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Environment and Resource Evaluation in the Musi-Banyuasin Coastal Zone South Sumatra

A Discussion Based on Preliminary Studies Conducted by Team Ekologi IPB

Proyek Pendidikan dan Penelitian Lingkungan
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in the Musi Banyuasin Coastal Zone, South Sumatra

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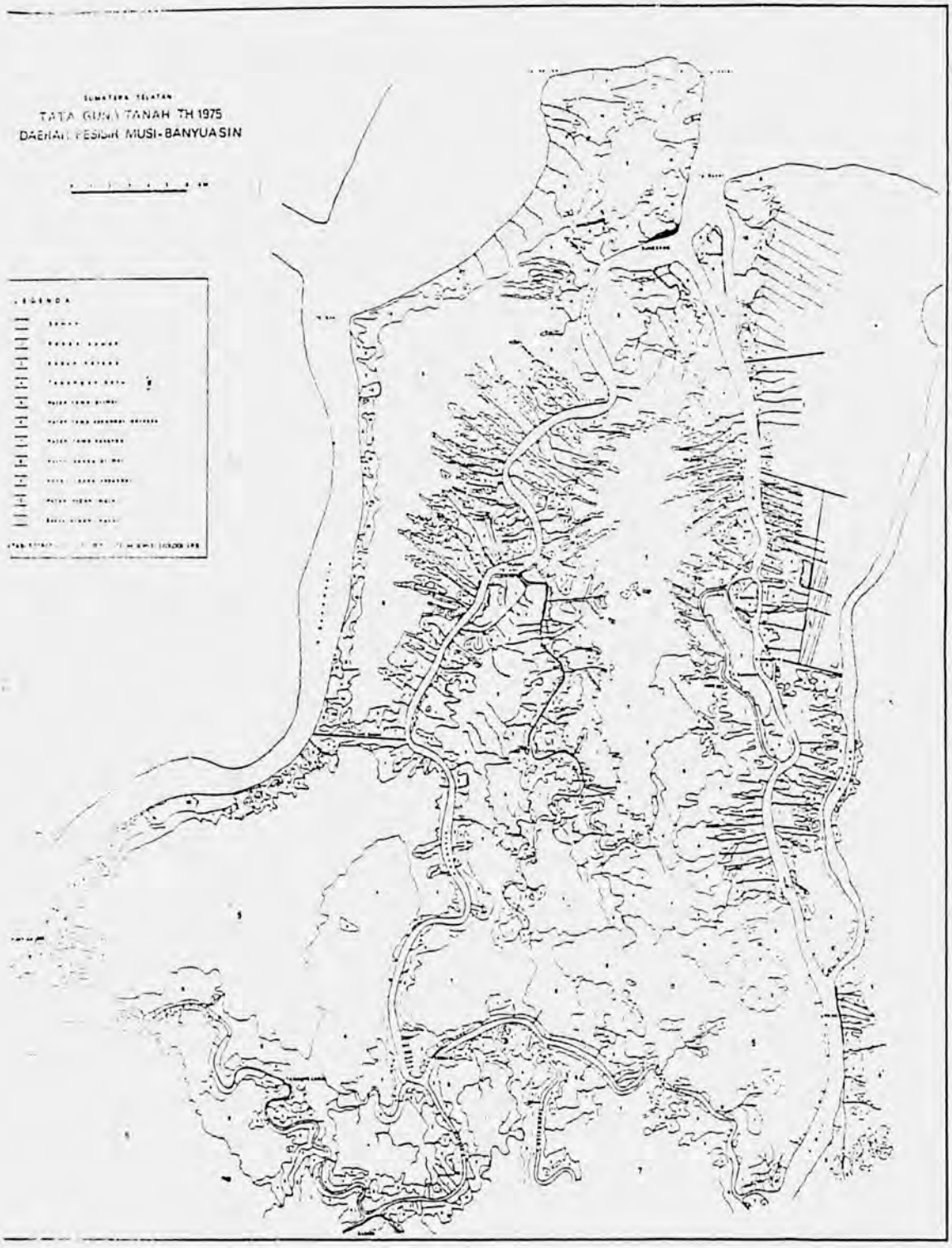
Agricultural development of the coastal forest swamplands in Sumatra and Kalimantan has long been considered a possibility for increasing food production and for contributing to regional economic growth of these islands. Because population density is low development concepts have always been linked to transmigration of farmers from Java or Bali. Through the Proyek Pembukaan Persawahan Pasang Surut (P4S) in the Ministry of Public Works a systematic program of land resource development was initiated in REPELITA I in several test sites in Sumatra and Kalimantan. During the Second Five Year Plan this program will be greatly expanded. An upper limit of one million ha of land opened to settlement has been discussed.

