The Coastal Environmental Profile of Segara Anakan-Cilacap, South Java, Indonesia

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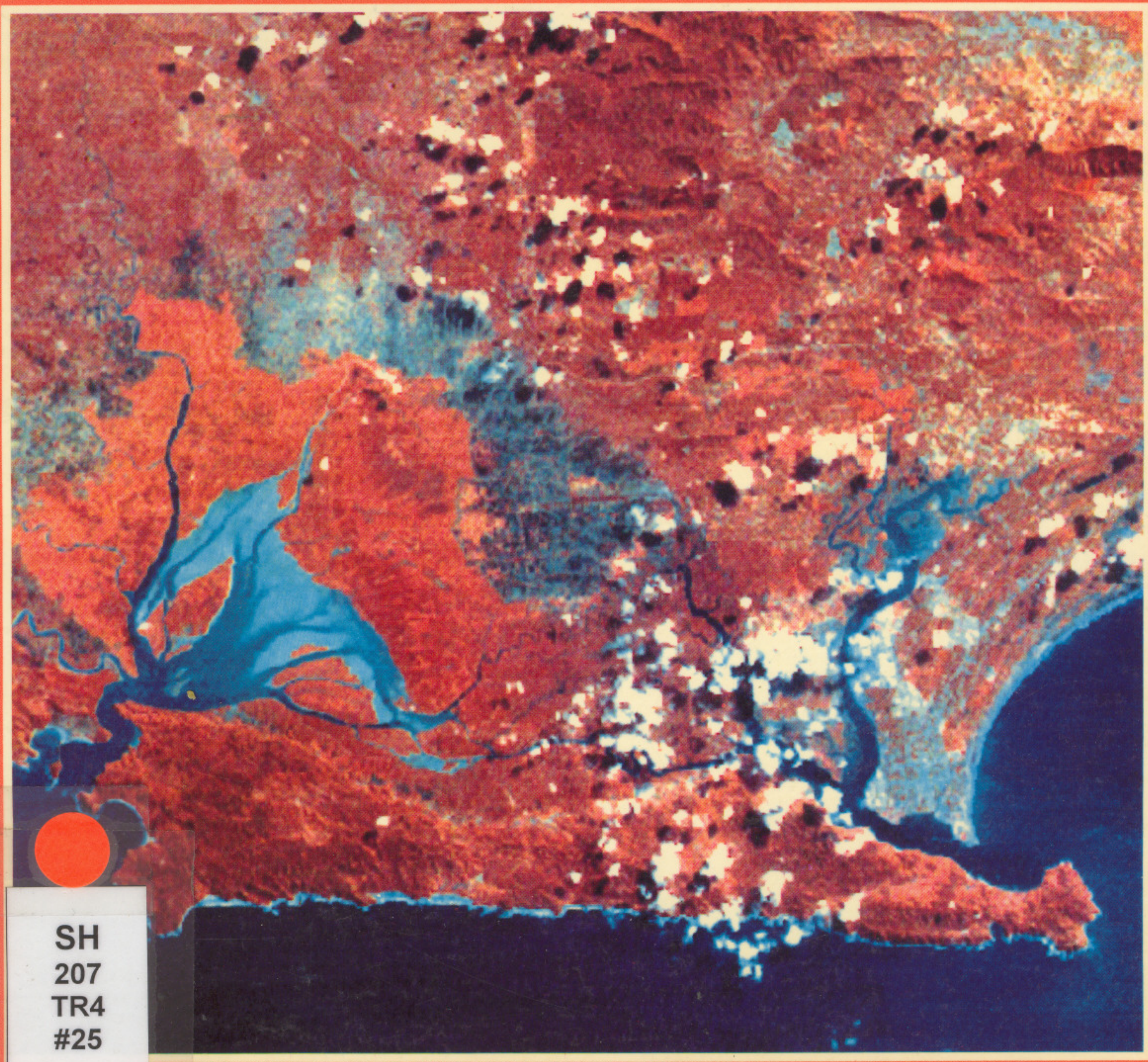

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Cover: *(Front)* False color composite of Bands 1,2 and 3 of landsat-MSS sub-image taken on 17 May 1987 and processed at Earth Resources Satellite Ground Receiving Station, National Institute of Aeronautics and Space (LAPAN), Indonesia. Shown, among others, are Nusa Kambangan *(below)*, which looks like part of the main island of Java, Cilacap *(lower right)*, Cilacap Bay and Segara Anakan *(left)* with its various levels of turbidities and swampy area.

(Back, counterclockwise) (1) The accretion of silt adjacent to the mangrove forest continues with the high rate of sedimentation to Segara Anakan. (2) Traditional crab fishermen place their traps near the mangrove forest in protected waterways. (3) Segara Anakan fishermen market some of their catch in the nearby town of Cilacap through fish vendors.

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List of Acronyms and Abbreviations

AAETE	Agency for Agricultural Education, Training and Extension
AARD	Agency for Agricultural Research and Development
ASEAN	Association of Southeast Asian Nations
BAKN	Civil Service Administration Board
BAKOSURTANAL	National Coordinating Agency for Surveys and Mapping
BAPPEDA	Provincial and District Planning Board
BAPPENAS	National Development Planning Board
BATAN	National Atomic and Energy Agency
BKKBN	National Family Planning Coordination Board
BPK	Supreme Audit Body
BPPT	Agency for Assessment and Application of Technology
BPS	Central Bureau of Statistics
BULOG	State Logistics Board
CIDA	Canadian International Development Agency
CORD	Centre for Oceanological Research and Development
CRM	Coastal resources management
CRMP	Coastal Resources Management Project
DBH	Diameter at breast height
DGF	Directorate General of Fisheries
DGWRD	Directorate General of Water Resources Development
DPA	Supreme Advisory Council
DPR	People's Representative Council
ECI	Engineering Consultants, Inc.
ECT	Economic Team
EIA	Environmental impact assessment
ET	Ecology Team
FSC	Fisheries Service Cilacap
HNSI	Himpunan Nelayan Selurah Indonesia (All Indonesian Fishermen Association)
ICLARM	International Center for Living Aquatic Resources Management
IHE-ARD-MPW	Institute of Hydraulic Engineering-Agency for Research and Development-Ministry of Public Works
LAPAN	National Institute of Aeronautics and Space
LIPI	Indonesian Institute of Sciences
LPSM	People's Self Reliance Development Group
MA	Ministry of Agriculture
MC	Ministry of Cooperatives
MDS	Ministry of Defense and Security
MEC	Ministry of Education and Culture
MF	Ministry of Forestry

MHA	Ministry of Home Affairs
MME	Ministry of Mining and Energy
MPR	People's Consultative Assembly
MPW	Ministry of Public Works
msl	mean sea level
MSRT	Ministry of State for Research and Technology
MSY	Maximum sustainable yield
MT	Ministry of Transportation
MTPT	Ministry of Tourism, Posts and Telecommunications
NAB	National Agrarian Board
NGO	Nongovernmental organization
NKPA	Nusa Kambangan Prison Authority
Perhutani	State Forest Corporation
PKK	Pendidikan Kesejahteraan Keluarga (Women's Vocational Training)
ppt	parts per thousand
RICA	Research Institute for Coastal Aquaculture
RIMF	Research Institute for Marine Fisheries
SMPE	State Ministry of Population and Environment
US	United States
USAID	United States Agency for International Development

Preface

Indonesia has the second longest coastline (81,000 km) of all countries in the world. Tremendous benefits could be derived from the coastal resources. But, as in many developing countries, these resources are being quickly depleted and degraded. The Segara (lagoon) Anakan-Cilacap area, on the south coast of Central Java, is rich in resources but is rapidly being altered by human activities. The key resource use problems and conflicts in the area include:

1. High levels of sedimentation in the lagoon resulting from poor upland agricultural practices, modern flood control measures and natural causes;
2. Loss of mangroves and tidal swamplands which support traditional fisheries;
3. Overfishing and use of destructive methods;
4. Agricultural runoff and potential pesticide and oil pollution in the lagoon;
5. Improper utilization of the mangrove forest;
6. Management of the large inputs of silt, resulting land accretion and decreasing size of the lagoon; and
7. Declining socioeconomic/livelihood status of the already poor inhabitants of Segara Anakan.

The Segara Anakan-Cilacap coastal region is the only major estuarine-mangrove zone in Java which supports intensive use by local people. The renewable resources and unique values of the area require sound management strategies which can be implemented practically.

Many development programs have been attempted and exist in the area. Human settlement plans, industrial sites, port construction, agroforestry activities and proposed recreation-tourism plans are examples. But not all are compatible with sound resource use, and several have caused conflicts among users and environmental degradation.

Water quality in the area varies greatly in time and space due to the influence of tidal inflows mixing with river water. Most parameters indicate a suitable condition for fisheries. However, high levels of sedimentation have an impact on bottom fauna, depreciating it and the fisheries as a whole while the lagoon decreases in size.

The Segara Anakan-Cilacap area is inhabited by two ethnic groups, the Javanese and the Sundanese. Social and economic solidarity among these peoples at the grass roots level is strong in a traditional sense but not through formal organization. Thus, it will be important to consider the implications of CRM on the peoples' traditional life-style and how they can participate in the process.

