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Panchadweepam smare nityam: Ecoconservation and sustainable management of islands of Mandovi estuary

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Ancient Indians said *panchakanya smaret nityam* when they remembered the qualities of five immortal women –the "**panchakanyas**"_Ahilya, Draupadi, Sita, Tara and Mandodari.
Modern Goans need to remember the five important islands of Mandovi- the *panchadweepas*-Chodan/Chorao, Divadi/Divar, Cumbarjua, Jua Or Santo estevam and Capao which are an integral part of their history, culture and identity.

Mandovi and Zuari are ecological, economic, cultural lifelines of Goa. Tectonic activities distorted the courses of these rivers. The tidal effect of Mandovi reaches upto Ganjem. Mandovi could be said to be a river which failed to form a true delta but created many islands in the estuarine zone. Tiswadi taluka is at the heart of Goa. It comprises only islands. Tiswadi is now connected by bridges and has lost its' geographical character as an island. But the remaining five-Chodan /Chorao, Divadi /Divar, Cumbarjua, Jua/Santo estevam and Capao are ecologically fragile low lying estuarine islands. These 'Pancha-dweepas" (Sanskrit term for a group of five islands) are rich in biodiversity. How these Panchdweepas evolved?. Millions of years ago giant basaltic outcrops (inselbergs) were projecting from Mandovi. Heavy weathering of these rocks resulted in lateritization. Huge quantities of silt deposited around these rocky outcrops created vast mangrove forests which were crisscrossed by creeks. The dominant mangroves are Rhizophora murconata, Sonneratia alba and Avicennia offcinalis. Chorao Island has denser mangrove vegetation dominated by A. Officinalis, R. Mucronata and S. Alba. The mangroves were reclaimed systematically by the fist settlers about 3-4000 years ago. They were the founders of the 'Gaunkaris' or the present day communidades. Khazan lands were created for cultivation of wild rice varieties. More lands were added by extending the embankments. The area of each island in the Panchadweepas, the number of households and population statistics is given in the **Table 1.** It shows that this group occupies about 5000 hectares or 50 sq. Kms. area. Chorao is the largest island and Capao the smallest. Cumbarjua is the most densely populated island, whereas Santo estevam has more number of residential houses. In all these islands the houses are situated at the foot of the hills and along the bank of the river. Cumbarjua and Santo estevam are very densely populated and there is no land resource left for new housing settlements.

Table 1
Area of Village, Households And Population Statistics

Name of the Island	Area In hectares	No. Of Households	No. Of Residential Houses	Total population (Including institutional & houseless population)		
				P	M	F
Chorao	1983.21	1107	1055	5577	2744	2833
Capao	130.33	43	43	176	94	82
Cumbarjua	240.15	740	675	4239	2170	2069
Divar	1616.94	1048	1024	4817	2374	2443
Jua/Santo estevam	826.79	1083	1071	4555	2148	2407
Total	4797.42	4021	3868	19364	9530	9834

(Source: District Census Handbook North Goa, 1991)

Traditional ecotechnology

The *Panchdweepas* are repositories of traditional ecotechnology. The art was practiced for thousands of years. Surrounded by estuarine waters, the aquifers of these islands were at the risk of becoming saline. The maintenance of the outer and inner Khazan bundhs was crucial for the ecological and food security of the islanders. The communidades trained the people to manage the bundhs. The spirit of self reliance is now dying alongwith the traditional knowledge.

Rainwater harvesting system

Ponds

The annual rainfall in these islands is nearly about 300cm (300mm). The rain water falls on ground and finds it way directly into the river Mandovi through the drainage system. No matter some quantity of it get absorbed into the ground in the initial phase of rainfall when the ground is dry and hard. Earlier in these islands there were ponds which were dug into the khazan lands to store the monsoon runoff. The distance between the two ponds was nearly 100 - 200m and there used to be 10 – 15 ponds in each khazan land depending on the area The water was used for vegetable cultivation in winter season.

