of angiosperms, 200 species of birds and more than 50 species of reptiles and amphibians are believed to be endangered.

After the end of British rule strict protection has led to the revival in numbers of species such as Tiger and Blackbuck among mammals; Great Indian Bustard among birds and Estuarine crocodile among reptiles. Now hunting and killing are no major threats though trapping/snaring smaller animals and birds still is. The greatest threat due to the exploding human population & its multifarious activities is the destruction of wild life habitat. Main pressures on different habitats are as follows:

Habitat	Pressures
Alpine meadows	Grazing & trampling by domestic animals
Coniferous woods	Felling, road building, labour settlements
Broadleaved forest	Human settlement, felling, road building, shifting cultivation, social forestry
Tropical evergreen and semi-evergreen forest	All above factors plus permanent cultivation and collection of rare plants, insects
Rivers & riverine habitats	Dams, lift irrigation, fouling by domestic & industrial waste and effluents, encroachment by agriculture & industry.

Habitat	Pressures
Grassland & scrub	Grazing, spread of agriculture, water-logging, fouling by human settlements & industry, social forestry
Barren waste & stony upland	Grazing, spread of agriculture, water-logging, fouling by industrial waste
Hills and plateaus	Grazing, cutting and felling, shifting cultivation, human settlement
Moist deciduous & dry deciduous forests	Grazing, cutting & felling, social forestry, spread of agriculture & industry, dams and reservoir spread.
Brooks & streams	Dams & barrages and fouling by human and industrial waste
Tidal estuaries & lagoons	Over-fishing, dredging for sand, fouling by human and industrial waste and defence activities
Open sea	Over-fishing, fouling by shipping waste & oil spills, drilling for oil, effluents of atomic energy installations and defence activities
Open sky	Fouling by industrial emissions, obstacles due to tall pylons, skyscrapers, towers, overhead cables, commercial & defence air traffic near airports & weapons tests
Desert	Canals, spread of agriculture, grazing, human settlement, boring for deep water, scientific collection of rare flora and fauna, defence tests, water-logging and salinity.

Though some of the pressures are the result of normal human survival activities, it must be remembered that they seriously affect and destroy wildlife habitat if carried out on an enormous scale and indiscriminately.

These pressures have decimated populations of wildlife a great deal though certain species have benefited due to their close association with man. (These include urban animals and birds, rodents, scavengers etc.) Some have resisted pressures by preying upon man's associates (domestic animals) or adapting to the changed situation.

No documentation or detailed study however, of the effects of human population explosion on particular life forms exists.

Recently I had an opportunity to study the status of a large bird who traditionally lives in close proximity to human beings. This bird is Sarus Crane, the tallest flying bird in the world. The bird used to be found at the beginning of this century, from Sind to the Burma border and from the foothills of the Himalaya to north Maharashtra. Now however, I found its range much reduced. It is now resident mainly in 4 states: Haryana, UP, Rajasthan and Gujerath. There are peripheral populations in MP and Maharashtra & an occasional pair or two in some pockets in Himachal Pradesh. In the last 20 years it has ceased to be resident in Punjab and Bihar. Over much of its present range Sarus receives protection on account of religious sentiments. Wherever it is not so protected, for example in tribal belts and Assam & other eastern states, it has ceased to exist.

I examined the character of districts in which Sarus crane is still found ⁱⁿ significant numbers. If suitable habitat remains Sarus can live even in highly industrialized areas. This is so in Gurgaon, Sonipat, Kota, Kheda and Vadodara districts. Canal seepage areas, large wetlands, irrigated agriculture and favourable ethos of human population allow Sarus to live amongst human populations. But Kota, Kheda and Vadodara though highly industrialised, show very little increase in urbanisation and human density of population. In UP loss of suitable habitat has forced Sarus to retreat to the so-called backward districts in the state. These districts again, show very little increase ⁱⁿ urbanisation and population density. Traditionally Sarus was never far from agriculture. But where agriculture is highly mechanised, where use of inorganic fertilizers and insecticides is high, Sarus has disappeared e.g. from Punjab and some districts of Haryana and UP. Sarus is now found in areas

where agriculture is of low intensity and not sufficiently modernized; where yields are low due probably to low consumption of fertilizers and where due to salt-affected and water-logged conditions, no large-scale investment in agriculture is made and where agriculture may be more or less practised as subsistence farming.