Development is simple compared to upland technical irrigation. A drainage and irrigation ditch system is cut across the delta and swamp forest is clear cut, non-commercial timber and brush burned and rice or other crops planted. Within a year or two of settlement the first harvest can be obtained. This pattern is a modification of methods used by Buginese from South Sulawesi. They are the traditional traders and coastal zone settlers in many parts of Indonesia. Three other models for development exist. One is the polder system which aims at careful regulation of water level through a combination of dikes, water gates and pumps. The second model is the estuary-delta resource unit common on the north coast of Java. Resource use by villagers in this high food production zone is a mixture of rice and other plant crop culture, animal husbandry, intensive brackishwater and offshore fisheries plus [illegible] or saltwater aquaculture and salt ponds. The third model is sustained-yield harvest of swamp forest timber and other products, with or without agriculture and fisheries development.

From a resources and environment perspective the important questions of swampland development hinge not so much on the level of rice yield from the problem soils but on the overall possibilities of maintaining an ecologically and economically productive land and water system. In the absence of planned development the swamplands will still be opened by shifting cultivators through timber removal and by various kinds of exploration and road networks to coastal ports. The major part of Indonesia's fish catch is dependent on either fresh or brackishwater swamp areas. Consequently any plan for development must consider the long-term impact on fisheries. An area-based strategy of development offers the best opportunity for resolving potential resource conflicts and focusing technical inputs to create optimal management procedures. For some time to come optimal management procedures may be defined simply as those which maintain permanency of settlement and stability of work opportunities in the diverse kinds of natural resource exploitation now being practised. Although it may be assumed that the PWS land development program offers this management possibility it cannot be achieved without a broad-based understanding of social and ecological variables influencing the delta and estuarine environments.

At the request of the Ministry of Public Works IPB initiated resource and environment studies in a 100 000 ha area of the Musi-Banyuasin coastal zone in South Sumatra in early 1978. This study area includes Delta Upang where 8000 transmigrants are now settled. The study area is shown in Figure 1. The land deposits are considered to be very recent perhaps less than 1000 years. Its management presents the typical difficulties inherent to these areas. Figure 2 illustrates the dynamic nature of land opening resulting from fires agricultural settlement and logging. There is a possibility of major harbor development and road construction to overcome navigational difficulties by oil tankers and freighters in the shallow Musi river. One long-established coastal village serves as a port for coastal fishing vessels and the rich estuarine fish trade. Most of the area including the mangrove swamps, is under either local or central government timber concessions. A regional environmental inventory approach has been followed in the IPB studies in order to document the multiplicity of activities and to identify important interrelationships among system components.