Wells

In these islands most of the private household wells have head-walls and are provided with “Rathis”. But the wells which are property of the entire village are without head-walls and lack the “Rathis”. The water table falls down beyond the normal and even sometimes wells get dried up in summer-season.

Traditional techniques of water treatment

The islanders used traditional methods to ensure safe drinking water quality. These were as follows:-

- By inserting roughly small part of Nellie tree into the well
- By dropping powder of dried ground seeds of drumstick (after removing outer skin of the seed) into the well.
- By dropping leaves of Tulsi or Neem into the well.
- By putting ash of plant litter into the well. This ash was considered to have antifungal and antibacterial properties.

Maintaining the precious Khazan bundhs

What protects the Panchdweepas from flooding and submergence?. It is an intricate system of outer and inner embankments, sluice gets and backwaters. Engineering drawings of this system made to the scale are not available.

Table 2 gives the information on the Khazan bundhs and sluice gates in these islands.

Table 2 Islands’ Khazan lands

Name of the Island	Name of the Khazan land/ bund	Length of bund (Approx. in meters)	No. of Sluice gates
Chorao	Bandonem Khazan	4000	1
	Batotem – Khazan	5000 – 6000	1
	Cantore – Khazan	5500	1
	Cavo Khazan	3000	1
	Dupenam Khazan	4500	1
	Khandle – Khazan	4500	1
	Macazan Khazan	6000	1
	Varona Khazan	3000 – 4000	1
	Sarel Khazan	5000	1
Divar	Amboi Khazan	2000	2
	Tarze Khazan	1000	1
	Inzne Khazan	1000	1
	Naye Khazan	1000	1
	Naroa Khazan	2000	2
	Molar Khazan	2000	2
	Navelim Khazan	2500	2
	Golti Khazan	8000 - 9000	4
	Vanxim Khazan (Capao)	2000	2 (unoperational)

Jua/Santo estevam	Vai Khazan	2000	1
	Tarze vattoi Khazan	3000 to 4000	2
	Plani Khazan	4000	1
	Madapoin Khazan	2500	1
	Khawajo – Kator Khazan	2000	1
Cumbarjua	Kundaiker Kator Khazan	3000	1
	Tir khazan	4000	1
	Chuna kator	3000	1
	Impte khazan	2000	1 (small of 1 door)
	Katurli-khazan	1500	1 (small of 1 door)

The information regarding the repair of the Khazan bunds by using traditional technology was collected from local farmers in Navelim– Divar. Bunds form the life-line of the khazan lands. The construction of bunds involves mainly two steps, namely *Thor* and *Cupto*. Most of this knowledge is not documented.

***Thor*:**

Bunds are usually constructed by using alluvial mud. The preliminary step involves spreading of alluvial mud layer on the place where bund is being constructed. On this layer of alluvial mud, layer of paddy straw is placed to keep the layer of mud compact. This alternate arrangement of alluvial mud layer and paddy straw layer is known as Thor in local language.

***Cupto*:**

After the completion of the above step, namely *Thor*, the second step involved is referred as *Cupto*. In this step, roughly arranged alluvial mud layer surface (i.e. after Thor) is made smooth manually by punching and spreading the mud by hand. This procedure adopted for leveling or smoothening rough surface of bund is referred as *Cupto*. It imparts intactness to the bund.

Chonoi- This is a method adopted for repairing the bunds which are partly damaged. The boring creatures like crabs found in the vicinity of the bunds make holes in the bund. If these are not plugged immediately then the bundhs get weakened.. So when the holes begin to appear in the bund, that spot or the portion of the bund is cut into rectangular or funnel shape by using simple traditional tools as *Khore, Pikas and Kudal*. This cut portion of the bund is then filled with fresh alluvial mud. In other words, *Chonoi* is the technique adopted to prevent further damage to the bunds and thus is a very useful for rejuvenating damaged portions.