It may be presumed the growth in human population and human activities have similarly affected many other life forms and outside protected areas and sanctuaries wild life forms are increasingly becoming scarcer and scarcer.

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RIVER IMPROVEMENT?.....FOR WHOM?

Pune's natural assets include the hills surrounding the city on 3 sides and the river basin of the two rivers that flow through it and have their confluence right in its centre. Unfortunately the growth of the city has meant deterioration and not enhancement in the quality of these assets. Carelessness, faulty planning and greed are responsible for this deterioration.

A river is aptly called a life line. From its source in the mountains to its mouth at the sea, a river provides sustenance to a number of life forms including not only those living on its banks but also those who take advantage of its water cycle and transportation facilities (MAINLY NON-HUMANS). Ideally for planning purposes the whole course of the river should be treated as a single unit. The natural functions the river and streams perform and the interaction these have with the surrounding landscape should form the basis of such planning. In India the usual practice is to consider only the total availability of water in a river basin. But the efficiency of the sources of water, its surface and underground distribution, its relation with the water table, the flow of nutrients and minerals during wet and dry seasons, the ability of the surrounding landscape to modulate the daily and seasonal energy pulse and thermal efficiency, the functions of the floodplain and hyporheic zone are not considered at all. The result is a water management system that attaches great importance to storages, less to distribution of stored water and utterly neglects all the other functions of a natural river system.

In Pune we inherit a river system that exhibits all the benefits and disadvantages of the present skewed water management set up. The growth of the city is directly related to the water made available by the storages upstream : Khadakwasla and Panshet. The latter indirectly encouraged shifting cultivation and deforestation of the catchment area (see M. Gadgil's articles and Ecological Society's report on the Panshet catchment). The streams in the catchment dried up, slopes were denuded and the flow and temperature regimes in the channel suffered reversal and imbalance.

It is this water laden with sediment, low in oxygen content and warmth and as it neared the city, increasingly contaminated by non-point source pollution (see Birds of a Polluted River by P. Gole in the Journal of Bombay Natural History Society Vol.81, (3), Dec. 1984) that enters the city limits today. The unplanned growth of the city has led to more or less complete collapse of its old sewerage system. The city therefore, adds to the river its load of human excreta and waste, together with detergents, oils and grease, industrial effluents and toxic chemicals. The result is very high BOD, COD and MPN count. Aquatic life forms in the river have undergone a drastic change as a consequence and those useful to human beings have mostly disappeared. In the

fifties over 400 plants were recorded in the river basin. By 1982 less than 200 remained and this number and their quality must have further deteriorated today.

Unfortunately PMC's river improvement plan is not going to reverse this trend.

Engineering measures such as channelization of streams are increasingly being abandoned in developed countries today. They are being replaced by biological measures and soft engineering approaches. They aim to restore the natural functions of the river by optimizing flows and floods, keeping the course zigzag(meanders), ensuring buffer zones with their characteristic riverine vegetation and filters, creating wetlands to reduce the velocity and force of floods, allowing room for floodplain discharge of sediments and maintaining a variety of habitats along the river course for the return of fish and other aquatic life. Nothing of this sort is being attempted in Pune's rivers today.

On the other hand channelization will destroy whatever natural filters that remain in the basin today leading to greater concentration of suspended sediment and toxicants in the flow. Danger that the channel will be silted up soon is very real. Roads planned on both sides of the channel will further reduce the area of open spaces in the city, lead to higher discharge of particulate matter in the river water and whatever flood plain that remains today will get choked up and die.

The west and east flowing rivercourse of the city is an important corridor through which westerlies flow and reduce the temperature of this heat island. Once this corridor is transformed into a highway, the cool breeze from the west will get quickly warmed by the automobile exhausts and this contaminated air will be circulated through the city.

