INTERCONECTIONS BETWEEN A DELTA AND ITS DRAINAGE BASIN. STATE-OF-THE-ART (THE CASE OF DANUBE DELTA)

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ABSTRACT. - **Interconections between a delta and its drainage basin – state-of-the-art (the case of Danube Delta).** Deltas represent similar centres of "gravity" of drainage basins in what regards the concentration of water volumes, sediments, transported pollutants, etc. The majority of the deltas experience a mixture of drainage basin fresh waters and of the riparian marine/oceanic basin salty waters, fact that produces different mineralisation gradients which play a major role in the existence of a variety of ecosystems and obviously of a huge biodiversity. In view of it, deltas are points of attraction for numerous economic activities that make use of their natural resources – agricultural (and mainly fish-rearing), industrial (oil and natural gas deposits), transport, tourism, etc. These activities are associated with large concentrations of populations which put pressure on the ecological conditions of the environment, already in a fragile state of equilibrium. Hence increased vulnerability through pollution, loss of biodiversity, that is of natural capital. Although the Danube Delta is not particularly overpopulated, yet human intervetion did affect this area, as did its drainage basin of 817,000 km^2 afferent to 16 states, mostly industrialised ones, with a population of 80 million people. In order to single out the relationships between drainage basin and the delta, and the consequences involved, and based on the models devised at the Workshop on "Improving the Planning and Management of Modified Mega-Deltas", The Hague, The Netherlands, September 24-26, 2001, the state of the Danube Delta was circumscribed to the following aspects: hydrological modification, sediment loss, eutrophication, and toxic substances.

Generalities

Deltas represent centres around which drainage basins gravitate, also concentrating water volumes, transported sediments, pollutants, etc.

Most deltas contain a mixture of drainage basin fresh waters and riverain marine/oceanic salt waters. The mineralisation gradients released are vital for the range of ecosystems and their great biodiversity.

Deltas also bring together numerous economic activities connected with their natural resources: agricultural (mainly fishing), industrial (oil and gas deposits), transport (links between continents and seas), tourism, etc. These activities also entail big concentrations of population, hence increased human

pressure on the natural environment of the deltas and the drainage basins close to the marine coastal areas.

The links between deltas and drainage basins materialise in the use of water power, the construction of storage-lakes, the extraction of building-materials from the river-beds, the river-carried alluvia sedimented inside the deltas by high flood-waves and forming the alluvial plains and, above all the ecological relationships impacting the state of the deltaic ecosystems.

As a result of growing economic interest and population in the area, deltas become ever more vulnerable to pollution, hazards and loss of biodiversity, basically of their natural capital.

This situation, emerging against a global climate change background that leads to the elevation of the sea level, enhances the critical problems reported inside the deltas. Therefores the pressure put upon the deltas and the marine littoral zones calls for urgent planning and development measures[1].

Major delta management targets

At the Conference on the Sustainable Development of Deltas – SDD'98, Amsterdam, 23rd-27th November, 1998 and the World Water Forum – WWF-2000, Stockholm, 2000, the idea of a Delta Project was advanced with a view the synthetising major issues currently facing the deltas and scheduled to the be discussed at the 2003 third World Water Forum in Japan.

The main problems to be analysed and synthetised in the Delta Project and debated at the Mega-deltas Workshop were the following:

-What major changes are affecting the deltas now and supposeddly in the future....(natural, socio-economic and ecologic);

-What man-induced nutrients and sediments are flown into the deltas;

-What information on the best delta management practices is relevant and applicable to other deltas;

-What optimum concepts and tools promoting delta management are already put in place;

-What research work projects are necessary to promote adequate future management programmes.

Selection criteria for the management of major modified deltas

-present delta area (Fig. 1)

-drainage basin water volume (annual mean) flowing through the delta to the sea/ocean (Fig. 2)

[1] The over one million long sea coasts fom the habitat of more than 60% of the global population, being an area of transport and comunication of much of the goods and services, and a rich yet vulnerable ecosystem at the some time.

-volume of transient alluvia and its effects on inside delta silting and advancement of the delta front;
-morphological and socio-economic impact of the sea level elevation on the delta front;
-how much money is needed to protect the environmentand present socio-economic losses (risks for the population from river flooding, storms and sea-water overflows; port installations, river transport, fishing, valuable natural habitats and wildlife (Figs 4,5).