Khazans of Panchdweepas

Divar:-

The khazan land of Navelim village tends to get flooded during rainy season due to damaged portion of the outer bund. Wooden logs driven in the silt used to prevent further damage to bund or to discharge the wave energy which otherwise directly collides on the broken section of bund and results in further deterioration. As a result of

which approximately about 70% of this Khazan land gets submerged under water. So also due to persistent flooding every year some portion of the Khazan land, which was cultivated (*Sarod*) 15 years back is left abandoned and slowly turning into mangrove forest.

Capao

The khazan land of Capao is completely taken the form of mangrove forest. The outer and inner bunds are densely covered by mangrove vegetation and shrubs in Capao, which makes difficult to walk on bund and hence maintenance and repairs becomes a tedious job. These Khazan lands were known to have two sluice gates, which are now unoperational.

Cumbarjua:-

All the khazans at Cumbarjua island are cultivated during rainy season (*sarod*) except katurlr khazan and Impte khazan which gets flooded during monsoon. There is gradual decline in the cultivation of winter fed agriculture form i.e. *varye*. The sluice gates of first three khazans (See Table 2) comprise of more than three doors whereas sluice gates of other two khazans comprises of only one door.

Jua

The Jua village is surrounded by bund except Tonk ward and little part of Curpin. The bund is of alluvial mud. These bunds form the six khazans of the land. Besides this khazans there are private owned lands such as Sapal, whose bund length is about 2km, Babal about 1km and area of 30ha. (approx) and 10ha (approx) respectively. The total bund length about 10-12km. Sides of the bund is covered with coconut plantation and mangrove vegetation. The bund from Curpin to Akhada is converted into tar roads. Each khazan has sluice gate of two to three doors.

The agroeconomy of the islands:-sustainable livelihood is affected

The traditional economy of these islands was based on simple, sustainable enterprises such as fisheries , cultivation of rainfed paddy and irrigated vegetable crops, horticulture especially production of several varieties of Mangoes which are highly prized even today in Panjim market, adobe brickmaking, pottery and other rural enterprises. Alluvial sand mining also yielded income to the sand miners although lately it is affecting the river ecology. It has been reported that there were salt pans in Chorao island but no evidence is found today in the altered island topography.

Decline of Agro-horticulture:-

Table 3 gives the information on different types of vegetable crops traditionally cultivated in these islands. The system of microirrigated winter vegetable cultivation was known as 'Varye' . These islands were once the "salad bowls' of Old Goa and Panjim towns. The fresh farm produce used to be transported to Panjim by canoes. The islands had evolved some rare strains of vegetables suited to saline conditions. Unfortunately, these seems to have been lost.

Fertile top soil erosion, frequent ingress of saline water has resulted in heavy crop losses. In our survey a rapid estimate of these losses was made in 2000. This data is given in **Table 4.** More than 500 hectares of land was affected. Our estimates show a dismal picture of damage to islands' sustainable agro-economy. The loss of employment was to the tune of 1000. Since 1997 we estimate that the cumulative losses of agricultural income from these five islands could be Rs. 150-250 millions.

Decline of Traditional fisheries:-

All over the world islands develop their unique fishing practices and gears. Islands in Goa are not an exception. Unfortunately these techniques and gears are slowly disappearing. We have described some of the techniques used in the surveyed islands.

Different Techniques Used To Capture Fish:

Important fishing techniques employed are mainly Shore seines, Gill nets, Cash nets, Hook and Line nets and Mini - auto trawls. Some of the techniques used for fishing are briefly described below:

a.) ***Khutawni*:** is the fish capture technique in which number of bamboos are inserted into the mud in the vicinity of bund in zig – zag manner. The fish net is first immersed into the mud during low – tide. At this time one end of the net is fixed into the mud by placing stone onto it. At the time of high tide when water level starts rising, the other end of the net is tied to the bamboo just above the level of water rise anticipated during high tide. When the level of water falls to a minimum during low tide whatever fish trapped in the net is removed and sold.

b.) ***Katali*:** In this form of fish capture technique, the fisherman sitting on the canoe suspend the net in the river water during high tide or low tide with one end of the net resting in his hand. After the insertion of the whole net into the river water, he waits for a while and then reverts the above procedure i.e. he then pulls the net inside the canoe in segments and trapped fish is removed.