The river is still used by Pune's citizens for a number of purposes. In fact they are perforce compelled to use the dirty water as they have no other choice. Even hospital linen is washed in this water. In 1982 in the riverfront improvement plan prepared by the Ecological Society and submitted to PMC, all these uses were considered, regulated and streamlined by providing definite space for each of them. The PMC in its present plan makes no such effort. The citizens therefore, will continue to use the river-front for these purposes and this may make a mockery of improvement measures.

The improvement measures planned by PMC for the river therefore, will not only lead to further degradation of Pune's natural heritage but will also prove lethal to areas downstream.

The PMC plan it seems will benefit the vehicle owners, contractors and builders without caring a damn for the citizens. This is business as usual. Is it not?

प्रकाश वि. गोळे
संचालक
इकोलॉजिकल सोसायटी
पाषाण रस्ता
पुणे ४११००८

दि. ३० एप्रिल १९९८

श्री. माधवराव चितळे
अध्यक्ष, सिंचन आयोग
महाराष्ट्र शासन
वाल्मी, औरंगाबाद

माननीय महोदय,

औरंगाबाद येथे नुकत्याच पार पडलेल्या 'सरोवरांची गुणवत्ता' या कार्यशाळेत भाग घेण्याची संधी दिल्याबद्दल मी आपला आभारी आहे. मात्र वेळेच्या अभावी मला अभिप्रेत असलेले सर्व मुद्दे मांडणे मला शक्य झाले नाही. ते मांडण्याचा प्रयत्न सोबतच्या छोट्या लेखात केलेला आहे.

या संबंधात तपशीलाची जरूर लागल्यास मी तो आनंदाने पुरवू शकेन. तसेच जे काही प्रयोग पुण्याजवळच्या काही धरण योजनांवर मी सिंचन विभागाच्या सहकार्याने करून पाहिले आहेत, त्यांस आयोगास भेट द्यावयाची असल्यास अथवा त्याबद्दल माहितीची जरूरी लागल्यास कृपया मला कळवावे.

कळावे, लोभ असावा.

आपला

प्रकाश गोळे

Restoration of Degraded Eco-systems

Over huge areas technical progress has so disturbed eco-system processes and structures, that land cannot be used productively without improvement. The devastation includes mine & quarry sites, derelict industrial land, saline and/or waterlogged agricultural land, overgrazed lands & lands that are victims of severe erosion due to removal of vegetation. The result is earth's capacity to produce renewable resources is severely damaged while demand for such resources is increasing.

The discipline of restoration ecology aims to provide a scientifically sound basis for the reconstruction and function of damaged or destroyed eco-systems, and produce self-supporting systems, which are resilient to subsequent damage. But in many cases we do not know how to create a particular assemblage of species or that the time needed to achieve the desired result is far too long. To restore an eco-system to a particular condition in the past, is not possible many times.

The dictionary meaning of restoration is the act of restoring to a former

State or position, or to an ^{un-}impaired or perfect condition, or to bring back to original state, or to a healthy or vigorous state. Rehabilitation is the action of restoring a thing to a previous condition or status. But something that is rehabilitated is not expected to be in the original healthy state. It is only an improvement from a degraded state.

Remediation is the act of remedying. A process of improvement.

Reclamation is to bring back to a particular state e.g. the making of land fit for cultivation.

Replacement is to provide a substitute. Enhancement is the establishment of an alternative eco-system. It is to increase in value, importance or attractiveness.

Mitigation is to appease or to moderate. It may involve the improvement of quite another eco-system.

When the restoration of eco-systems is referred to, we are particularly interested in the restoration of the fundamental processes by which eco-systems work. We can talk of restoration

of habitats, of communities or species or of quality. Our intention should always be to focus on the restoration of functions, of processes, of biological potential, i.e. the whole eco-systems.

In many cases restoration may be unrealistic, expensive or may take too much time. In such cases rehabilitation, replacement or reclamation to a particular usage may be an option. It may also include renewing and maintaining eco-system health.

How we think of eco-systems affects restoration. Are eco-systems strictly biogeochemical processing or productivity factories, or do they include a site or collection of species? What role does history play in the current-state of the system? An idealized view of nature makes it difficult to understand that natural communities are constantly changing and that a number of internal and external processes maintain these systems. Because of change, transformation & interactions, a time dimension is a necessary part of an eco-system.