Poverty and inadequate drinking water lead to poor health. There is lack of education so that the implications of overuse of natural resources are not readily understood. A final and important consideration is the lack of institutional-govemmental coordination in the area. Without such coordination in a potential management plan, success will be limited.

In light of these issues and the recognition of the value of the coastal resources, it is apparent that sustainable use management is necessary. The ASEAN-US CRMP (Indonesian component) is beginning to generate an integrated management plan for Segara Anakan-Cilacap area. This coastal profile is the first attempt to summarize appropriate existing information on management of the area so that implementation can proceed. Since around 1970, intentions to stabilize the use of resources have led to baseline studies and accumulation of many data. However, data gaps still exist and much of the information gathered is not relevant for management purposes.

Many of the data in this profile are derived from a study on the ecological aspects of Segara Anakan carried out by the Ecology Team, Faculty of Fisheries, Bogor Agricultural University. The study's main objective was to obtain basic ecological information from which future resources management alternatives could be derived. The study results were contained in the "Ecological aspects of Segara Anakan in relation to its future management" (1984), which was made possible by the Institute of Hydraulic Engineering, Agency for Research and Development, Ministry of Public Works (IHE-ARD-MPW), Indonesia, and the research team.

The study consisted of a preparatory stage, a pre-survey and field surveys. The preparatory stage was conducted in Bogor and Bandung in July to October 1982. The pre-survey was in July 1982 in Segara Anakan and its surroundings, and the field work, in July to November 1983. Two comprehensive studies were conducted in July and November 1983, each for three weeks. Between these periods, monthly monitoring was done. Emphasis on the interaction of inter- and intraecological components has provided better understanding of the dynamics and importance of each component to the Segara Anakan ecosystem.

The Ecology Team consisted of: Ir. Supomo T.H. Wardoyo (leader), Dr. Ir. Kardiyo Praptokardiyo (vice leader), Dr. Ir. Joko Purwanto, Ir. Kadarwan Soewardi, Chairul Muluk, M.Sc., Drs. Sukristiono Sukardjo, Dr. Ir. Enan M. Adiwilaga, Ir. Bambang Irawan, Ir. Gelar Wira Atmadja, Ir. Hermanu Triwidodo, Ir. Warti Sumarsini, Ir. Asryanto, Ir. Djuwito Djunadi, Eddy Kurniarayadi, A.B. Djunaedi, Ruslan and Sodikin.

Another important reference is the Engineering Consultants, Inc. (ECI) report to the Lower Citanduy River Basin Project under the MPW. The report, which was based on primary data and the above study, made recommendations for the physical maintenance of Segara Anakan. The report is discussed in this profile.

The document was originally compiled by Mr. Tatang Sujastani, the Project Consultant engaged to review all the literature on the area. It has since been reviewed by several persons whose attention is much appreciated. These were: Dr. David McCauley (USAID-Jakarta); Mr. Tatang Sujastani (Department of Fisheries, Ministry of Development, Brunei Darussalam); Dr. Daniel Pauly (ICLARM); Mr. Jay Maclean (ICLARM); and Ir. Chairul Muluk (Bogor Agricultural University).

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Foreword

The coastal waters of Southeast Asian countries have some of the world's richest ecosystems characterized by extensive coral reefs and mangrove forests. Blessed with warm tropical climate and high rainfall, these waters are further enriched with nutrients from land which enable them to support a wide diversity of marine life. Because economic benefits could be derived from them, the coastal zones in these countries teem with human settlements. Over 70% of the population in the region live in coastal areas which are characterized by high-level resource exploitation brought about by increasing population pressure and associated economic activities over the last two decades. Large-scale destruction of the region's valuable resources has caused serious degradation of the environment, thus affecting the economic condition and quality of life of the coastal inhabitants. This lamentable situation is mainly the result of ineffective or poor management of the coastal resources.

It is essential to consider coastal resources as valuable assets that should be utilized on a sustainable basis. Unisectoral overuse of some resources has caused grave problems. Indiscriminate logging and mining in upland areas might have brought large economic benefits to companies undertaking these activities and, to a certain extent, increased government revenues, but could prove detrimental to lowland activities such as fisheries, aquaculture and coastal-tourism-dependent industries. Similarly, unregulated fishing efforts and the use of destructive fishing methods, such as mechanized push-netting and dynamiting, have caused serious destruction of fish habitats and reduction of fish stocks. Indiscriminate cutting of mangroves for aquaculture, fuel wood, timber and the like have brought temporary gains in fish production, fuel wood and timber supply but losses in nursery areas of commercially important fish and shrimp, coastal erosion and land accretion.

The coastal zones of most nations in the Association of Southeast Asian Nations (ASEAN) are subjected to increasing population and economic pressures manifested by a variety of coastal activities, notably, fishing, coastal aquaculture, waste disposal, salt-making, tin mining, oil drilling, tanker traffic, rural construction and industrialization. This situation is aggravated by the expanding economic activities attempting to uplift the standard of living of coastal people, the majority of which live below the official poverty line.

Some ASEAN nations have formulated regulatory measures for their coastal resources management (CRM) such as the issuance of permits to fishing, logging, mangrove harvesting, etc. However, most of these measures have not proven effective due partly to enforcement failure and largely to lack of support for the communities concerned.

Experience in CRM in developed nations suggests the need for an integrated, interdisciplinary and multisectoral approach in developing management plans providing a course of action usable for daily management of the coastal areas.

The ASEAN-United States (US) Coastal Resources Management Project (CRMP) arose from the existing CRM problems. Its goal is to increase existing capabilities within ASEAN nations for developing and implementing CRM strategies. The project, which is funded by the US Agency for International Development (USAID) and executed by the International Center for

Living Aquatic Resources Management (ICLARM), attempts to attain its goals through these activities:

- analyzing, documenting and disseminating information on trends in coastal resources development;
- increasing awareness of the importance of CRM policies and identifying, and where possible, strengthening existing management capabilities;
- providing technical solutions to coastal resources use conflicts; and
- promoting institutional arrangements that bring multisectoral planning to coastal resources development.

In addition to implementing training and information dissemination programs, CRMP also attempts to develop site-specific CRM plans to formulate integrated strategies that could be implemented in the prevailing conditions in each nation.

Indonesia is an archipelagic nation with an extensive coastline. The coastal area is thickly populated and heavily utilized, thus, playing a significant role in ensuring stability of the rural economy. Like other developing nations, Indonesia faces problems on resource use conflicts primarily caused by poor planning and management. Poverty, especially in the rural areas, aggravates the problems.

Sustainable development is achieved through adequate resource use planning and effective management. Many countries which have paid a substantial price for not protecting their primary resources have begun undertaking appropriate coastal area planning and developing practical management strategies. Indonesia is one of these countries.

The project has chosen Segara Anakan as pilot site for one of the case studies being conducted in the ASEAN region. As shown by research, the lagoon performs significant ecological and economic functions such as serving as a nursery area for finfish and shrimp. *The coastal environmental profile of Segara Anakan-Cilacap, South Java, Indonesia* is the result of an exhaustive primary and secondary research over a two-year period by the planning team. Nevertheless, information gaps were also identified for further study by the research team. This profile will be valuable in the formulation of a management plan for the area.

Mr. Tatang Sujastani of Indonesia did a lot in compiling the initial project report on Segara Anakan. Dr. Alan T. White and Ms. Marie Sol M. Sadorra, both of ICLARM, put in a lot of personal efforts in editing this profile. Dr. Purwito Martosubroto of the Directorate General of Fisheries, Indonesia, also provided valuable assistance which facilitated data collection and interpretation. Rachel C. Josue and Rachel Atanacio, both of ICLARM, typed the manuscript and drew the figures, respectively. All these efforts are greatly appreciated.

Chua Thia-Eng
Project Coordinator
ASEAN-US Coastal Resources
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Chapter 1
Introduction

TATANG SUJASTANI AND
ECOLOGY TEAM - BOGOR AGRICULTURAL UNIVERSITY

Segara Anakan and its surrounding environments in the Cilacap coastal area are a unique ecological feature in Java (Fig. 1.1). The area, a continuation of the Citanduy Depression Zone of Java (Rahardjo 1982), has long been recognized as resource-rich. Numerous proposals have been made for resource development and management. Interest in the development of the area dates back prior to World War II when attempts were made to divert part of the downstream portion of Citanduy River into Segara Anakan.

Blommenstein (Ludwig 1985) considered the possibility of converting Segara Anakan into a polder by diking Citanduy and diverting its discharge directly to the Indian Ocean. He intended to close off Segara Anakan from the sea by means of cutoff dikes at the outlets. It was further proposed that the resulting polder be drained by pumping and that entry of local rainfall runoffs flush the salt water so the area could be converted to productive agricultural land.

The Citanduy River Basin Development Project (DGWRD-DR 1976) envisioned the conversion of the lagoon from a brackishwater tidal estuary into a freshwater lake. This was to be accomplished by the construction of tidal levees and gates at the outlets to the sea; the diversion of the silt-laden Citanduy River directly to Indian Ocean; and the diversion of Donan River into the lagoon. The surrounding tidal-dependent mangrove, tidal swamp and marsh areas would be naturally desalinated by this procedure and reclaimed for agriculture (Ludwig 1985).