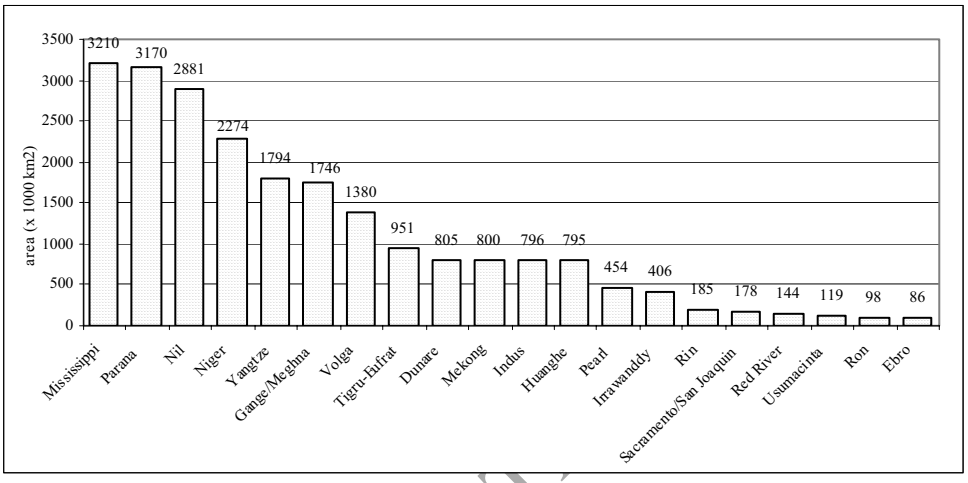

Fig. 1. Drainage basin area

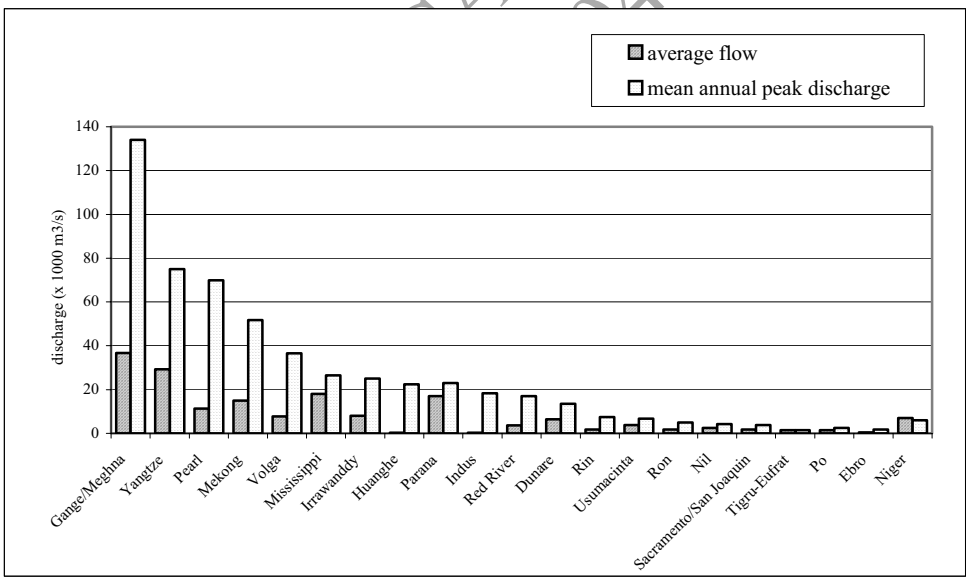

Fig. 2. Characteristic flow rates

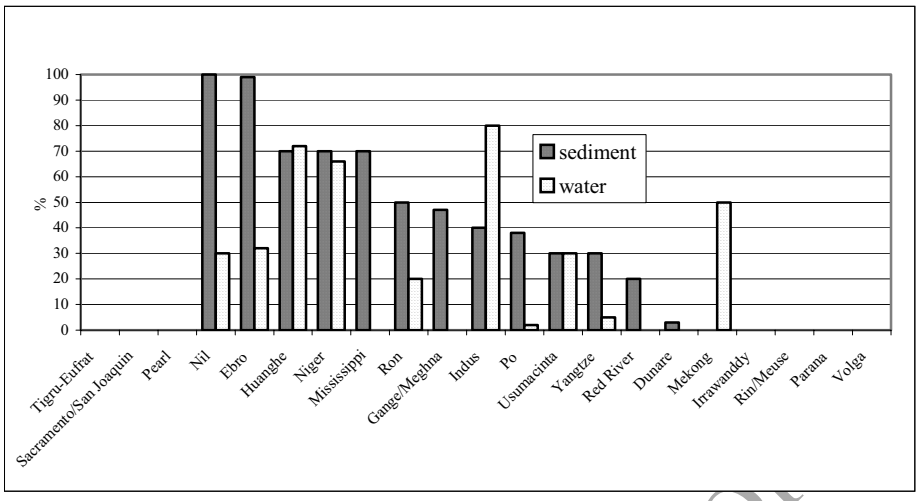

Fig. 3. Water and sediments flowing into the deltas

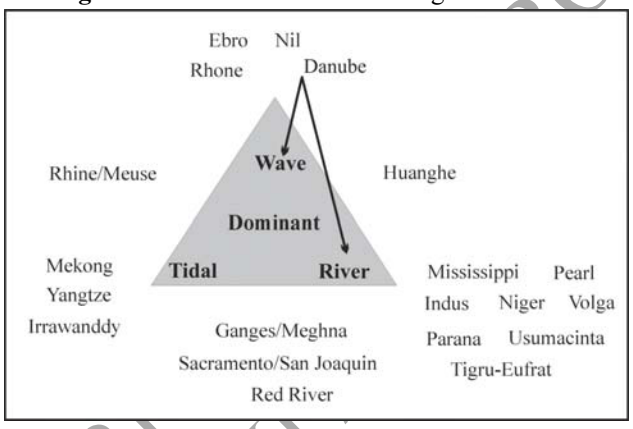

Fig. 4. Main forces acting on the deltas

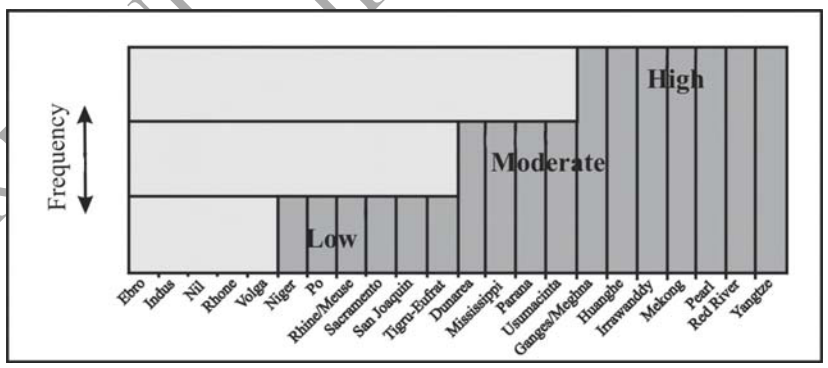

Fig. 5. Frequency of destructive storms and cyclones in the deltas

The term "modified delta" implies the following:
-direct changes within the delta area through longitudinal dyking, polder, deepening and maintenance of a navigable channel adequated to the fluviatile/maritime transport tonnage, consolidation works to control delta arms and delta front erosion;
-land use changes by turning some wetlands into agricultural terrain, port constructions, exploitations of oil and natural gas, etc.;
-changes in the drainage basin-to-delta water flow and sediment regime by transfer to other basins, socio-economic water sampling, construction of storage-lakes, and flood control;
-water quality changes and their effects on the ecological balance of deltaic ecosystems.

Delta selection for **The Modified Mega-deltas Workshop** was a two-phase process:
1) filling in the questionaire and 2) elaborating background papers, both subjected to debates on the aspects affecting the deltas of the Chang Jiang, Danube, Ebro, Ganges-Bahmaputra, Huanghe, Indus, Irrawady, Mekong, Mississippi, Niger, Nile, Parana, Pearl (Xi Jiang), Po, Red (Hong Ha), Rhine/Meuse/Scheldt, Sacramento/San Joaquin, Tigris/Euphrates, Usumancita/Grijalva – Mexico.