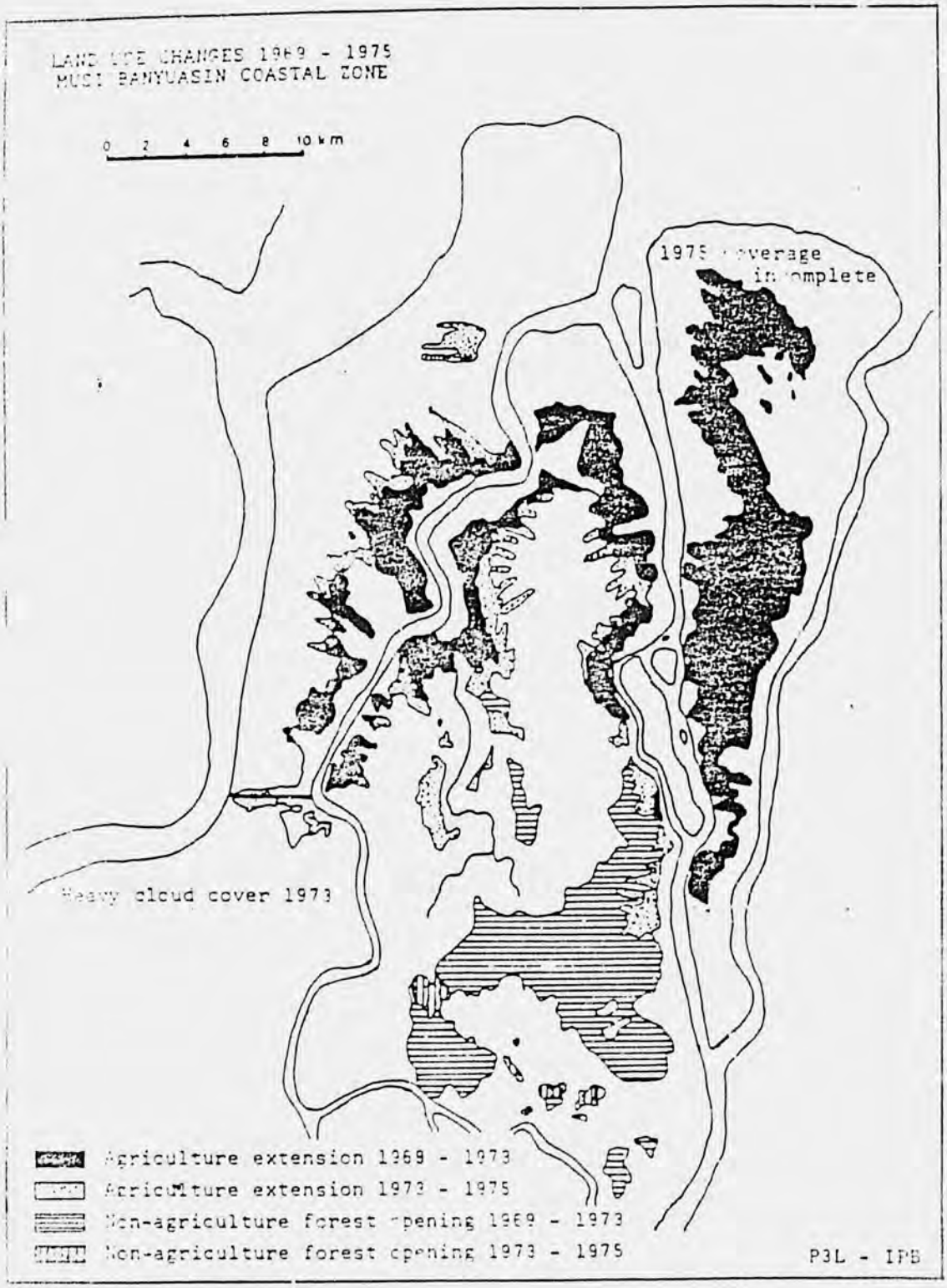


Banyuasin coastal zone based on uncontrolled 1975 aerial photography. Coverage of Delta Upang is incomplete.

LEGEND

1	Rice fields	5	Primary swamp forest	9	Secondary mangrove forest
2	Abandoned Rice fields	6	Secondary swamp forest	10	Pure nipah stand
3	Coconut groves	7	Brush	11	Former nipah stand
4	Newly cleared land	8	Primary mangrove forest		

Figure 1


LAND USE CHANGES 1969 - 1975
MUSI BANYUASIN COASTAL ZONE
0 2 4 6 8 10 km
1975 coverage incomplete
Heavy cloud cover 1973
Agriculture extension 1969 - 1973
Agriculture extension 1973 - 1975
Non-agriculture forest opening 1969 - 1973
Non-agriculture forest opening 1973 - 1975
P3L - IPB

The field work and secondary data compilation is being carried out by 9 research teams drawn from a multidisciplinary environmental research training project for government department and university staff at Institut Pertanian Bogor. The relationship between essential study topics and the study teams is shown in Figure 3. A summary of information collected during the first phase of study is provided in Table 1. The work is intended to be complementary to soil survey and test farm agronomy studies, and to the hydraulic and settlement design team efforts. A complete report of the first phase studies covering work carried out between March and October 1978 is available (in Indonesian). The analysis is intended to serve as a basis for immediate planning decisions, to serve as a baseline for future monitoring of environmental changes and as a guideline for more in-depth study of critical or potentially critical problems. The intention is to provide a positive base for a strategy of integrated natural resource management for the conditions found in this major estuarine swampland. The work is not intended to form a complete environmental impact assessment for the P4S program. In this paper the more important of the problems are reviewed, with suggestions for an area-based resource management policy.

Coastal System Components

Although the land relief and depth profiles of the delta and estuary indicate only slight topographic variation it is sufficient to clearly differentiate zones. In fact, the basic characteristic of this type of coastal zone is sharp gradients which limit habitat dimensions. Consequently resource capability assessment must be carried out on a suitably micro-level. The various zones are shown in Figure 4. Salt intrusion is perhaps the most critical variable, even to sediment deposition (through flocculation). In the build-up of the land system it gradually becomes self-sealing against salt intrusion and in some spots even to flood waters. By opening canals man runs the risk of changing sediment deposition patterns, gradually leaching the organic deposits and in agricultural development of killing crops or damaging the soil through excessive sodium. On the other hand, the seawater is a buffer which can flush or neutralize toxic elements as well as restore fertility. Canals may serve for aquaculture or for habitat and feeding grounds of