It was noted in 1975 that the major fisheries value of the lagoon was as a source of shrimp and finfish captured by offshore fishing vessels. The value of fish captured within the lagoon was considered small in comparison. The possibility of using the shallow freshwater lake resulting from the proposed development for aquaculture appeared to be limited. Subsequent reports on the Segara Anakan Reclamation Project indicated that the sedimentation filling rate had accelerated rapidly and that the usefulness of the lagoon as envisioned before was seriously impaired (Ludwig 1985). (Table 1.1 shows the change in land and water areas from 1900 to 1984.)

These studies focused on the reclamation aspect and were oriented to augmenting available agricultural land. The ecological and fisheries studies were limited.

Since these proposals were made, the Ecology Team has shown that Segara Anakan performs a significant biogeographical role for many aquatic organisms and, in particular, for migratory populations. Ecologically, the interrelated mangrove complex and the Segara Anakan aquatic systems are believed to have a significant role to the adjoining marine coastal ecosystem. On the other hand, this adjoining system and the water drainage systems flowing into the lagoon perform important functions. The resources which evolved from these dynamic interactions are exploited by the local inhabitants, and thus possess a socioeconomic role. The

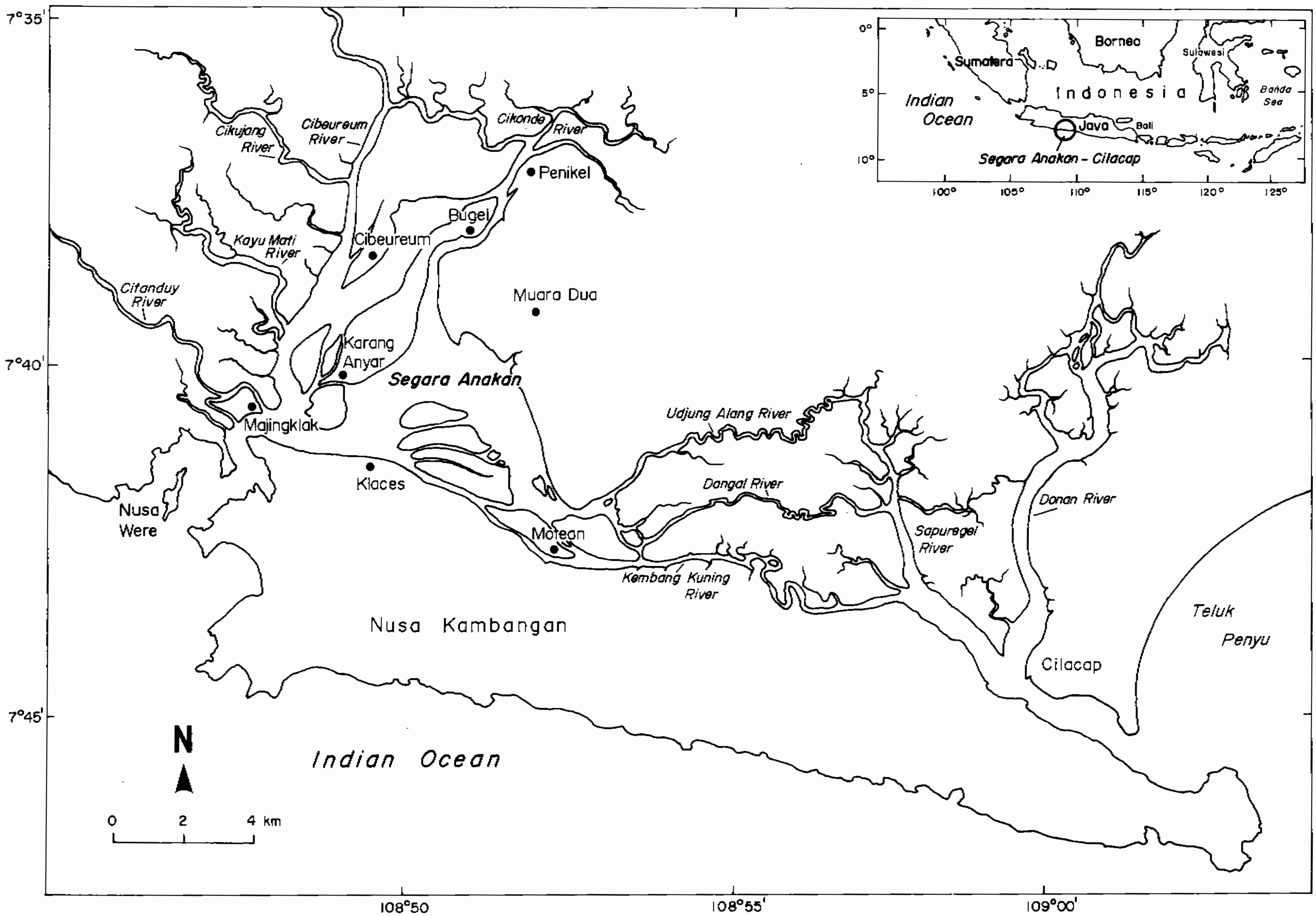

Fig. 1.1. Segara Anakan-Cilacap and vicinity.

Table 1.1. Change in Segara Anakan land and water areas (ha) from 1900 to 1984 (Ludwig 1985).

Year	Total lagoon area including islands	Island area	Net water area	Water area loss Total	Water area loss Per year
1900	6,898	223	6,675		
1924	6,791	346	6,445	230	10
1940	6,645	596	6,049	396	25
1946	6,061	649	5,412	637	106
1961	5,444	707	4,737	675	45
1978	4,831	979	3,852	885	52
1980	4,680	1,042	3,636	214	107
1982	4,375	1,169	3,206	432	216
1983	4,313	1,354	2,959	247	247
1984	4,050	1,289	2,761	198	198

conceptual linkages of the lagoon and drainage basin; the roles performed by Segara Anakan; and management possibilities are shown in Fig. 1.2.

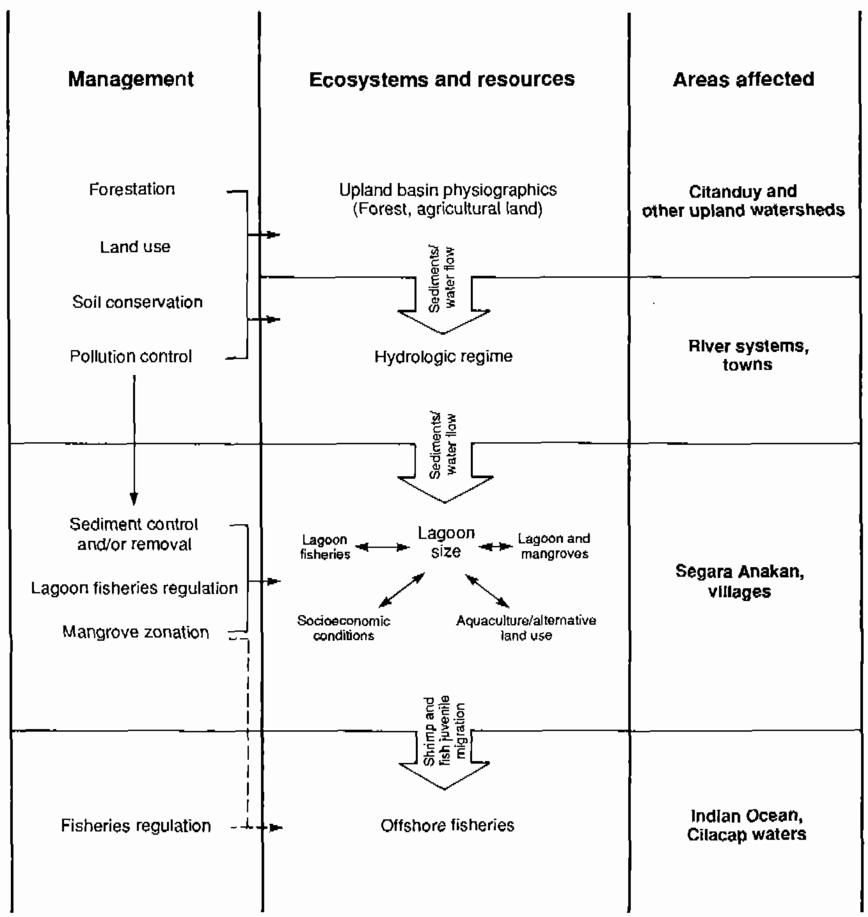

Fig. 1.2. Conceptual overview of upland Segara Anakan ecosystem and human interaction.

At present, the Segara Anakan system constitutes and/or is affected by six linked components, each having a significant role (Fig. 1.2). The important components and processes in the area are:

1. Hydrological aspects;
2. Natural resource ecosystems (mangrove, offshore and lagoon system);
3. Physiographical aspects, which include: hydrological changes, land subsidence and submergence and erosion in the upper river basin and the adjacent coastal lands;
4. Terrestrial vegetation; and
5. Socioeconomic aspects which include human activities affecting the area and how people are affected by the changing resource base.

Siltation may adversely affect some fish species in the lagoon, but may benefit others, especially those with the ability to adjust to the resulting water system. This condition arises due to environmental changes, often drastic, which will further cause changes in the availability and/or accessibility of preferred habitat which may function as refuge, spawning, nursery, feeding or general living area; and natural food supply, both in quality and quantity.