Some deltas like Mackenzie and Lena were omitted because they had not been altered by man in a signifiant manner, whereas others, eg. Orinoco, are not that relevant. Although the mouth of the Amazon englobes several isles among its arms, yet man had not tampered with it so as to make management works necessary.

Some other major selection requirements/conditions
-The drainage basin should lie on the territory of several states, that is to be of international importance; this requirement was met by 13 deltas: the Danube (16 states), Ganges-Bahmaputra, Indus, Irrawandy, Mekong, Niger, Nile, Paraná, Red, Rhine, Rhône, Tigris/Euphrates and Usumancinta.
-The drainage basin should be owned mainly by developed states, which was the case of 6 deltas only: of the Ebro, Mississippi, Po, Rhine, Rhône and Sacramento/San Joaquin.

A special place has the Danube which drains both developed countries (Germany, Austria, to a lesser extent Switzerland and Italy), but mostly countries under economic transition, one of them being Romania.
-The extent of the conservation (protection) versus economic development conflict; from this viewpoint deltas are some of the most vulnerable regions.
-Financing, the money spent on planning and management projects; as a rule, the largest sums are earmarked to the construction and maintenance of engeneering works in order to control flooding, navigation and erosion, as well as to other constructions of public interest and far less to the conservation of biodiversity and ecological reconstruction.
-The amount of money spent on lost wasted or destroyed projects (flood protection, and draining works, etc.).

-Development and management activities with negative environmental, socio-economic and cultural effects, most of them hard to estimate financially (loss or degradation of wetlands, aquatoria, habitats of national and international relevance, eg. of migratory birds and fishes, fresh waters as part and parcel of the life cycle, etc.).

Hydrological and geomorphological problems, as well as conflicts in the use of naturalresources generated by changes made to the drainage basin that alter the water regime; the intensive use of the drainage basin and the delta natural resources far beyound their recovery capacity; planning and management projects that ought to be promoted by the countries involved.

So, the main objective of the first stage of the Delta Project discussed at the Modified Mega-Deltas – 2001 Workshop was to make the best of the experience gained in the planning and management of some deltas and find the ways and means for the sustainable development of other deltas in terms of their natural particularities and human activity there in. Altaining these objectivesmeans having relevant information and correct assessments on the state of modified deltas in order to implement adequate management practices.

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As already mentioned, a number of questionnaire-based and theme-related materials had been elaborated before the Workshop proceedings had started for participants to become familiar with the topics of debate.

However, the lack of the information solicited, or the distinct fields the authors were specialists in (geography, biology, hydrotechnics, economy, etc.) made the materials very heteregenous and flawed.

At the end of the Proceedings, participants were requested to produce a 4-5-page synthesis on a pre-established theme. The Danube Delta synthesis was published in the Scientific Annals/2002 Journal issued by the Danube Delta Institute for Research and Development – Tulcea, Romania.

The Workshop's conclusion was that adequate delta management calls for the elaboration of some projects to deal with the problems little tackled in greater depth.

In view of the above, the implementation of a regional programme (Asian Deltas: Their Evolution and Recent Changes) targeting the most critical aspects of Asian deltas has lately been suggested.

The position of the Danube Delta among the other 20 deltas, State-of-the-art

Despite the fact that participants in the workshop presented incomplete information on some deltas, or contradictory data for others compared to encyclopaedic references (delta area, population), yet the table and graphs do enable some remarks in connection with the Danube Delta.

- In the first place, and most important, is its positive condition, man having modified it in proportion of 42% (agricultural and fish-rearing farms, forest plantations) compared to all the other deltas.

- In the second place, and as important, is the low human pressure inside it (4 inh./km2) compared to 2,325 inh./ km2 in the Pearl Delta and 2,000 inh./km2 in the Chang Jiang Delta, both in China. The protection and use of the highly fragile Danube Delta environment raises special problems (Fig. 6).
- In the third place, the extent of knowledge, and research of the geographical, biological and economic particularities and even of management (undertaken after 1990) enables an assessment of the natural heritage (biodiversity, resources) and in this way ensure its better protection and utilisation.
- Being a biosphere reserve and functioning under a special law and an administrative body of its own, the Danube Delta stands out against the other deltas as a model and reference point hardly attainable by them in their present condition.