Table 1. Data available from field surveys

Team	Data Collected
Climatology	Rainfall 1916-1975
	Long-term variation
	Regional distribution of total rainfall and days of rainfall
	Seasonal variation
	Frequency of heavy rainfall and days without rain
	Frequency of dry spells
	Evaporation
	Temperature and relative humidity in survey area
Geomorphology	Classification of river bank stability : erosion and sedimentation
	River and canal depth profiles
	Coastal and mudflat depth profiles
	Determination of sedimentation rates
Soil and Water Chemistry	Soil types
	Chemical characteristics of soils
	Water chemistry characteristics
	Groundwater depth and chemistry
	Vegetation in relation to soil ecosystem
Hydrology	Tidal harmonic constants
	Tidal propagation rate
	Tidal range at 6 stations
Aquatic Biology	Physical and chemical characteristics of water
	Distribution and abundance of aquatic organisms
	Benthic organisms
	Shrimp (adult and larvae)
	Fish (adult and larvae)
	Plankton
Forestry	Species composition, structure, forest reproduction, production in mangrove and freshwater swamp forest
	Protected wildlife and plants
	Log exports from tidal area in South Sumatra
Animal Husbandry	Abundance of domesticated animals
	Development of domesticated animal population
	Level of livestock care
	Duck production potential
	Livestock feed
Plant Pest and Disease	Major pests and diseases of cultivated plants
	Intensity of infestation
Social Economics	Demography
	Population increase 1969-1974
	Size and distribution of population
	Age composition and sex ratio
	Social
	Settlement patterns
	Cooperation patterns
	Land use law
	Education
	Public health and nutrition
	Economic infrastructure
	Location of market-places
	Credit facilities
	Industrial facilities
	Farm management analysis
	Cost analysis
	Income analysis
	Activity analysis

Figure 3. Relationship between study teams and research topics.