Segara Anakan and its adjacent areas as estuarine lagoons are important as sources of fisheries commodities for food and commerce by the local people. Maintenance of productive fisheries may require limitation of fishing effort and protection of habitat. The fisheries resources and estuarine-mangrove habitat are modified by: (1) increases in sedimentation; (2) reduction of mangroves by human encroachment; (3) potential influence of pollution from pesticides in the agricultural runoff water; (4) water pollution from human settlements and industrial sites; and (5) overfishing of the lagoon fisheries.

Chapter 2
Geography and Physical Setting

ECOLOGY TEAM - BOGOR AGRICULTURAL UNIVERSITY,
MULIA PURBA AND TATANG SUJASTANI

Segara Anakan

The Segara Anakan-Cilacap area is located on the southeast coast of Central Java (Fig. 2.1). It is protected from Indian Ocean by Nusa (island) Kambangan, having two openings to the ocean, the western (at the southwest corner of the lagoon) and the eastern passages. Freshwater inflow from the three major rivers of Citanduy, Cibeureum and Kawunganten and other minor rivers is discharged through these passages into the Indian Ocean. The lagoon is influenced by tidal actions of Indian Ocean through the passages. The eastern opening is long, shallow and narrow; while the western opening is more important for tidal action as it is shorter, deeper and wider than the eastern channel and carries a much greater proportion of the tidal water. A part of Citanduy water discharge flows indirectly into Segara Anakan through Nusa Were and Cibeureum River (Fig. 2.1).

Segara Anakan consists of a central lagoon surrounded by mangrove swamps and intertidal land which have been converted into ricefields. The central lagoon is surrounded by about an equal area of sloughs and tributaries draining from mangrove swamps and intertidal converted land. These systems cover a total land area of about 8,345 ha (ECI 1974a). There are about 15,000 ha of mangrove tidal swamps, and the entire area is about 25,000 ha (Table 2.1).

The morphometric details of the lagoon are shown in Table 2.2. The surface area of Segara Anakan is about 3,225 ha. Maximum depth of the west opening channel is about 10-14 m. The average depth of the lagoon, however, is only 1.48 m. Water depth varies from 0.2-2.6 m below mean sea level (msl). These data clearly illustrate that the larger part of the lagoon is an extensive shallow area, originally part of the tidal mudflat. The lagoon's volume, as estimated in 1976, was more than 50% water less than 0.5 m deep, whereas only 10% of the lagoon volume was found below 3 m. Thus, thermal stratification and oxygen depletion in the deep layer is unlikely, and wind-driven turbulence is pronounced, causing intense and frequent mixing.

The large, swampy lagoon west of Cilacap City is a southeast continuation of the broad alluvial plain of Citanduy. It is surrounded by the estuaries of Citanduy-Cibeureum and Donan Rivers, sheltered by Nusa Kambangan from the waves and currents of Indian Ocean. The river silt loads dominate the deposition causing a narrowing and shallowing of the lagoon. The tide-affected lowland is swampy, crisscrossed by tidal channels underlined by alluvium and swamp sediments consisting of clay and silt mixed with organic materials (Rahardjo 1982).

The Segara Anakan area and volume have been gradually decreasing because of upland sediment intrusion which is causing sediment accretion. Several islands have developed

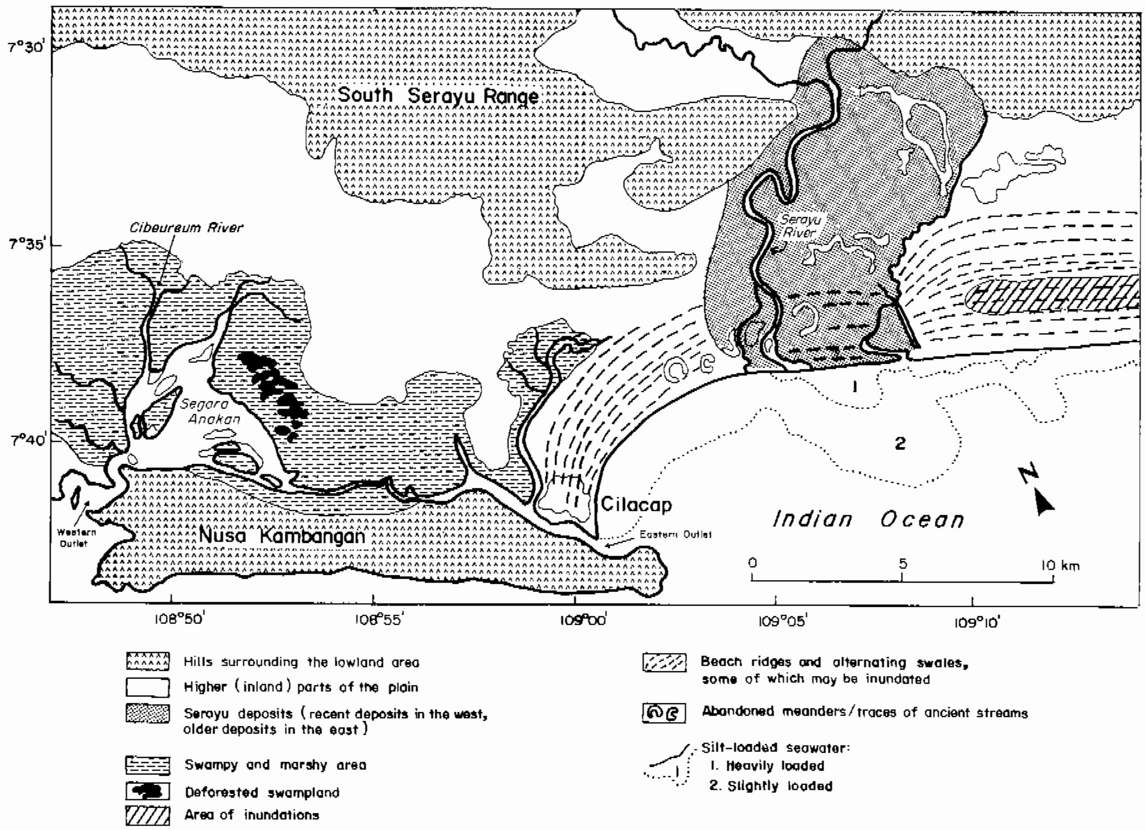

Fig. 2.1. General geomorphology of Cilacap region based on LANDSAT MSS 4, 5 and 6 (27 August 1978 image interpretation) (Hadisumarno et al. 1982).

Table 2.1. Tidal swamp and associated saline areas, Segara Anakan and environs (Ludwig 1984).

	Landscape areas (ha)					
	Tidal swamps		Tidal	Formerly cultivated		
Zone	Mangrove	Formerly cultivated	marsh	Tidal swamp	Tidal marsh	Total
West Citanduy	119	-	-	122	-	241
Citanduy-Cibeureum	1,928	558	-	2,658	823	5,967
Cibeureum-Jagadenda	1,882	294	-	1,468	721	4,365
Jagadenda-Udjung Alang	4,128	11	206	510	1,774	6,629
Udjung Alang-Sapuregel	2,962	-	-	-	-	2,962
Sapuregel-Donan	1,564	-	-	34	41	1,639
East Donan	844	-	-	39	41	924
Nusa Kambangan	1,734	-	-	-	114	1,851
Islands in Segara Anakan	390	-	-	-	-	390
Total	15,551	863	206	4,831	3,514	24,968

in the lagoon and are increasing in size. Other islands have joined the mainland. The accretion rate in the lagoon varies with the erosion rates in the Segara Anakan Basin and/or Citanduy River Basin.

The rate has also increased following river improvement works of straightening, channel enlargement and the construction of levees (ECI 1987). Fig. 2.2 shows the land accretion in 1976 and 1980. In 1986, the lagoon area was 2,700 ha (a decrease of 58% since 1903).

Table 2.2. Morphometrical data of Segara Anakan (ET 1984).