Eco-systems are many times open, are regulated by external

processes and are subject to natural disturbances, like fires & flood. Restoring or managing vegetation in a human-modified context, requires active and ongoing intervention.

Although the interactions among species or of species with their physical environment, can be generalized, the specific dynamics of any system after initiating restoration, depends on its history, accidental arrival or extinction of species, current processes acting on the site and the site's place in the landscape. There is no one ideal state of reference for any type of community or eco-system.

Processes arising outside the eco-system can regulate the system as much as can internal processes. The need for restoration ecology is to develop models that combine general principles with unique site conditions.

Importance of Soil Ecology

In degraded eco-systems, it is the loss vegetation is that is the most obvious & significant event. If only original vegetation is removed, fugitive species will colonize, once the disturbance is removed. These species have a high

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Highly degraded areas may represent an actual cost in terms of damage to health and the need for measures to protect the public against effects such as pollution.

Although a full valuation may present a realistic assessment of the social benefits of ecological restoration, it does not necessarily represent the benefit to those who must pay for the work.

The environmental benefits of restoration take time to realize & may accrue only in future. Future benefits are discounted in value. The discounting rate will be the prevailing rate of interest. There are social reasons to choose a lower rate of discount considering the interests of future generations.

Minimum Area

For realizing benefits a certain minimum area is needed. To achieve a reduction of suspended solids in rivers a ratio of wetlands to total drainage area of 1:20 was desirable. Total biodiversity in intensive agriculture increases significantly as we increase the numbers of species-rich strips of vegetation. Many birds & mammals use a variety of habitats, so a larger area is necessary.

We still have a very imperfect knowledge of the importance of a particular species in an eco-system. The existence of certain

Species for eco-system stability may be difficult to find out. Therefore, precautionary principle suggests that the full value is greater than that estimated by summing the known benefits.

Criteria for Restoration Targets and Performance Monitoring

A holistic approach sets forth the following:

- 1) Functional equivalency of habitats & of organism components (plants, animals, microbes)
- 2) Structural equivalency of habitats & of organism components: a full representation of trophic groupings (bottom & mid-feeders); a proper balance between native & exotic species; and an appropriate distribution of, and connectivity between, habitat elements.
- 3) Elemental equivalency of habitats and of organism components reflected in such indices as biodiversity or a self-sustaining convergence of a species composition.

The communication of complex science to executive non-specialists and to interested lay people poses a particular challenge to which ecologists have not always sought to respond positively. By relating eco-system to habitat, and habitat to the driving level of variables such as hydrology & geomorphology, restoration ecology makes a further major

contribution to establishing sustainable outcomes.

It need not be the case that investment in restoration should always be directed to the "worst" state. Engineering a new habitat may seem inherently more attractive to many people than making social or economic sacrifices to reduce disturbing impacts. In some cases removal of disturbing stress may trigger natural restoration.

Restoration ecologists should be well aware of the value system of the society which they serve & that the society is well-informed on the expert product of ecological research. Restoration ecologists need to explain the consequences of their work. There may be restrictions in access, and the initial appearance may be unattractive, giving rise to a perception that money is being wasted.

Refer to : European Ecological Federation
European Federation of Environmental Professionals.

Message :-

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Slo - Kedar Gogate had called up. He wanted to talk to Madam. He will be ringing later on.

Kakhi

Meeta Kapoor

PC 1 - 11 & Division

Central Pollution Control Board

Prakash Bhatnagar - East Arjun Nagar

Delhi - 32

European Ecological

Federation of India

European Federation of

Env. Professionals

Restoration of Degraded Ecosystems

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growth rate. Subsequent colonization may come from small areas where the species of original vegetation exist. If the soil remains, recovery may be quick and easy.

But in many cases, soil is gone and what remains is a skeletal material, composed of raw mineral fragments & particles, sand and rock. Clay minerals, finer rock particles, organic matter with nutrients are absent. There is complete absence of propagules, physical hostility and lack of resources impeding immigration of species.