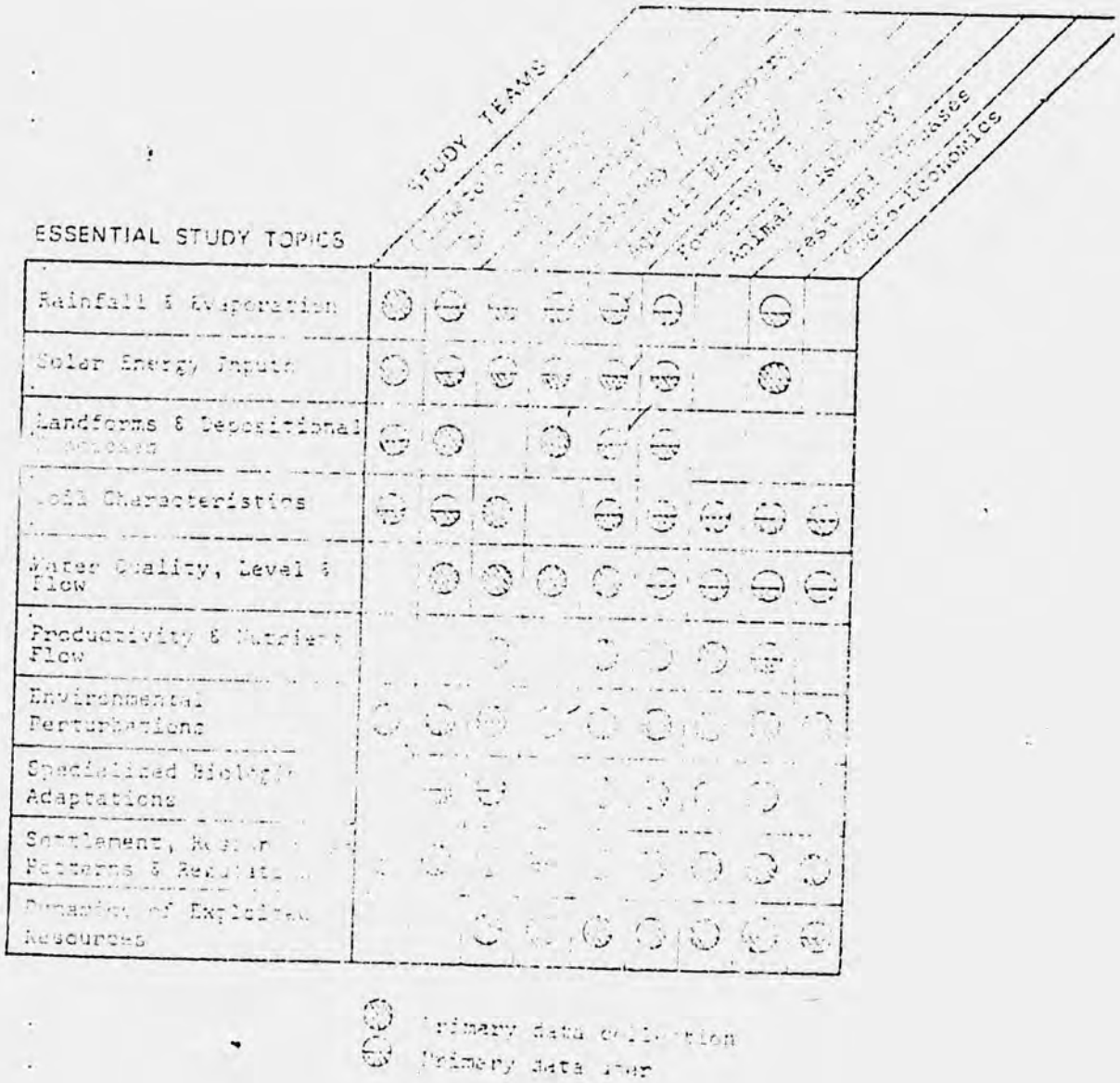
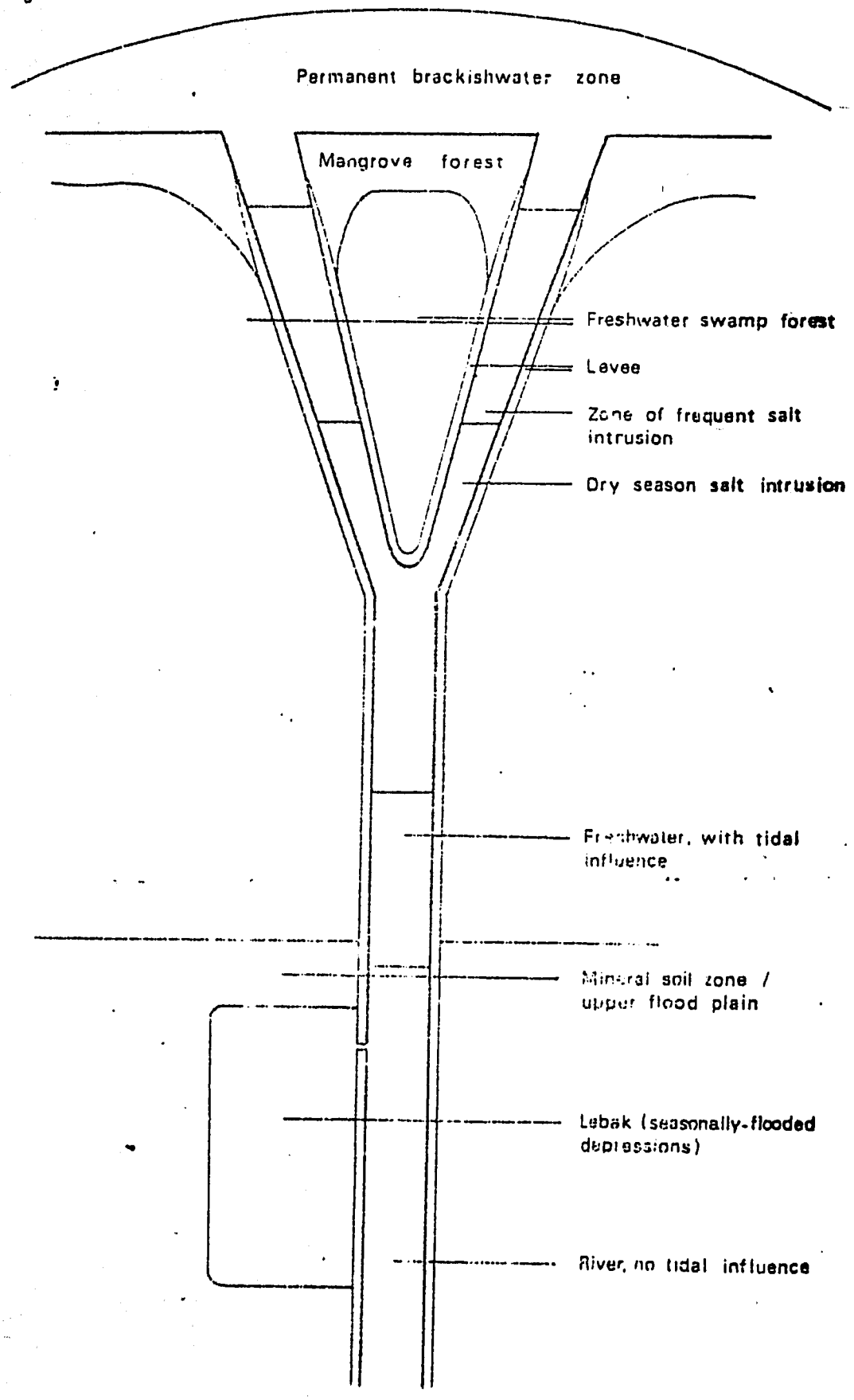