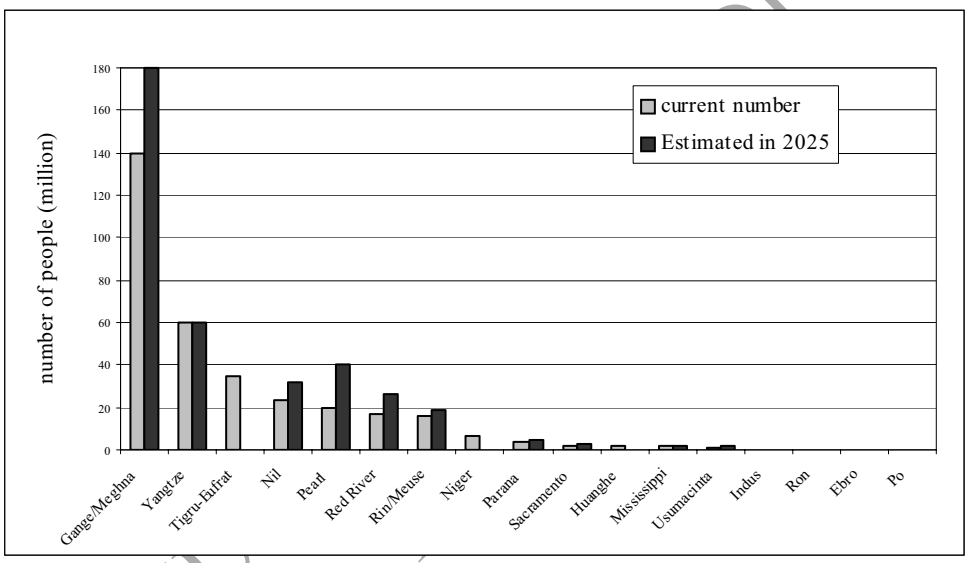

Fig. 6. Deltaic population

Although the Danube Delta has been spared the problems confronting the other deltas, yet the pollutants carried by the River, which flows on the territory of industrially developed and farming-intensive states do affect its area, so that adequate measures to protect its extremely valuable genetic fund are a must.

Models 1-7 present the main aspects of and impacts on the Danube Delta relevant of its current state-of-the-art.

Tab.1. Characteristic elements of few world deltas

No.	*Name of delta*	*Area (km^2)*	*Drainage basin*			*Delta population*	
			Name	*Area(km^2)*	*Discharge (m^3/s)*	*no. inh.*	*inh./km^2*
1.	Changjiang (Yangtze)	30000	Changjiang	1,794,000	29,300	60,000,000	2,000
2.	**Danube**	**5600**	**Danube**	**805,300**	**6,480**	**15,000**	**4,3**
3.	Ebro	330	Ebro	85,550	409	47,700	144.5
4.	Gange-Brahmaputra	105640	Gange-Brahmaputra -Meghna	1,746,000	36,700	140,000,000	1,320
5.	Huanghe	42000	Huanghe	794,700	340	1,789,000	43
6.	Indus	6000	Indus	796,000	230	200,000	33
7.	Irrawaddy	46400	Irrawaddy	406,000	8,024	19,400,000	418
8.	Mekong	51176	Mekong	810000	15,000	17,000,000	332
9.	Mississippi	28000	Mississippi	3,210,000	18,000	1,500,000	53,6
10.	Niger	29100	Niger	2,274,000	7,000	6,570,000	226
11.	Nile	20000	Nile	2,881,000		22,500,000	1,125
12.	Parana	14100	Parana	3,170,000	17,000	4,000,000	284
13.	Pearl (Xi Jiang)	8600	West River	453,700	11,400	20,000,000	2,325
14.	Po	540	Po	70,092	1,500	19,500	36
15.	Red (Hong Ha)	22000	Red River	144,000	3,600	17,000,000	773
16.	Rhône	1455	Rhône	97,800	1,700	70,000	48
17.	Sacramento-San Joaquin	1620	Sacramento-San Joaquin	178,000		2,000,000	1,235
18.	Tigre-Euphratus	15000 20000	Tigre-Euphratus	950,876	1,456		
19.	Usumacinta/Grijalva	2100	Usumacinta	118,500	3,720	1,383,900	659