Bringing soil from outside is always expensive, damaging to other sites and may not have characteristics of the original soil. Excellent plant growth can be achieved by a rooting medium that provides nothing but water and soluble plant nutrients.

As natural immigration is very slow, proper species, preferably, nitrogen-fixing ones, have to be introduced. Compaction has to be removed to allow root penetration. Spreading an inert-mulch is also important. Erosion control can be achieved by "nurse species"

which are commonly cereals, such as Sorghum or wheat. Finer material of excavation, tunnelling can also be used. Absence of phosphorus may affect plant growth. In such a situation, sewage sludge may be used as it contains high levels of phosphorus. A digested sewage sludge can also provide nitrogen.

Acidity can be modified by application of lime and introduction of acid-tolerant species. Contaminated material from mines needs to be covered with uncontaminated waste material from other sites.

Because of the original site conditions, the species to be favoured can only be those adapted to those basic conditions. Eventually natural successional processes, even with minimum intervention, are likely to lead to changes in soil conditions which may ultimately cause the replacement of the desired species by others. Analysis and experimentation over several years are important.

Soil Micro-organisms

Concomitant with ecosystem degradation is generalized damage of

the soil microbiota. This disturbs nutrient cycling. Mycorrhizal fungi represent an integral part of the soil microbiota. Arbuscular, ectomycorrhiza, mycorrhiza of the Ericales & orchidaceous mycorrhiza are the major types. Dark-septate fungi also colonize a wide range of plants. They may lead to a significant increase in dry weight or/and shoot phosphorus content of host plants.

Microbial biomass decreases with increasing soil moisture stress. Mycorrhizal fungal hyphae create a physical connection between the root surface and soil particles and increase the water and nutrient-absorbing surface area of the root system. Mycorrhizal association affects plant succession. These fungi may prevent stagnation of community development. If during excavation surface soil can be stored, it may facilitate survival of beneficial micro-organisms. Storing should be properly done in dry & wet climates. Its duration should be short and not too deep piles should be made.

Safe Sites

Safe site is an environment immediately surrounding a seed which is

favourable to germination & establishment -
It protects propagules from hazards specific
to a site, such as dry conditions, grazing etc.
They are the targets towards which propa-
gules are directed.

Diaspore entrapment is facilitated by
extant plants or vegetation patches in windy
& arid environments. Vertebrate & Bird
dispersed seeds are also provided shelter
here. For germination & recruitment the
safe site must have favourable micro-
climate, adequate soil structure / texture
& nutrient & water content.

Neighbouring plants may compete with
propagules, but they also enhance establish-
ment. If it is a mother plant of the
seed, it may provide favourable conditions
- canopy, litter supply etc. Juveniles of
the same species, established outside a
dense cluster, may protect the inner
ones from desiccation or frost. Non con-
specific adults provide protection and
favourable conditions in edaphic terms.

Development of established perennial
plants often leads to the appearance of
secondary safe sites resulting from self-
thinning. Data on topsoil / seed bank
status are important. A reference system
nearby facilitates selection of sites.

Distance to remnant-natural habitats or earlier restored areas which represent-diaspore sources is of primary importance. Indigenous plants, especially legumes, are important. Safety islands include pre-grown transplants representing an appropriate mixture of species & life forms - saplings, young shrubs, grasses, legumes, seeds. Introduction of grown plants may be necessary. They should provide a favourable micro-climate.

Transplants may be brought in containers, with some supply of nutrient-rich garden soil. They are planted in clusters with migration corridors for propagules. Evaluation may be done every 3 years.

Plant-Animal Mutualism

Sometimes the association is an obligate mutualism; each species requires the other at a critical stage of the life history for survival. Sometimes it is facultative, causing an enhanced performance when both are present-but persistence is still possible when one partner deserts or never finds another. Both types of mutualisms can occur in a community (restored) & will affect the life of many species.

Introduction of plant-species is not enough. Pollinators have to be attracted. Some plants have generalised, open, radially symmetrical flower shapes & can attract many different insects. Some plants require queen bumble bees, some require solitary bees. Large, social bees are more ^{selective} about plants. Honey bees forage 8 km from the hive, so also bumble-bees. Future reproduction of plants is not possible if they do not get pollinators.