Figure 4



Lowland Land and Water Zones

fish and shrimp. The seawater helps unlock the otherwise unavailable nutrients of the blackwater effluent which drains from the organic soils. These examples illustrate the difficulty in evaluating the environmental impact of development. Salt hazard is related to river discharge in an inverse fashion. Consequently the hazard is much higher in the Banyuasin basin of the study area since it is a lowland basin with a drainage area only 1/4 the area of the Musi watershed. The distribution of salinity late in the wet season is shown in Figure 3. Values of 7 to 8 or above on this conductivity scale represent salinity levels dangerous to agriculture. The variation is striking and strongly correlates with the patterns of traditional agricultural settlement seen in Figure 1. The pattern of wet season salinity may be more important than dry season since only one crop per year is grown by these agriculturalists. An illustration of the need to consider interactions among cycles.

This very brief introduction to the coastal ecotone (or more properly, series of ecotones) provides the minimal basis for understanding the resource problems and strategies discussed below.

Important Potential Problems and Strategies for Their Solution

1. Declining system fertility.

Unlike upland tropical forests in which the nutrient supply is almost completely locked up in the plant biomass, the freshwater swamp forest creates a substantial organic bank in the form of peat. The peats in Upang are eutrophic accounting for the reasonable rice yields which may be obtained when they are developed. There is a question of balance once the land is opened. The possible sources of nutrient inflow and outflow are shown in Table 1. It may be postulated that gradual leaching of the organic material will have an adverse effect on estuarine and canal productivity. However it may turn out that the allochthonous nutrient supply from upriver floating vegetation and debris is in fact the major nutrient supplier along with mangrove vegetation. These are hypotheses which could be tested through careful field observation.