Total surface area	3,225	ha
Maximum depth	14	m
Mean depth	1.48	m
Width	3.9	km
Length	10.4	km
Water level fluctuation	41-191	cm
Water surface area at:		
high water level	829	ha
low water level	488	ha
Volume below msl	29.1	million m^3

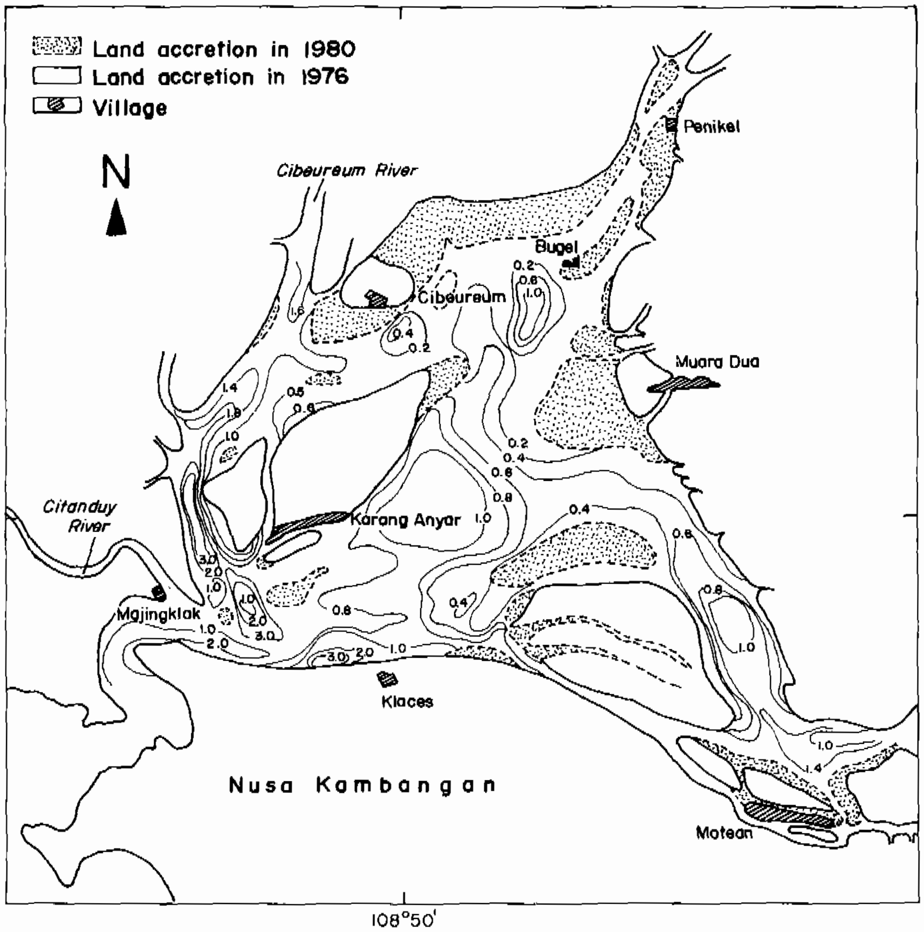

Fig. 2.2. Segara Anakan configuration, based on July 1980 survey showing bottom depth contours (m) and land accretion (adapted from ECI 1974a).

If the present conditions prevail, it is estimated that the lagoon will become a mangrove forest with a network of tidal waterways draining into the western outlet by year 2000 (ECI 1987). In November 1986, the volume below msl of Segara Anakan was estimated to be significantly lower than the early 1900s. The western outlet has also undergone changes being 40 m deep in 1817 and now 10 m deep at most places (ECI 1987). These changes are due to sediment deposition in the channel which reduces the tidal flow and reflects sediment accretion in the lagoon. The eastern outlet has not changed much.

Segara Anakan Catchment Area and Land Use

The Segara Anakan catchment area forms the lower end of Citanduy Valley which extends from Sidareja Lowlands and the origin of Cijulang River in the west to the headwaters of Jeruk Legi River in the east, and from the headwaters of Cihaur River in the north to Nusa Kambangan in the south. The topographic and physiographic characteristics of the catchment area are encompassed by the lagoon and its environs which cover about 32,500 ha of Sidareja east and 63,500 ha of the north area. The lagoon principally collects the runoff and inflowing water from Citanduy/Ciseel River Basin (ECI 1972; ECI 1973; ECI 1974a) (Fig. 2.3).

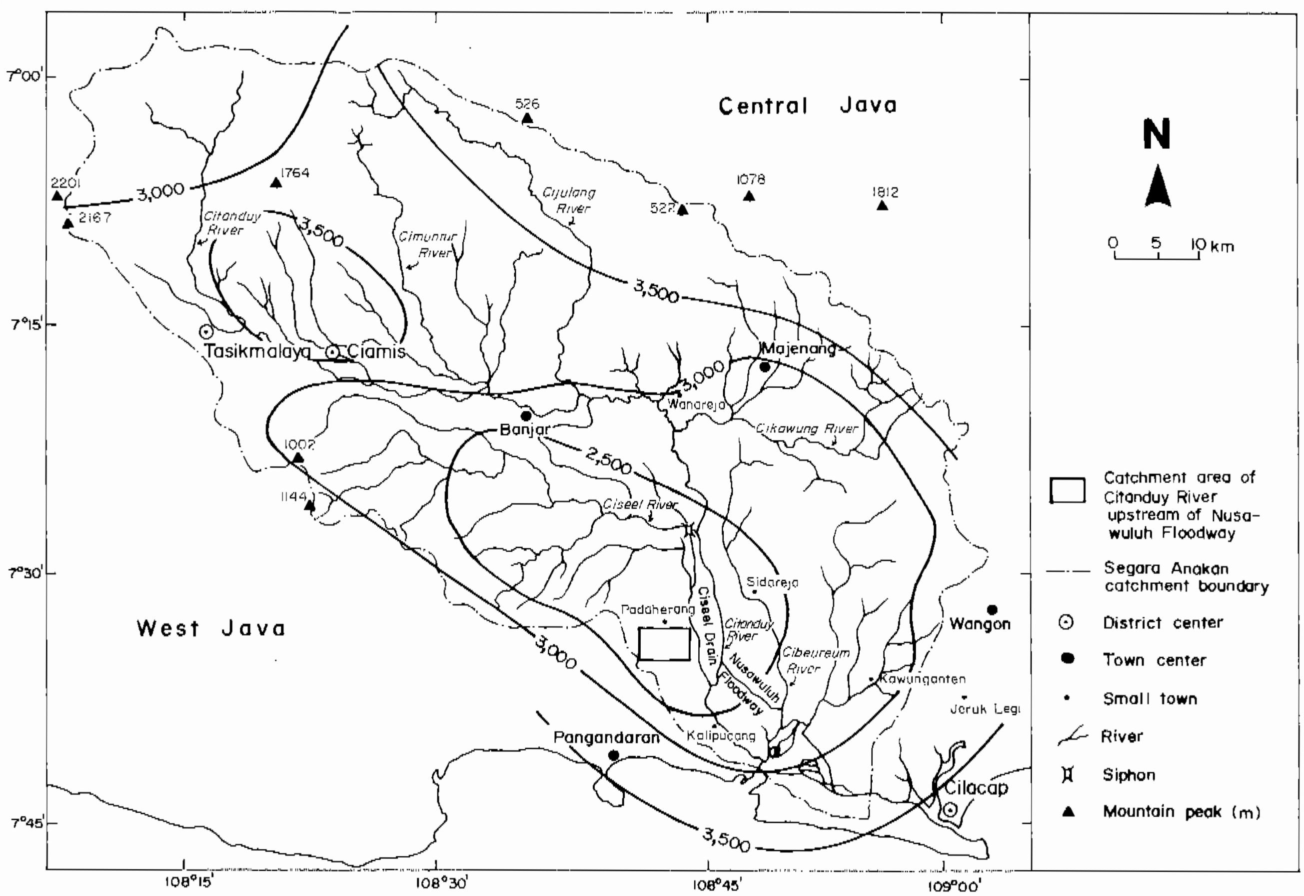

Fig. 2.3. Citanduy and Segara Anakan catchment area, showing mean annual rainfall (mm) for period 1915-1984 (ECI 1987)

The drainage pattern in the upper reaches of Citanduy/Ciseel River Basin features incised residual soils formed from weathered quarternary volcanic materials, tertiary basalts and andesites, while the volcanic ash and debris erupted from Galunggong Mountain are mixed with these soils. At higher and lower elevations, the soils are endosols and latosols, respectively (ECI 1973; ECI 1974b; ECI 1979b).

Downstream from Tasikmalaya, Citanduy River flows through a narrow V-shaped valley with steep slopes, varying in depth from 75-100 m. This midstream section, which terminates at Banjar, has a total length of 65 km and drops from an altitude of 335 to 15 m above sea level at Banjar (ECI 1974a) (Fig. 2.3).

A short distance upstream from Banjar, Citanduy River is joined by Cimuntur River. The Cijulang and Cikawung Rivers join Citanduy at a point downstream at Banjar. From this point, Citanduy flows through Wanareja Swamp. Here, the gradient suddenly flattens, and the valley widens into flood plains. Upon emerging from Wanareja Swamp, the river meanders through a flood plain until it reaches the sea. The flood plain is composed of sedimentary deposits built up from sediments brought down from the upper reaches of the river (ECI 1974b).

The overall Citanduy/Segara Catchment Area then consists of two main basins, the Citanduy River System with an area of 350,000 ha and the Segara Anakan Basin with 96,000 ha (ECI 1975) (Fig. 2.3). In Citanduy, about 290,000 ha are upland and the rest, lowland. In Segara Anakan, 32,500 ha are the lagoon environs and the rest, the east and north areas of Sidareja. The lagoon environs consist of 8,150 ha of water area and 24,350 ha of mangroves/tidal marshes/tidal swamps, 8,345 ha of which had been converted to paddy by 1972. The Citanduy Basin is regarded as separate from Segara Anakan Basin. However, because Citanduy River passes through the southwest corner of Segara Anakan on its way through the western outlet to the sea, the river tends to flow into the lagoon and deposit much sediment load there during flood tide. Only part of this load is flushed out during ebb tide.