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3. *** (2000), *Ecological gradients in the Danube Delta lakes – present state and man-induced changes*, RIZA the Netherlands, Danube Delta National Institute Romania and Danube Delta Biosphere Reserve Authoriry, Romania, RIZA report no. 2000.015.
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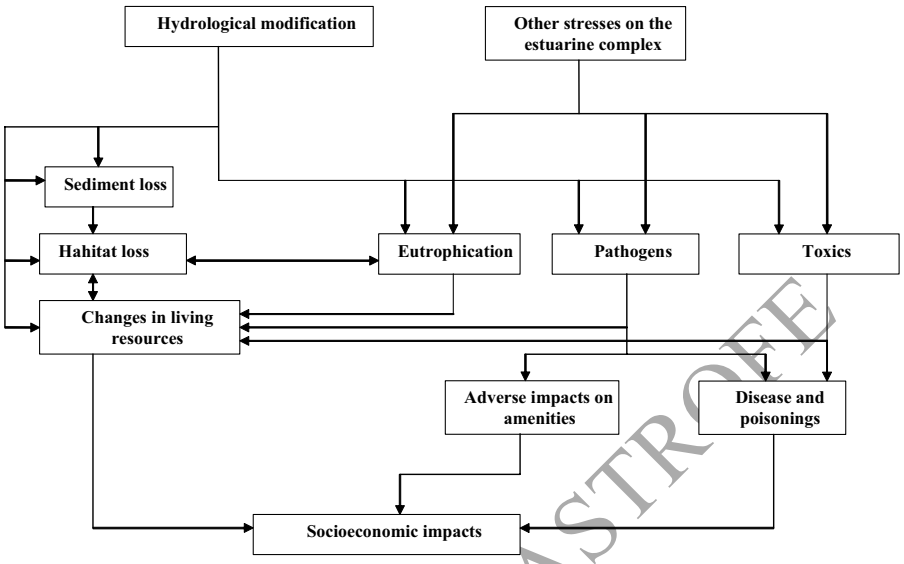
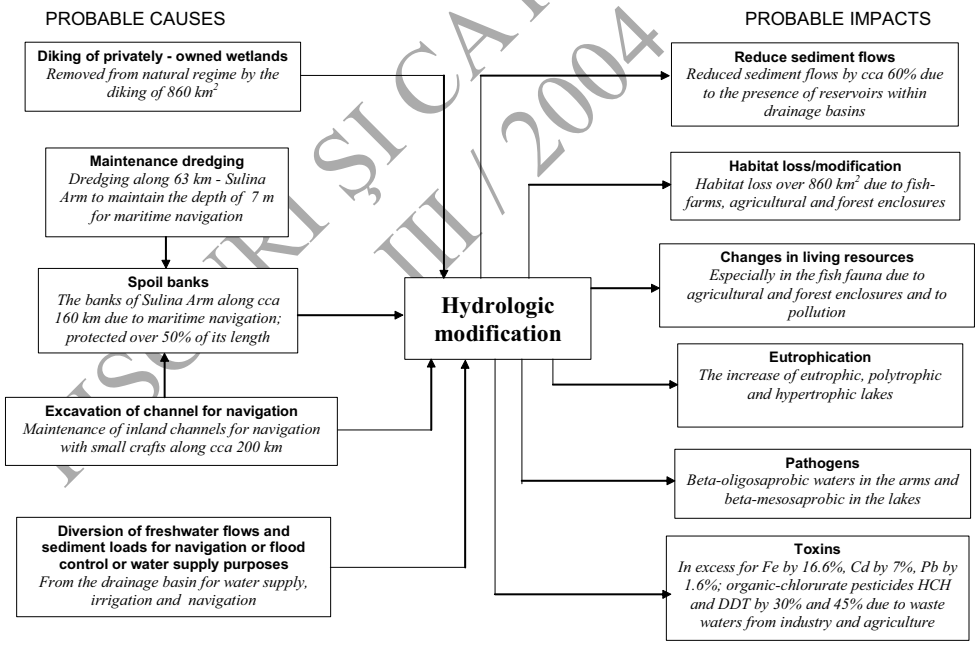
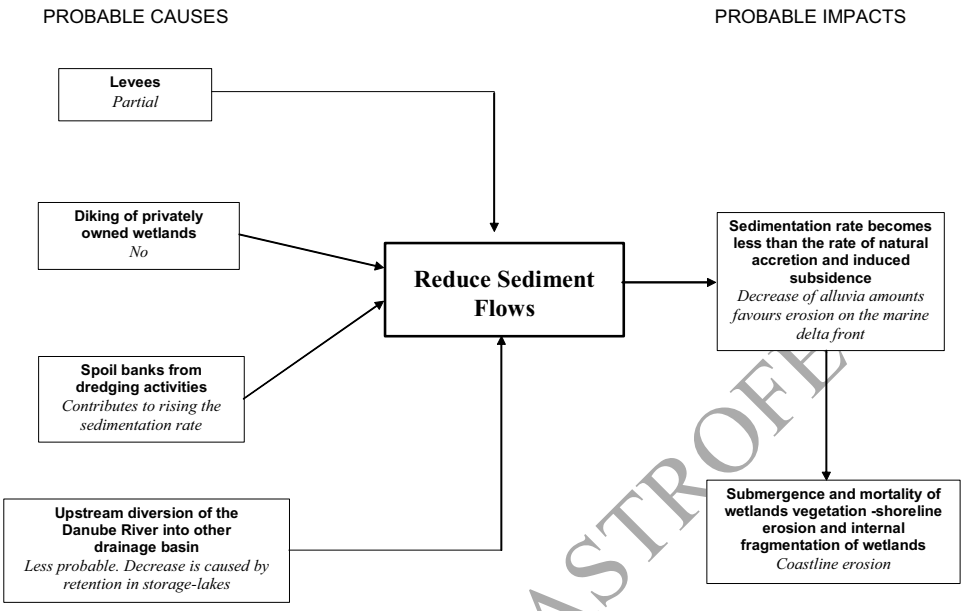
M.1 Interconnections Among The Priority Problems in the Deltas