Phosphorus and perhaps micronutrient deficiencies coupled with

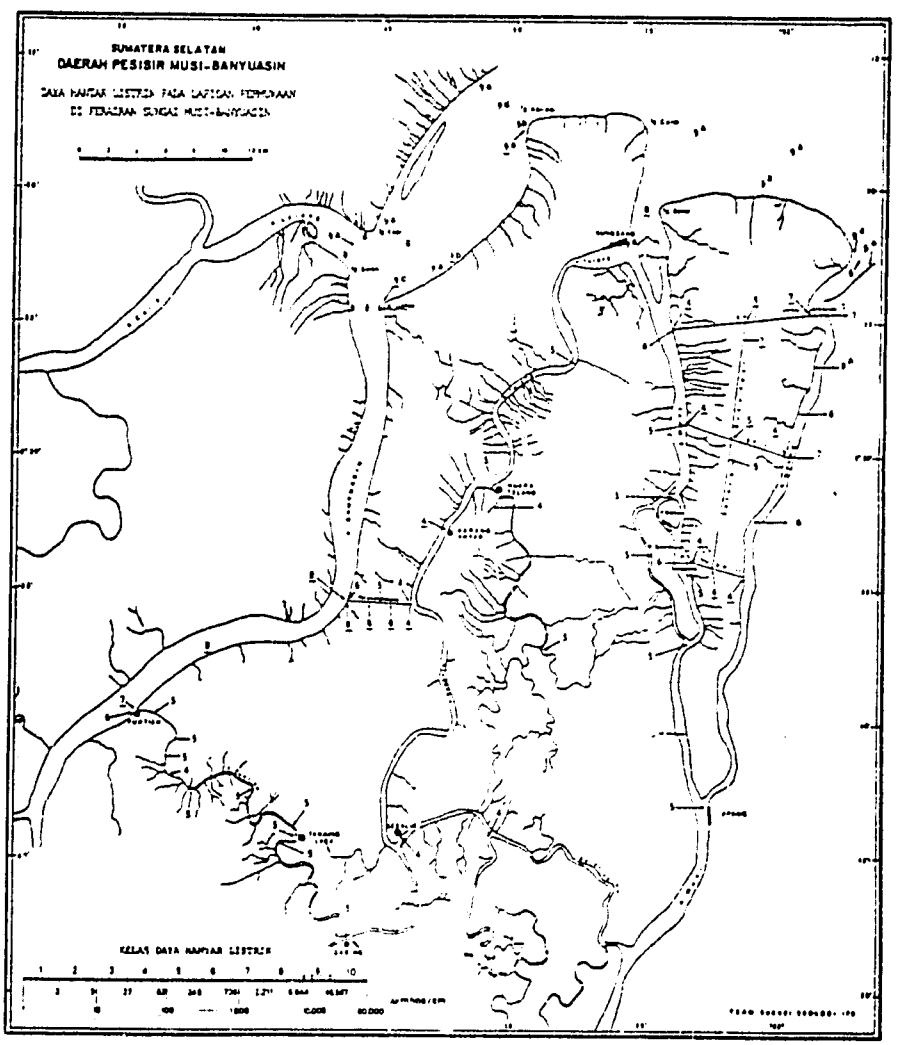


Figure 5. Distribution of surface water conductivity March April 1975 Underlined values obtained at highest high tides.

Table 3. Postulated Nutrient exchanges in the Musi river coastal zone.

1. Matrix

Outflow from \ Inflow to	A	B	C	D	E	F	G	H	I	J	K	L
A seawater		↔	-	-	-	-	-	-	-	+	-	+
B brackish/coastal water	↔		→	↔	+	+	+	-	-	+	-	?
C brackishwater swamp	-	↔		?	+	-	?	-	-	+	-	?
D "white water" river	-	↔	+		+	↔	↔	?	+	?	-	-
E "black water" river	-	↔	+	+		-	?	?	-	?	-	-
F levee vegetation	-	↔	+	→	+		+	-	-	+	-	-
G back swamp vegetation	-	?	+	-	↔	+		+	↔	+	-	-
H peat dome vegetation	-	-	?	?	→	?	+		↔	+	-	-
I f.w. organic soil deposits	-	?	+	?	↔	?	+	+		+	-	-
J clay deposits	-	?	↔	+	-	→	+	+	+		-	-
K drifting organic matter (from upstream)	-	↔	+	+	-	+	?	-	?	+		-
L rainwater	-	?	-	?	?	-	?	+	?	-	-	

↔ substantial exchange
+ moderate exchange
- no significant exchange
? uncertain

soil toxicity are the principal concerns of agronomists. Peak fertility occurs in the second year thereafter a decline occurs resulting in land abandonment between 3 and 30 years after the start of cultivation. Fertilizers are not an easy solution since they are readily flushed from the system or are quickly and almost irreversibly bound. The limitations on fertility would also hold for fish ponds. In freshwater the limiting factor will be phosphorus while in brackish water it is likely to be nitrogen.

STRATEGY (1) Protect known channels of nutrient inputs; (2) Control rate of decline by minimal land drainage, by periodic seawater flushing and by specialized planting methods (3) Build up a thin layer of conditioned soil through a combination of chemical and organic material applications; (4) Use the dry season as a period for restoring soil fertility by cultivating high productivity local plants.

2. Water level and quality control.

It is the upper floodplain not the deltaic zone which receives the highest floodwaters. They would seldom seem to exceed 1 to 1.5 m in Upang. Water level rather than sunshine duration governs the planting time for rice. On the basis of historical rainfall records in most years there is insufficient dry season rainfall for reliable planting of rainfed rice. Irrigation in the dry season carries the risk of severe salt intrusion for 2 to 3 months. Drinking water for humans and livestock, bathing water and water needed for any sort of industrial process, does not meet minimum standards in this period.

Soil drying and subsidence relative to water level are serious long-term impacts caused through poor water control. The extremely dry years (about 20% of all years) may be the most significant in terms of ecological change. For example very large areas of primary swamp forest were burned over in the exceptionally dry year 1972.

STRATEGY: (1) Optimize crop scheduling according to natural system constraints including solar radiation inputs, water availability and quality, likelihood of pest damage (2) Develop minimum water control devices to keep soil close to saturation at all times. (3) develop rainfall traps and low technology solar stills to overcome drinking water problems (4) Regulate forest use in extremely dry years.

3. Pest and disease control .

The dimensions of the pest and disease control are make more difficult by the following factors

1. Newly opened areas have not reach equilibrium conditions and in such a disturbed habitat can be expected
2. Abandoned agricultural land and forested areas near present agricultural lands constitute habitats suitable to pool pest and disease organism and vectors. It is hypothesised that such reservoirs are a significant factor in pest control programs.
3. Pest and disease build-up occurs in transmigrant rice fields at the end of the wet season. So far this build-up has prevented a dry season rice crop In addition because Bugis and local inhabitant plant traditional varieties which are still about two months from harvest at the time of transmigrant harvest the population of pest may be transfered to these fields.