c.) ***Zari*:** is a technique used for catching crabs. The equipment is made up of iron rod which is bent into round or rectangular shape to which net is attached. The food to attract the crab is tied horizontally to the *zari*. The nylon rope is tied to the equipment (*zari*) and it is then inserted into the river water during high tide.

d.) ***Coble*:** To make this equipment, the bamboo is cut into four equal parts vertically and one cut portion of the bamboo out of the four equal cut parts is bent into circular form around which the net is attached. This form of fishing is employed while fishing in the backwaters (i.e. *Poye*, etc.). The fisherman holds the coble in both the hands and drags it in the water for less than half minute and then lifts the *coble* to find if there is any capture of fish or not.

e.) ***Sitari*:** It is a technique in which nylon thread is tied to a bamboo stick at one end and the other end of the nylon thread which remains suspended is attached with curved thin hanger like equipment, locally known as *goro* which is available in different sizes to trap different species of the fish. The sharp tip of the *goro* is made illusive by attaching food to it, the fish comes to eat food attached to it and while doing so this sharp pointed hanger pierces their mouth and fish gets trapped.

f.) ***Polare*:** It is similar to *Sitari*. But in this technique nylon thread is wrapped around any suitable material (Ex. Wooden block, etc.). To the one end sharp pointed curved thin hanger(*goro*) of very small size is tied to which food is attached and just above this hanger heavy substance known as *shishe* in local language is tied. The nylon thread equipped with this arrangement is then thrown into the river water. Due to the attachment of heavy substance it travels fairly long distance before falling into the water. All other things are similar to *Sitari*.

Although the above techniques are still in use, the fish and shellfish diversity and the catch is also declining. The number of active fishermen is also on decline. This information is based on directorate of fisheries data for the year 2000. **Table 5** gives information on islands' fisherpeople and the fish catch.

Table 3 Different Varieties Of Traditional Vegetables Cultivated during winter using *Varye sy*stem of microirrigation

Local/Common Name	Scientific Name	Part used as Vegetable	Additional use and features	Present production status
Tambdi bhaji	*Amaranthus*	Entire	Rich in Iron, cellulose and fibre	Declining
Konkan dhudi, Bottle gourd	*Lavgenaria Vulgaris*	Fruit	Large size and soft texture Medicinal use	Common
Mullo, Radish	*Raphanus Sativus*	Entire plant	Taleigao variety of medicinal value	Seed not available, variety conserved by certain growers
Tendli, Gerkin	*Coccinia indica*	Fruit	Small variety Large variety	Not very common Grown for market
Okra, Bhendi, Lady's finger	*Hibiscus esculeuts*	Fruit	Satponi (large) Early fruiting Small	Seed not easily available Common
Valochi bhaji/ Climbing Spinach	*Basella alba*	Leaves tender shoots	Rich in Iron, Vitamin A	Very common
Piao, Onion	*Allium Cepa*	Bulb	As a seasoning agent, of medicinal value	Local variety Endangered
Vaingan, Brinjal, Eggplant	*Solanum melongena*	Fruit	Round purple (Annual) Long green (perennial) Long greenish-purple(perennial)	Common Very rare Common
Alsando, Lentil Chovlli Moog, Mung,	*Lens asculenta* *Vigna unguiculata*	Pod, seed, leave Seed Seed	Nutritive White + Brown Nutritive value	Declining Endangered Local variety

Green gram	*Phaseolus aureas*			Extinct

Table 4 Estimate of Annual Loss Due To Decline In Agriculture in *Panchadweepas (2000)*

Name of the island	Single crop area (in hectares)	Double crop area (in hectares)	Total area (in hectares)	Annual loss in single crop area in lakh Rs.	Annual loss in double crop area in lakh Rs.	Estimated total loss per year in lakh Rs.
Chorao	120	20	140	28	8	36
Capao	25	Negligible	25	6	-	6
Cumbarjua	20	10	30	4.8	4	8.8
Divar	150	50	200	36	20	56
Jua	30	10	40	7.2	4	11.2