Several smaller rivers in Segara Anakan Watershed discharge into the lagoon and deposit their silt there, but the main problem of acceleration of the lagoon's filling rate is from Citanduy Basin. About 30% of this basin is flat and presents no erosion problem; 50% (between 35 and 500 m high) has undulating/hilly topography with terraces and so has little erosion; and the rest (< 500 m high) has steep slopes with fine textured soil which easily erodes if not covered with vegetation. In 1975, some 74,000 ha of Segara Anakan Watershed Area were said to be in the "critical erosion" category (ECI 1975). About 25% (about 117,543 ha) of the Citanduy Basin has gentle slopes (> 100 m high); 45% (about 207,143 ha), between 100 to 500 m high; 18% (about 83,163 ha), between 500 to 1,000 m high; and the rest, more than 1,000 m high.

Of the 96,000 ha in the Segara Anakan Watershed, 83,500 ha are used: 58% for farming; 38%, forestry (mangroves); and 4%, other uses (ECI 1975). Napitupulu and Ramu (1980) estimated the land use pattern for Segara Anakan Basin as follows: forestry and plantation, 27,000 ha (28%); upland, 11,000 ha (11.5%); homes and gardens, 11,000 ha (11.5%); lowland rice, 23,000 ha (24%); and mangrove and lagoon, 24,000 ha (25%). For Citanduy Basin, land use is primarily between agriculture (57%) and forestry and plantation (33%) (RMI 1986). The patterns are constantly changing so that by 1989 the present areas will have changed somewhat.

Climate

Two seasons affect the area, the rainy or wet, from November to April, and the dry, from July to September. The average monthly rainfall ranges from 100-180 mm during the latter, and from 180-400 mm during the former. The average annual rainfall is about 2,900 mm with a range of 87 mm in August to 378 mm in November. Table 2.3 shows the climatic data for Cilacap and Segara Anakan and Table 2.4, for the larger Cilacap region.

The equatorial climate has a high average monthly temperature of 26.7°C. The deviation of the mean monthly temperature from the mean annual temperature is seldom greater than 1°C, and the difference between the maximum and minimum temperatures is about 7°C. The

Table 2.3. Climatological data for Cilacap and its adjacent area in maximum and average of 10 years (Uktolseya 1984).

Month	Wind direction variations	Maximum wind velocity (knots)	Height of waves (m)	Average temperature (^{o}C)	Average pressure (mb)	Average rainfall (mm)
January	W-SW-S	17	2.5	30.9	1,009	354
February	SW-S-SE	16	1.5	31.0	1,008	252
March	W-SW-SE	16	1.5	31.3	1,009	235
April	E-SE	20	2.5	30.1	1,010	171
May	E-SE	20	2.5	30.1	1,010	312
June	E-SE	16	1.5	28.9	1,010	357
July	SE	22	4.0	28.0	1,010	149
August	SE	20	2.5	28.4	1,010	102
September	SE	18	2.5	28.6	1,011	179
October	SE	17	2.5	29.5	1,011	362
November	SE	16	1.5.	30.2	1,010	436
December	SE-S-NW	15	1.5	30.5	1,010	333

average monthly humidity ranges from 81 to 86% and the average of 100% sunshine hours is for a period of about 8 hours (800-1600 hours) (Tables 2.3 and 2.4).

Lake evaporation is high with a mean of 149 mm for September and October. This correlates with wind velocities of 9.9 and 10.3 knots, respectively, for these two months.

Hydrology, Tides and Currents

The total drainage area of Segara Anakan is about 960 km^2. About 150 km^2 of this area is the watershed of Donan River. The total daily inflow into Segara Anakan from its own watershed was about 20.5 million m^3 (Ludwig 1985) (Table 2.5).

The water movement of the lagoon is influenced mainly by river runoff and tide from Indian Ocean. The tide is mixed and predominantly semidiurnal, with tidal range between 0.40 and 1.90 m. Typical daily tide fluctuation is shown in Figs. 2.4-2.6. The tidal phase of the lagoon at the western entrance lags that in Cilacap for about 1-2 hours (Uktolseya 1984). On the west, water exchange between the sea and Segara Anakan is mainly through Citanduy River Channel, a western entrance. On the east, it is through the eastern passage joined with Donan and Sapuregel Rivers.

During the rising tide, the tidal currents flow into Segara Anakan through both passages mixing at a point east of Motean. Water flows back with receding tides from this point following the same course when it entered (Uktolseya 1984).

The western tidal current, running west to east, lasts for about 5 hours after low water level is achieved, and with the receding tide, flows westward for the same period. Variations in the tidal current in the eastern or western passage become slower at the meeting point.

During flood tide, seawater is pushed to the lagoon through its two inlets. While tidal energy penetrates the lagoon from both inlets, the main source of seawater to the lagoon is from the western inlet. The volume of water passing the mouth of the western entrance during flood tide is about 26 million m^3 for spring tide and 10 million m^3 for neap tide. This mixture of fresh- and saltwater is distributed to Citanduy River, to the main lagoon and the rivers directly draining

Table 2.4. Climatological characteristics of the broad study area and Segara Anakan (ECI 1979a).

Month	Cilacap Temperature (°C)	Cilacap Humidity (%)	Cilacap Sunshine hours (%)	Cilacap Evaporation (mm)	Cilacap Rain (mm)	Tasikmalaya Temperature (°C)	Tasikmalaya Humidity (%)	Tasikmalaya Sunshine hours (%)	Tasikmalaya Evaporation (mm)	Tasikmalaya Rain (mm)	Segara Anakan Rainfall (mm)
January	27.2	84.5	46	101	328	25.5	79	40	109	388	304
February	27.6	83.8	59	101	273	25.8	80	39	99	370	288
March	27.4	84.2	51	106	297	25.8	80	54	114	397	302
April	27.5	85.8	53	108	316	25.1	80	59	113	283	268
May	27.1	84.1	60	110	297	25.1	82	38	92	245	216
June	26.3	83.7	59	106	283	24.4	80	47	90	167	178
July	25.4	83.7	49	110	237	23.8	81	54	100	166	141
August	25.1	82.7	66	133	143	24.6	78	56	114	104	102
September	25.8	81.2	69	149	141	24.0	78	39	113	126	112
October	26.6	82.9	54	148	375	25.0	77	40	121	277	293
November	27.1	84.2	42	122	448	25.0	81	43	114	354	359
December	27.1	85.1	39	106	400	25.2	80	34	112	394	344
Total	-	-	-	1,400	3,538	-	-	-	1,291	3,271	2,907
Average	26.7	83.8	53.9	116.7	294.8	24.9	79.7	45.3	107.6	272.6	242.3

Table 2.5. Hydrology of rivers tributary to Segara Anakan (Ludwig 1985).

Basin and river	Basin area (km^2)	Average flows (m^3/day) Dry season	Average flows (m^3/day) Rainy season	Average flows (m^3/day) Annual average	Estimated silt transport into lagoon (t/year)
Citanduy Basin	3,500				
Citanduy River		14.77×10^6	24.45×10^6	19.61×10^6	3,039,000
Segara Anakan Basin	960				
Cibereum River		$.05 \times 10^6$	$.17 \times 10^6$	$.11 \times 10^6$	9,000
Cihaur/Cikonde River		$.08 \times 10^6$	1.50×10^6	$.79 \times 10^6$	2,194,000
Total	4,460	14.90×10^6	26.12×10^6	20.51×10^6	5,242,000

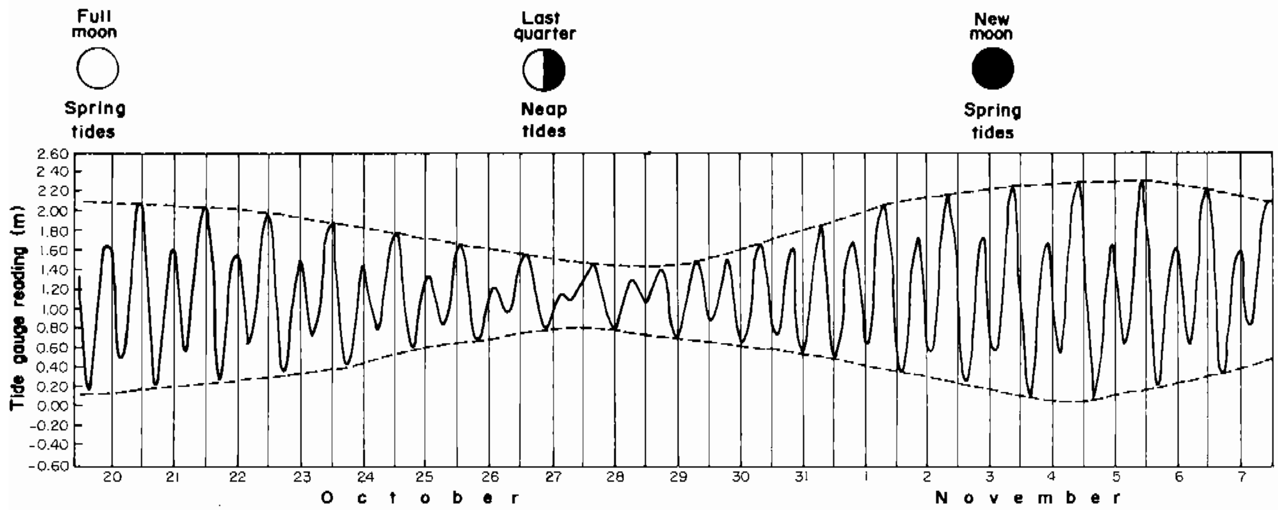

Fig. 2.4. Tidal records at Cilacap, October-November 1986 (ECI 1987).