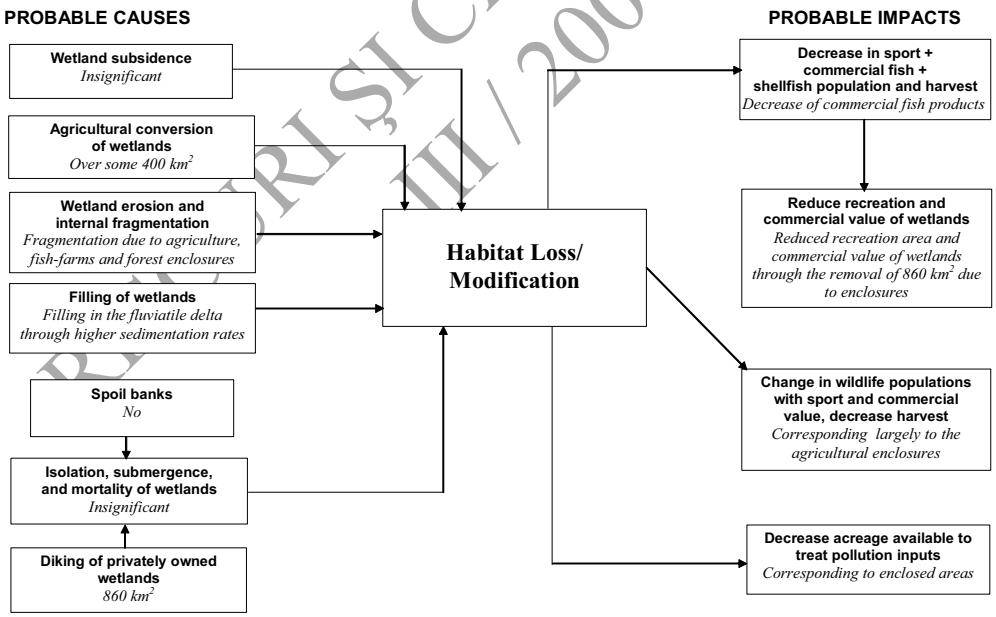
M.2 Hydrologic Modifications in the Danube Delta