A large population of flowers may yield few seeds when pollinators are sparse. Restoration should avoid extremely large or small stands of single plant-species. Clusters that resemble local natural population sizes & distribution patterns seem likely to be the most effective initial plan.

Many insects are restricted to narrow portions of larger landscapes. Geometrid moths prefer the cover of woods, and only forage at the edge of fields, while noctuid moths range more broadly into the open. Seed production is better in sunnier micro-sites. Sequentially flowering species will reduce competition for pollinators. It may maximise seed set among plants & enhance populations of generalist pollinators in the area.

Seed disperser species include birds, bats, reptiles, ants & even fish. Each animal has its own foraging & dispersal behaviour. We can introduce plants that seed quickly. These seeds can be removed & deposited. Unwanted exotic species have to be removed. Wind can also be a disperser. Bird nests & perches increase chances of deposition. Seeds are often dispersed again by small rodents who tear through animal droppings for seeds or find wind-dispersed seeds, and cache them elsewhere.

Ant foragers, important for many woodland species, would come into the habitat only later, when soil conditions had developed a structure more amenable for ant-nests. Many frugivorous birds prefer openings & disturbed microhabitats at the edges of woodlands to hunt for fruit.

Development of Criteria for Restoration

Use of plant varieties that tolerate pollutants & toxins can be made in the beginning. Surrounding biotopes and habitats are important to see how the restoration area fitted in. Climate and geology must be suitable if we wish to restore a particular habitat, say a typical grassland. First, we might consider

linking unconnected patches. Secondly, we might consider infilling patches and altering ^{their} shape in an attempt to minimize the length of edge. We might also consider the recreation of an entire hydrological unit. Providing habitat to endangered or threatened species will be another approach. Another one is to create corridors or stepping stones. Soils of low fertility may be ideal for biotopes of conservation interest.

We may need to find out where a particular biotope formerly occurred & secondly we identify the current land-use. GIS approach may be useful. Species richness alone is inappropriate to assess patches of different sizes.

A patch containing more species typical to a biotope should be better. Long-term persistence of the patch will depend on the proximity of sources of further colonists. The extent to which patch boundaries correspond with habitat and biotope boundaries will determine species richness. Increasing patch size will help support species with large home ranges, which would not persist on smaller patches. Minimum area requirements of a species may be met by using a cluster of small patches.

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In many cases, created patches represent the early successional stages of particular biotopes. In the absence of management to maintain their condition, these patches will change, and where later successional stages surround them, they will be prone to invasions.

Those species which are essential elements in the biotope will be placed there during the restoration activity. In addition, certain other species, such as rarities or specialist indicators of the biotope, might be introduced. But many conservationists would hesitate to encourage a wide range of introductions of this type. They would however, expect critical species to establish on the new patches of biotope under their own powers of dispersal.

We could take the contour map and calculate an optimum solution by adding new patches at locations which would reduce the isolation of each square as much as possible. We could predict where to place new patches of heathland either on the basis of the biotope in general or for patches of habitat of particular species.

Species vs. Landscape Approach

In a landscape we see a population of patches distributed within the landscape

in a way which supports the interactions between them. The species-area concept leads us to a static view of the patches in the landscape & focuses our attention on the within-patch dynamics & not on the between-patch dynamics. For the most part, patches have been defined at what is effectively a human scale. It is essential to view the landscape and to delimit patches at a scale relevant to the organisms under consideration. There is interaction with other, sometimes distant, populations through the movement of populations individuals in what has become recognized as metapopulation dynamics.

We need to develop a picture of the landscape at a scale appropriate to the species under consideration. An insect will be seeking patches of its habitat & not examples of the biotope as a whole. For this group small biotope patches have to be created at the right places, but patches of habitat should be at locations which match the dynamics of individual species. To the conservationist it may be assumed that the presence of a biotope is alone sufficient to provide habitat to all species of interest, but this may not be the case.