Table 5 Fishing effort in the islands

Name of the island	**Total fisherman population**	**Active fisherman population**	**Yield in tones per Year (for year 2000)**
Chorao	109	53	109
Cumbarjua	184	43	78
Divar	180	54	103
Jua	212	64	96

Excellent traditional solid waste management:-

The agro-horticulture based economy of the islands also supported a responsible, low cost system of solid waste management. These were the days without plastic packaging materials. Our survey found interesting information on the solid waste reuse and recycling practices. The islanders had an unwritten "solid waste management ethic'. **Table 6** shows the type of cultivated crops and the agrowaste. **Table 7** provides information on the methods of recycling of various types of solid waste.

Use of modern methods of waste recycling:-

Table 8 gives the information on some modern practices of reuse or recycling the solid waste.

Table 6 Crops and agrowaste in the islands

Type of crop cultivated	Residue	Utilization
Rice Coconut Cashew nut Banana Vegetables Mango	Rice husk Coconut shells and leaves Cashew apple etc. Banana peels Leaves Mango peals	Cattle feed, fuel. Fuel. Feni distillation, food. Animal feed. Cattle feed, fuel. Cattle feed.

Table 7 Solid waste Type And Traditional Methods Of Solid Waste Recycling

Sr. No.	Type of Waste	Traditional method of Recycling
1.	Field crop waste Paddy straw Rice husk Sugarcane	Use as cattle feed, as fuel, as construction material for huts and used in bund construction. As animal feed, as fuel. As animal feed, as fuel.
2.	Garden Crop Waste Cashew apple Pineapple waste Banana pseudostems	To extract feni, cattle feed, as fuel. As fuel, animal feed. As fuel.
3. (i.) (ii.) (iii.) (iv.) (v.) (vi.)	Coconut Waste Trunk Leaf Husk Coir Pithand short Fibre Shells	As fuel, as logs, furniture, agricultural implements. As fuel, to construct thatch. Mats, decorative items, carpets etc. Carpets, insulating peds. Yarn and rope. Reclamation of land, mulching of soil, fuel.
4.	**Forestry Waste** Fresh litter Dry litter Dry leaves Cattle dung Fish waste	As manure. A fuel. To make biddies, patravalis. To make sheni, fertilizer, etc. As fertilizer. As animal feed.

	Saw dust	

Table 8 Waste Type and modern methods of solid waste Recycling

Sr. No.	Type of Waste	Modern method of Recycling/reuse
1.	Cashew shells	For extraction of oils (dink).
2.	Paddy straw	As bedding material in agriculture.
3.	Rice bran	Poultry feed.
4.	Saw dust	Poultry feed, fuel, animal feed.
5.	Coconut waste	
(i.)	Coir dust	Boards, insulation, fancy articles.
(ii.)	Shells	Moulded articles, fuel charcoal.
(iii.)	Leaves	To make decorative articles.
6.	Cattle dung	Raw material for bio-gas plant.
7.	Vegetable & Poultry waste	Raw material for bio-gas plant.
8.	Tree waste	Fuel, building boards, chemicals from wood distillates, insulation wool.
9.	Mango peels & kernels	N free extract starch for mix in wheat flour and oil from Kernel. Animal feed.
10.	Fish waste	Fertilizer.
11.	Poultry waste	Fertilizer

Major Problems Of *Panchdweepas*

Very poorly maintained and substantially damaged intricate system of bunds and the threats posed by sea level rise (SLR) are major problems. The former problem is presently faced by these islands and latter will be faced by them, gradually with every passing year. The SLR is slow phenomenon. There are two scenarios-One metre rise in sea level and Two metre rise by A.D. 2050-2080. The present height of the external embankments girdling the islands is about five-six meters. This would be inadequate to stop the submergence of vast low lying areas after the sea level rises. There are islandwise specific problems as well.