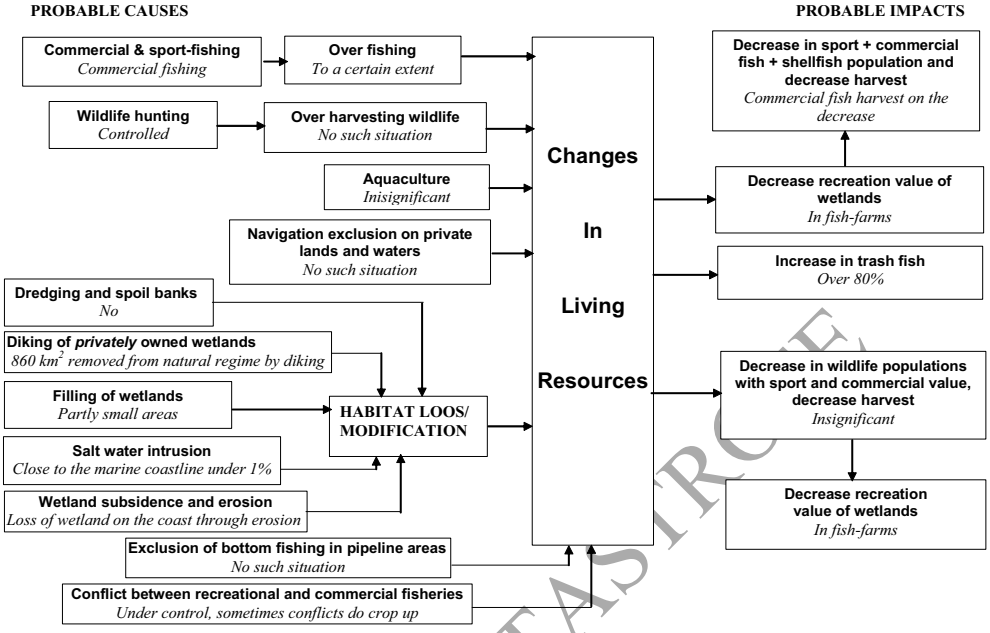
M.3 Reduce Sediment Flows In The Danube Delta



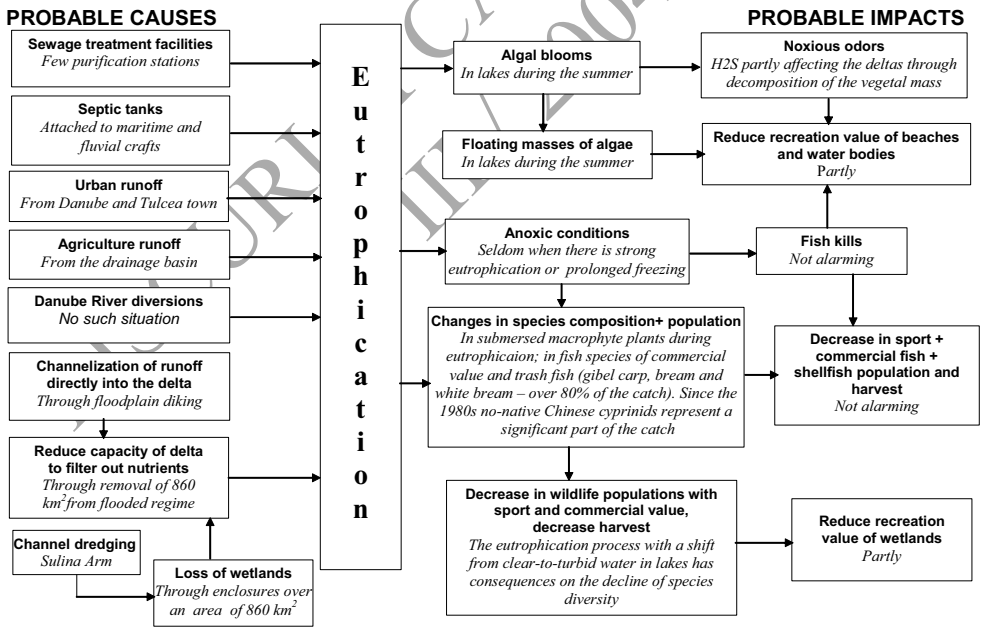
M.4 Habitat Loss/ Modification In The Danube Delta



M.5 Changes In Living Resources In The Danube Delta



M.6 Priority Problem Area: Eutrophication in the Danube Delta



M.7 Toxic Substances in the Danube Delta