A biotope may be a successional co-

community (grassland). Successional changes may make the patch uninhabitable for a particular species. Management to control succession is therefore, necessary. Also the amount of habitat that could be created by suitable management would be restricted by topography, soils, and hydrology. The most difficult part of the exercise is obtaining detailed knowledge of the dispersal patterns of the target species within the landscape.

We can expect small populations on patches will become extinct from time to time. Recolonization of the area will be from other populations. Looking at the landscape as a whole, the picture will remain stable & sustainable.

Ecological Engineering & Sustainable Development.

Restoration costs can be very high, vary widely and depend on factors such as the size of the site, the degree of damage, the extent of the remedial action, the availability of materials, and the technical difficulties in carrying out the project. Restoration often costs more than the potential value of the restored land.

Sometimes the conditions are very strict that the restored area meets the criteria

of species diversity and functional equivalence within a limited time period. This restricts the opportunity to take advantage of natural succession & increases the cost.

The aim of restoring mining land should not be to make land suitable for agriculture. It will be too expensive. Establishing some kind of vegetation will be cost-effective & allow uses such as nature reserve or recreation. Developing small sites may be more expensive than large ones as advantage of natural eco-processes cannot be taken. Restoring farmlands to wetland may be relatively inexpensive. Cheaper options however may take longer time as they take advantage of natural processes. Establishment of small zones which can be used by birds can be effected on waste heaps.

Croplands can be improved by relying on techniques giving low productivity. Restoration may be more feasible and acceptable where ^{value} cost of land is high. But economic argument for ecological restoration can be strengthened through a better understanding of the full value of restored areas, even if these are not reflected in the market.

The value of vegetation

Vegetation Management

The value of vegetation management should be realized in restoration. Vegetation promotes the accumulation of sediments in various ways. As the first plants manage to grow in hostile environments, they begin to reduce the windspeed so that sand and silt can settle & become trapped amongst the leaves & litter of the developing vegetation. Vegetation stabilizes the soil also through creating a cover of living and dead plant material which protects the mineral soil surface from the energy of wind & rain & prevents erosion. Finally, there is the remarkable capacity of roots and stolons of some species to bind loose sediments together.

Community of decomposers is also important. Organic materials like sugars and amino acids disappear quickly, but other products such as lignin & chitin, are decomposed much more slowly, and accumulate in a chemically altered form as humus in the soil. Many important soil properties depend on this material. In particular, the capacity of soils to retain cations is directly related to humus content, and the water-holding and drainage properties of the soil are also determined to a large extent.

by the nature of the clay-humus complex. Decomposers also play an important role in the immobilization and detoxification of pollutants. Wetlands can play a role in controlling non-point source pollution. These pollutants include phosphorus & nitrogen, metals such as copper, lead, zinc, a range of pesticides, sodium chloride, and sediment. The retentive properties of soil and sediment-particles are governed by micro-environmental redox conditions, which are controlled almost exclusively by bacterial metabolism. Microbial biomass is a major sink and nutrients are strongly retained by wetland communities as a result.

Vegetation has a major effect on routing of water. A forest canopy has a considerable capacity to intercept water & store it temporarily. The vegetation reduces the erosive force of water falling on the soil & the temporary storage of water by vegetation reduces peak flow & hence erosive effects. 2

India costs of flood damage & destruction of reservoirs & irrigation systems by sediments from misused slopes averaged \$1 billion a year & annual expenditure on preventive & compensatory measures was \$250 million between 1978 & 1985.

Mature vegetation typically has a closed nutrient cycle, in which the nutrients used by plants are regenerated almost entirely in situ. In contrast, early successional stages often have an open nutrient cycle which depends upon the input of nutrients from outside the system. The process of succession can be viewed as gradual accumulation of stocks of nutrients within the ecosystem.

The mere presence of a plant canopy increases inputs of elements owing to impaction of particles of various kinds and absorption of gases by plant surfaces. Succession can be speeded up by the planting of various fast growing leguminous species. ~~the~~

Nutrient cycling also helps in immobilizing pollutants within the ecosystem. Restoration of forest prevents unwanted substances to be washed down in water courses. Macrophytes in wetlands can also store these substances.