Ecoproblems of Chorao

Chorao is in very close proximity of the Arabian Sea. One of the major problems witnessed by this island is the contamination of well water by intruding salt water during summer season. The main cause of this problem is overexploitation of ground water. The salt water intrusion in Chorao may be attributed to aquaculture farms and installation of heavy duty pumping systems to exploit groundwater. This also adds to the problem of shortage of sweet water during peak summer months.

Ecoproblems of Divar

The submergence of the major portion of the low lying khazan lands under river water during rainy season and now also in summer season due to damaged intricate system of bunds is the major problem of this island. Frequent flooding of this areas as given boom to the growth of mangrove vegetation. Unless the growth of mangrove vegetation in this area is arrested then in coming years they will capture entire khazan land and if this happen it will give complete set back to the agricultural economy of this area. The khazan land of Capao has already turned into waste land.

Ecoproblems of Cumbarjua Island

The main problem witnessed by this island is the unpleasant odour evolved by manufacturing activities of a chemical plant, felt most convincingly during winter season. So also there is a shortage of water during peak of summer month. The heavy barge traffic through Cumbarjua canal produces strong wave action pressure on the bund. So, also there is decline in fish capture in this area due to oil spilling by barges and treated effluent discharge by foresaid industry.

Ecoproblems of Jua

The major problem witnessed is the island of Jua is overexploitation of mineral resources such as the alluvial sand leading to the extinction of bottom dwelling shell fish like *Khube* (clams) found in this area 20 years back. The other problem is mining jetty operating at Sarmanas.

There is also decline in both forms of agriculture, *sarod* and *Varye*. Flood is not frequent in this island, but it gets flooded only where there is heavy rainfall continuously for 2 to 3 days.

Towards better environmental management of the islands

On basis of our surveys and studies we have prepared an environmental management plan for these five islands. The salient aspects of this plan are included in **Table 9.**

Better Management Of Bunds:

The bunds in these islands are the life-line of the khazan land ecosystem. For the proper maintenance it is very essential that outer and inner bunds be well connected to each other so that bunds can be accessed easily whenever needed. The bunds are usually constructed of alluvial mud and laterite stone and hence have tendency to wear and tear from natural forces of river, inappropriate actions of humans and from hole boring creatures. Therefore certain firm measures must be taken for effective management of bunds. The following measures are suggested for effective maintenance and management of damaged bunds in their present form:

- Annual inspection of bunds and monthly inspection of those cross sections of bunds which get damaged frequently is first step towards effective management.
- Deforestation of mangroves need to be stopped. The mangroves in the vicinity of the bund absorb the bow shock waves from the barge traffic and reduce the erosion of the outer embankments. Technology of raising mangrove seedlings is available with NIO. It has been successfully used by the forest department. The breaks in mangrove vegetation need to be filled by planting new species.

- Constitution of villagers' panchayat level inspection committees. The gramsabhas need to constitute inspection committees to monitor the bundhs, their repair and maintenance works and for control of mangrove deforestation.

There should be mixture of traditional and new construction material used for building bunds. The laterite stones (rubble) of irregular dimension should be used while constructing outer walls of bunds and salinity resistant epoxy cement must be used in construction. So also it possible that damaged cross-sections of bunds could be constructed of concrete walls by using corrosion resistant epoxy cement.

Stringent guidelines must be set by captain of ports on the cruise channel and speed for barges and trawlers cruising island waters during high tides. The guidelines might be set in following manner:

a) The barges and trawlers should maintain certain speed while cruising the inland waters.
b) Fluorescent markers should be placed outside the bund (like speed breakers on the road) so by sighting this symbol the barges and trawlers will reduce their speed.
c) Routine inspections by the marine police wing

Better Design And Maintenance Of Sluice - Gates:

Unoperational conditions of Sluice-gate due to damaged and broken wooden structures serving as doors is another reason which adds to the increased impact of the river water on to the bunds. Following suggestions are made for normal operations of sluice gate.

- The wooden structure must be painted by *dikh* (Cashew Shell Extract) or oil bound Eco-friendly anti-fouling paint every year just before rainy season.
- The alternative material such as polyuretahnae, ferrocement , fibre glass can be used.