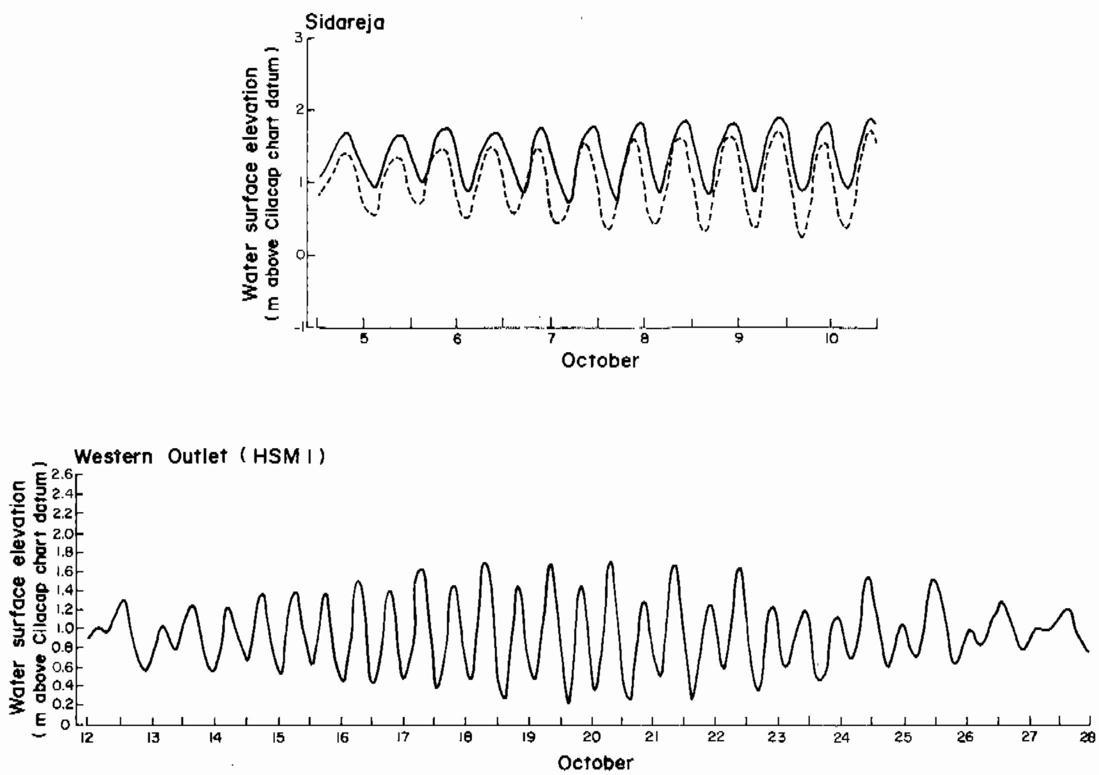

Fig. 2.5. Tidal records at Sidareja (October 1980) and at Western Outlet (October 1986) (ECI 1987).

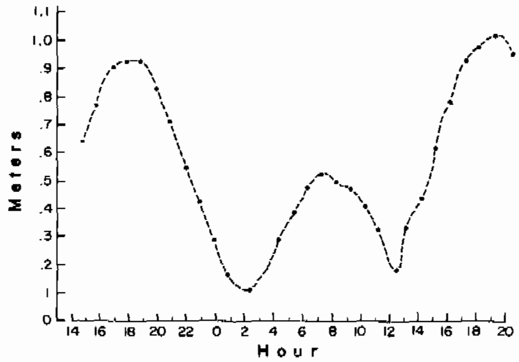

Fig. 2.6. Tidal records at Karang Anyar, 17-18 December 1987 (ECI 1987).

into it and to the mangrove forest. The water mass that passes the western entrance during a flood is a mixture of fresh- and seawater. During ebb tide, the Citanduy freshwater is discharged into Indian Ocean through the western entrance. Some of this water and its accompanying sediment remain near the mouth of the western entrance especially during weak coastal currents. This water after being mixed with saltwater is recirculated into the lagoon during the next flood tide.

Tidal measurements were also conducted by Hamidjojo in October to December 1980 at various places. At Karang Tengah, the tidal range was 1.30 m, whereas further to the north at Bugel and Cibeureum, the ranges were less. The tide influence could still be observed up to 10 km inland at Penikel (Hamidjojo 1982, Fig 2.7). ECI (1975) noted a maximum range of 2 m. Recent tidal measurements from Cilacap being tabulated by ECI are shown in Figs. 2.4-2.6.

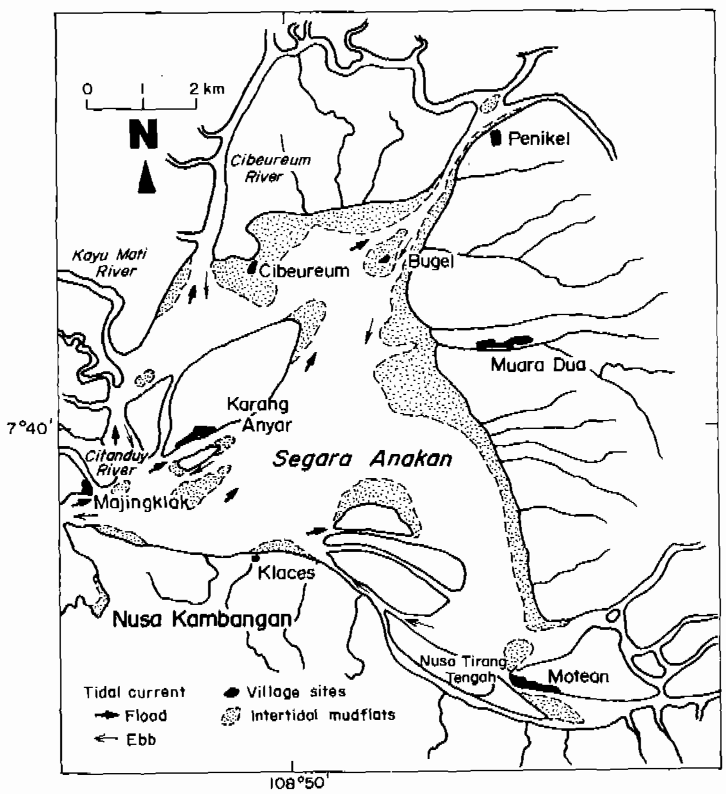

Fig. 2.7. Tidal current directions in Segara Anakan in December 1980 (Hamidjojo 1982).

The water movement of the lagoon can be differentiated into the following subareas:

1. The central subarea covers a large area with high salinity due to incursion of seawater. Water exchange through the west is dominant. The water passing through the river is vertically well mixed by rapid tidal current. Tidal currents are relatively fast with almost no immediate admixing with river runoff. These conditions result in the observed high salinities in the north of the subarea. During the dry season, the salinity range is about 20-28 ppt, and about 12-17 ppt during the wet season (Fig. 2.8).