Attempts to reintroduce floristic diversity into intensive agriculture have considerable beneficial effects. Increased diversity of insects means reduced pest damage.

Value of Restoration has direct-extractive uses such as timber, hunting & fishing; direct non-extractive uses such as recreation & tourism; indirect uses such as flood control, erosion,

protection, pest control, removal of pollutants; optional uses relate to possible use of the resources in future & passive uses such as care of natural environment, altruism for future generations & stewardship of nature.

When the goods are not traded, replacement-cost method is used, in which products are evaluated by comparison with the market value of a traded substitute.

Actual expenditure associated with the use of the area for tourism & recreation can be a measure of value (Transportation, accommodation, equipment). Travel costs consist of the monetary costs, the time spent to get to an area, and any entry fees to use the area. Alternatively, people can be asked what monetary value they placed upon a resource such as a restored eco-system.

This shows peoples' willingness to pay for the improvement, through charges to use the new goods & services or through increased taxation. Willingness to pay also reflects the willingness to enjoy passive benefits & not only direct. Replacement costs are also a measure of value. For example restoration of sand dunes & salt marshes along sea coast may obviate expenditure to build a sea-wall. Beneficial insects may replace the cost of using pesticides.

Energy and Natural Resource Management

1. Focus on sustainability of natural resources & energy: Information on availability of resources to be generated through survey, transparent system for information sharing regarding availability of natural resources, Energy Planning based on - demand has to be within availability, Promoting sustainable energy generation, gradually shifting from non-renewable to renewable energy sources, for sustainable and renewable energy dependence on the natural, photosynthesis based energy conversion processes, promote energy plantations, using resources in most natural form – avoid conversions
2. Plan for supply of energy services: In energy planning focus on what energy services (e.g., lighting) is required, identify the most environmentally benign solution, and plan accordingly.
3. Integrated resource planning for energy and resources (e.g., Energy efficiency should be increased and demand supply management):
4. Assign carbon quota to individuals and businesses and provide incentives for consumption within quota, and penalties/taxes for over consumption: Assign energy quota: A minimum amount of

energy required for a reasonable quality of life can be accessed at a subsidized rate, any consumption more than that to be priced at the actual realistic price (inclusive of environmental cost). Similar system for all natural resources, high taxes for luxury items, high rate of interest for home loans (e.g., linked with number of homes already owned).

5. Promote decentralization of energy and natural resource generation as well as management: Local self government bodies should decide local energy and natural resource generation and management policy, local production, consumption and recycling and waste management to be promoted – plan for self sufficient villages/clusters. Resource users' association, Systematic programme for capacity building at the local level
6. Preventing misuse/non use of natural resources (e.g., keeping land fallow, uncontrolled use of water, etc.): Requisition of unused building because buildings represent 'locked' in natural resources
7. Setting up energy efficiency and resource use and management standards and certifications at all levels for products and services. (E.g., on lines of ecohousing certification). Laws for products and use of natural resources (e.g., ban on use of CFCs, etc.), recycling of resources in phased out products to be the responsibility of

manufacturers, Incentives to use of resources for environment friendly activities

8. Rights of non humans with respect to use of natural resources: acknowledging the rights, and putting in place legal measures
9. Restoration of natural resources should be incorporated in as policy: Initiating models of ecorestoration (e.g., nirmal ganga abhiyan), extension activity for beneficiaries, preparing a nationwide programme. R&D for resource management. Promote agriculture of economically important forest products: to help preserve the natural biodiversity. This is to be linked with linking farming practices with establishing ecologically sensible land use patterns and livelihoods which should be based on local ecosystems and land classes (e.g., infrastructure development not on agricultural land). Link existing schemes such as EGS with restoration activities
10. Wide spread, professionally designed publicity campaigns for promoting sustainable life style: To link 'status' with sustainability (addressing the issue of people's aspirations)
11. Environmental rating of candidates appearing for election: Environmental outlook of candidate to be used as a parameter

while selecting candidates (by parties) as well as while endorsing or voting for candidates (by environmentally conscious voters or organisations)