Conservation Of The islands' backwaters the - *Poye*:

Poye is the traditional mechanism which holds excess of back water in the Khazan lands. The depth of this zig – zig channel has been reduced to a great extent in recent years. Therefore incentives must be given to desilt. The farmers whose lands fall adjacent to this areas should voluntarily accomplish this task prior to monsoon reason every year.

Controlling colonization of Of Mangrove Vegetation In Khazan Lands:

The mangrove vegetation has already colonized fairly large part of khazan lands at Navelim-Divar. It is possible to reclaim this khazan land but it is a tedious job, so efforts should be made to save remaining portions of the khazan lands. Following are some of the suggestions which can be put forward for restricting further growth of mangrove vegetation.

- The bund should be constructed before the last strip of mangrove vegetation in the Khazan lands.
- Ingress of river water in the khazan land should be controlled by proper management of bunds, sluice gates and *Poye*. Dept of Agriculture, Forest Dept. and farmers should take active role to solve this problem.

Restoration Of *Hondem* – the microirrigation Ponds:-

There is a large scale decline in *Varye*- winter irrigated agriculture. The small irrigation ponds are well maintained. Following suggestions are made to rejuvenate this system of microirrigation.

- The ponds need to be desilted and to increase storage capacity the depth should be increased
- The ponds could be piled with laterite stones to reduce siltation
- The farmers should take active role in rejuvenating the ponds.

Better Water Management For Domestic Purpose:

It is clear that during peak months of summer there arises problems like salt water intrusion and water scarcity. This problem can be solved by adopting following measures:-

- Salt intrusion can be restricted by sustainable exploitation of ground water resources.
- Use of bore wells should be stopped near the edges/periphery of the islands.
- Scarcity of water can be stopped by building water storage tanks for each wado within village.
- Also gradient/contour specific rain water harvesting methods must be employed The residents of the place, NGO's and panchayats and PWD would be the role players for solving this problem.

Adapting To Possible Sea - Level Rise:

The characters of estuarine water change due to eutrophication of coastal waters caused due to urbanization, industrialisation, agriculture and other land use practices. The SLR will affect the saline soils and their use and agricultural crops. Therefore to study the effects of SLR, modeling of estuarine systems at local levels are essential. Large area of land and coastal settlements will be submerged under water in the Jua, Cumbarjua, Chorao and Akhada. Major portion of the khazan lands will also be submerged and losses will be devastating in these islands. All the islands surveyed had no effective drainage system.

- An integrated ecological security system would have to built comprising a strong outer embankment, internal drainage system and storage reservoirs for flood waters. The height of outer bunds in these islands of Tiswadi should be raised by two metres and a green belt of plantation with soil binding local species should be raised in this area.
- SLR will bring changes in salinity in mangrove swamp and hence composition of species of both flora and fauna will be changing. So it would be necessary to study the physico-chemical conditions, productivity of benthos, phyto and zooplanktons, and availability of juvenile prawns and fish.
- It is also suggested to study the zonation and bio-mass production of different mangrove species so that they may be used for plantation in the marshy land and backwaters of islands of Tiswadi.
- Remote sensing can be used to understand and predict the likely charges that may occur in these islands with respect to Mandovi Zuari estuarine complex. .

Sustainable Management Of Alluvial Sand Mining In Mandovi River:

The overexploitation of the alluvial sand may result in the erosion of the river. Therefore when Government authority issues license for extraction sand following guidelines should be put to ensure sustainable exploitation of sand.

- The extraction of the sand must be restricted to certain minimum capacity for every month and that limit must not be exceeded.

Certain plots should be identified and marked in the river. Sand mining operations need to be confined only to these areas.

Preparing a sustainable community oriented ecotourism plan for the islands

Divar, Chorao, Cumbarjua and Jua-Santo Estevam are historic islands rich in breathtaking landscapes, biodiversity and numerous spots for historians, archaeologists, ecotourists, cyclists, anglers, bird watchers and photographers. The local community needs to benefit from any ecotourism plan. An imaginative ecotourism plan for these five islands could be prepared and placed before the gramsabhas of the village panchayats on the islands. The village panchayats guided by experts, conservationists, ecotourism planners would be able to develop their own packages for domestic and foreign visitors.