STRATEGY : (1) Application of pesticides and perhaps control of mammalian predators will be required (2) Research on dynamics of pest and disease build-up is essential to pinpoint optimal control period (3) Introduction of resistant crop varieties and possibly, biological control must be examined. Mammalian pests, including deer andmonkeys may be controlled through capture or sport hunting

4. Maintenance of fishery resources .

The longterm question of fishery srability includes maintenance of habitat system productivity and adequate stock levels.

STRATEGY : (1) Keep canals tidal creeks and mangrove forests in a condition suitable for migratory and resident fish and shrimp species (2) Develop fishery resources to the fullest extend possible through aquaculture and through traditional fishery techniques in order to provid. identification of social and economic value these resources (3) Avoid the introduction of advanced fishing techniques likely to quickly decimate fishery resources.

5. Maintenance of forest

The likelihood of maintaining freshwater swamp forest after the initiation of agricultural development is slight . However in some areas th. possibility exists that greater return can

be realized through sustained yield cutting of the fresh water forest than through agricultural development. Identification of landuse capabilities is essential for determining these areas. The forest resources that can be maintained near agricultural land on a longterm basis include the mangrove and nipah forest. These are important in : (1) Maintaining estuarine productivity

(2) Serving as a traditional source of firewood and timber products

(3) Preventing coastal erosion .

STRATEGY : (1) Reserve whole areas of freshwater swamp forest instead of small areas close to agricultural settlement (2) Develop an overall strategy of forest development in the coastal zone, so that concessions discriminate between the forests present: (3) Avoid complete removal of mangrove forest areas (4) Protect nipah forest from agricultural land development (5) Develop a strategy of silviculture and perenial crops in the agriculture areas .

6. Animal husbandry

The swamplands area are not suitable for large animals like water buffaloes, but present potentials for small stock which can be hand fed and ducks. The food supply could include low-value products perhaps including fish and agricultural waste products as well as some components of existing or introduced marsh vegetation. The problems of micro-nutrient deficiency e.g. Cu and Zn for pigs and of seasonal food scarcity which strongly influence pig production.

STRATEGY : (1) To develop adequate food supply by selecting or introducing edible grasses and diverting agricultural waste products to animal husbandry (2) Establish test farm trials of animal husbandry to overcome disease and farm management problems.

7. Human Settlement

While the limitations on agriculture are important for permanent settlement, the social interactions among settler groups and established residents and the problems of human disease and infrastructure development must be recognized. At present work opportunities and income are unevenly distributed among different groups,although labor shortages may be a critical factor in expanding agricultural development.

Pioneer landuse carries with it a higher risk of disease untill land and water regulations can be assured. Certain patterns of settlement and resource use will unnecessarily exacerbate the situation. For example, partial opening of the mangrove areas will increase populations of Anopheles sundaicus. Low quality dry season water supply is perhaps the single most important public health problem. Transport in the swampland is logically depending on waterways than on roads. Consequently, location of settlement near waterways is a crucial factor in access to markets. Because the swamplands are recent deposits with low weight bearing capacity the potential for industrial development and road construction is small.

STRATEGY : (1) Landrights and the right to resource exploitation among inhabitants must be determined in an equitable fashion among settlers and local inhabitants. (2) Land and water resources use zoning is required as an ecological basis for creating the pattern of human settlement (3) monitoring of ecological factors likely to contribute to human disease outbreaks is essential . (4) innovative concepts for basic human needs including housing and water supply e.g. inexpensive solar distillation units and sewage digester systems which (5).The patterns and location of housing should take into account settlers preferences, distance from agricultural fields and forests plus natural hazards, such as river bank erosion and extreme high or low water zones. (6) Major infrastructure developments such as ports, roads, canals and channel maintenance should take into account the possibility of erosion and deposition,and the impact of major submerged soil excavation on other resource uses.

Conclusion

The problems discussed above require an integrated strategy for coastal zone management which must fit in to a broader regional plan. The environment and resource evaluation must include environmental impact assessment, resource economics decision and analysis, and a monitoring program. The need for in depth research of selected topics must be stressed, as well as the coordination of studies. Unless there is a commitment of long-term agricultural

extension activities and effective means of regulating resource use the likehood it high for permanent damage to this overall balance of productivity in these coastal delta estuarine systems.