New institutional mechanism:-

The legislative assembly of Goa had passed an unanimous resolution in 1998 for integrated conservation and management of these islands. The department of forests was identified as nodal agency. No action has been taken since then. We suggest formation of an Island conservation and sustainable development agency (ICSDA) for this purpose.

Conclusions:-

The five estuarine islands in the Mandovi have a rich past and face a bleak ecological future unless all stakeholders come forward to plan for their conservation and sustainable development.

Table 9

Environmental Management Plan For Mandovi's estuarine islands

Ecoproblem	Area of action	Solution	Agencies identified for action
1. Broken sections of the bunds and damaged wooden structure of Sluice	Bunds protecting Khazan lands	• Bunds must be surveyed to identify the weak spots • Those sections of bunds, which	Farmers, Fishermen, Village Panchayats,

gates		are damaged or are on the verge of destruction must be identified and given immediate attention and repaired. • Growth of shrubs should not be allowed on the bunds. Since such condition make bunds unfavourable for working and maintenance task of bunds becomes a tedious job. • Removing laterite stones from the bundhs for the purpose of fishing should be avoided as it puts additional stress on already poorly maintained system of bunds. • Damaged/fouled wooden parts of the sluice gates should be replaced. • Economically viable and long-lasting material should be used to fabricate doors of sluice gates • Communidades should be rejuvenated at least to look actively in the affairs concerning the bunds. • Communidades should be made autonomous bodies to maintain, repair and restore the age old systems of bunds.	Communidades, Directorate of agriculture and NGO's.

		• The local people should be made aware of significance of bunds and their environmental and ecological importance.	
2. Flooding of the Paddy fields due to the ingress of Saline water.	Khazan lands Khazan lands	Outer and inner bunds forming primary and secondary system of defence against floods should be properly managed, maintained and repaired from time to time.	Farmers, Panchayats, Directorate of agriculture and NGO's.
3. Growth of Mangrove Vegetation in flooded farms	Surrounding bunds	Further growth of mangrove vegetation in Khazan lands should be restricted by proper maintenance and management of bunds and sluice gates.	Farmers, Panchayats and NGO's.
4. Cutting of the Mangrove Vegetation for fuel and for other miscellaneous purposes.	Village	Awareness among local people, farmers, fishermen should be brought to make them understand ecological, environmental and natural ability of mangroves to protect bunds from direct wave action of water.	Panchayats and NGO's.
5. Domestic sewage and waste water entering in the khazan lands and the estuary.	Khazan lands	Sewage and waste water treatment, vermitechnology, use of sludge cakes	Village Panchayats and NGO's.
6. Loss of Soil			

fertility		as soil conditioner, use of treated waste water for irrigation, diversion of waste water drains from water bodies.	Village Panchayats, NGO's and Directorate of agriculture.
	Village	• At least once in five years traditional method manuring Khazan soils should be adopted i.e. with cowdung and ash (gobor). • Flooding washes away fertile Soil, proper management of water and inner embankments must be done. • Khazan soils should not be kept abandoned from cultivation of crops.	
8. Agro - waste	Village	Use of straw and paddy hay as absorbant of oil from water bodies and liquid waste from barns, in bund making, as a cattle feed.	Village Panchayats, Directorate of agriculture.
9. Animal - waste	Village	Use of cattle waste for biogas production and as fuel and fertilizer and use of poultry and piggery waste as organic manure.	Village Panchayats, NGO's and Directorate of agriculture.
10. Solid - waste	Industry	Recycling of waste like plastic, glass, metal, increasing use of biodegradable material such as fabric and rubber, use	Village Panchayats, NGO's.

11. Industrial effluents		of sanitary landfill. Effluent treatment as per standards laid down by GPCB; Proper siting / location of industries.	SPCB, Directorate of industries and mines.

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