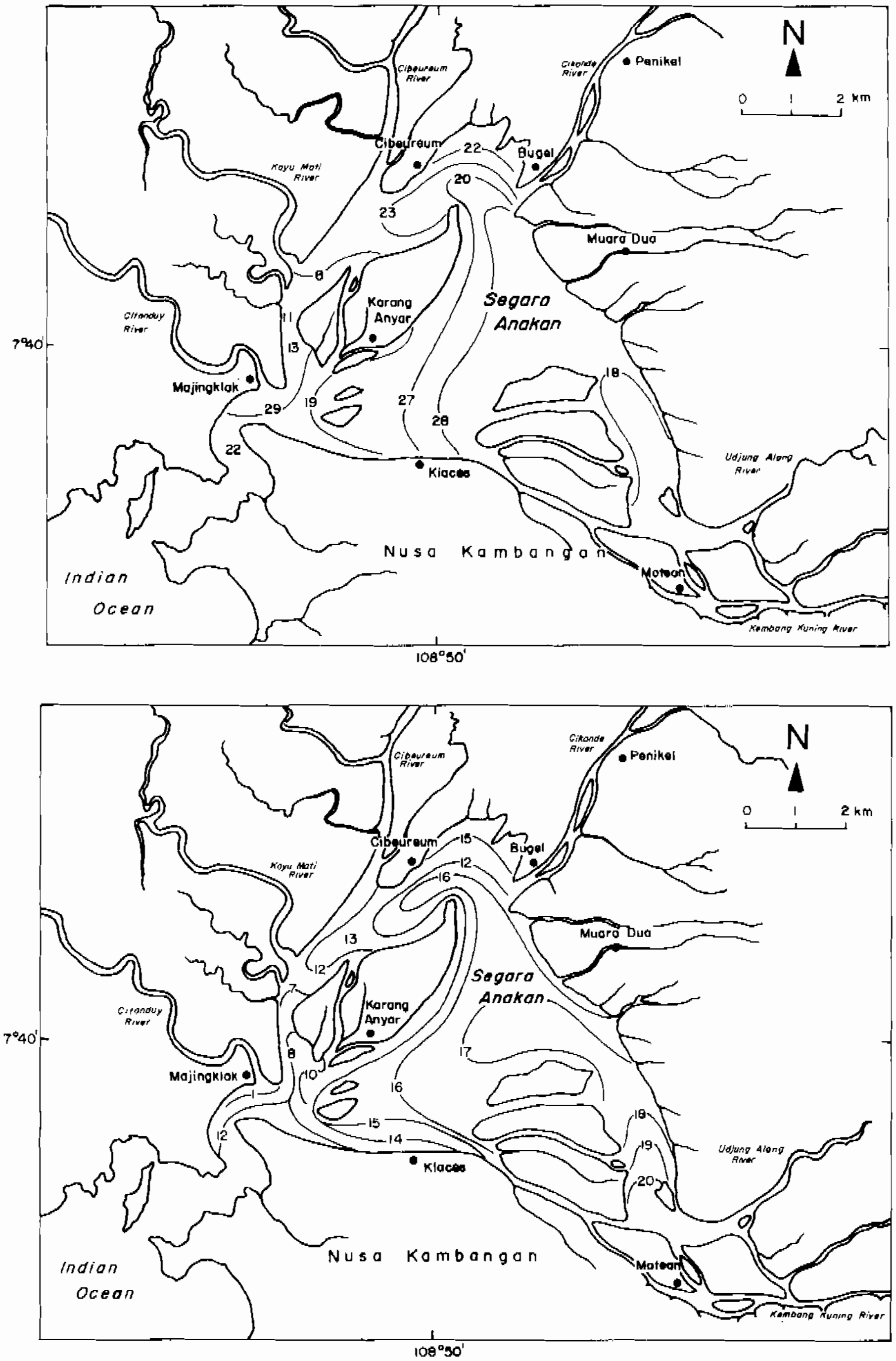

Fig. 2.8. Salinity distribution (ppt) in Segara Anakan in dry *(top)* and rainy *(below)* seasons (July and November 1983, respectively) (ET 1984).

2. The western subarea is a typical brackishwater area with a relatively stable salinity range of about 8-12 ppt, although under the influence of Cibeureum, Cikujang and Kayu Mati Rivers. At the mouth of Citanduy River, the inflowing freshwater contains a high load of silt, which is found south of Segara Anakan, creating a sharp halocline. The salinity in this subarea is low, between 1-8 ppt (Fig. 2.8).

3. The northern subarea is defined by its considerable water movements and varying salinity. It is mostly turbid and low in salinity. A general countercurrent is present where freshwater from Kawunganten River is easily distinguished from the lagoon water. During dry season, the salinity of the surface layer becomes higher due to increasing freshwater influx and stagnation of seawater. During rainy season, the salinity decreases to 7-12 ppt. These conditions strongly reflect the influence of Kawunganten River inflow (Fig. 2.10).

On 19 August 1987, ECI (1987) measured salinities at 16 locations in the main body of the lagoon, western outlet and Citanduy Estuary (Fig. 2.9). At each location, samples were taken at several depths. During the measuring, tidal conditions were recorded at Cilacap and Majingklak. However, the discharge from Citanduy and other rivers and tributaries were not known. It was, however, expected to be extremely low due to the continuing drought.

Several conclusions are drawn from the results of the measurements. The lagoon main water body has no vertical stratification and is also horizontally homogeneous. The Citanduy Estuary shows clear stratification and is categorized as a partially mixed estuary. The effect of the Citanduy freshwater discharge is noticeable in the low salinities of the thin upper layer of the western entrance water.

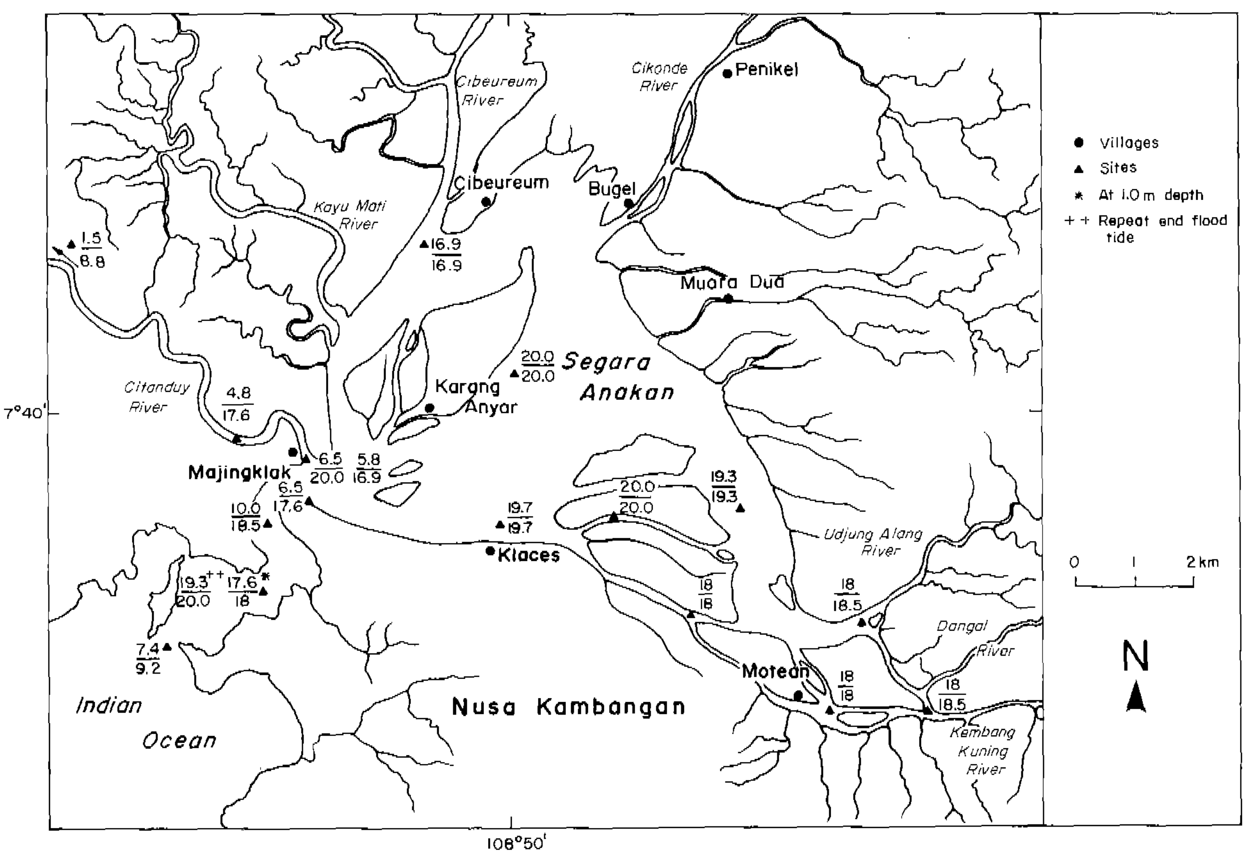

Fig. 2.9. Salinity distribution (ppt) in Segara Anakan and Citanduy River on 19 August 1987(ECI 1987).
Note: The numbers refer to surface and bottom samples, unless otherwise indicated.

Sedimentation Patterns

Tidal currents and wave action determine the orientation of shoals; once a shoal is developed, it becomes a shield that affects the pattern of water flow. The pattern of tidal currents is affected by the large shoals southwest of Citanduy, south of Cibeureum River and north of Karang Anyar. To the north and east, the tidal current is weaker due to the smaller tidal range, shallower depths and the meeting of two water masses (river discharge and tidal current from the eastern entrance). In the deeper channels (3-10 m), the current is strong enough to maintain a channel such as Kembang Kuning River which leads east to Cilacap (Hamidjojo 1982).

Sediment supply to Segara Anakan comes from Citanduy River, its upper watersheds (mainly Cibeureum and Cikonde Rivers) and a very small amount of shoreline sediment. Several studies were made to estimate the rate of sediment transport to the lagoon, but the results had considerable differences between them. It was difficult to obtain accurate figures because of too few samples of sediment taken from rivers. Also, the method used to compute sediment transport is subject to large error (ECI 1987).*

Based on these studies, the estimate of sediment transport in Citanduy and other rivers tributary to Segara Anakan is in the range of 5 to 10 million t per year. Much of the sediment comes from Citanduy River and is deposited in the lagoon. After the construction of Nusa Wuluh Floodway, which connects Citanduy and Cibeureum Rivers, sediment enters Segara Anakan through the floodway during periods of flooding. The second major source of sediment is from Segara Anakan Watershed and Cikonde and Cibeureum Rivers.

In the past few years, developments on tributaries to Cikonde River, which enters the lagoon near Bugel, have resulted in a large increase in sediment delivered to the northeastern portion of Segara Anakan. The developments, which include levees, channel enlargement and straightening, prevent the spillage of floodwater and increase the velocity of the water which carries much sediment to the lagoon.

ECI (1974a) estimated the load of the sediment from Citanduy River to be 14.3 x 10^6 t (19 x 10^6 m^3) annually. Since the mouth of Citanduy River is located close to the western outlet, a large portion of the sediment is carried into Indian Ocean and a small portion into the lagoon. It is difficult to estimate the latter portion. Assuming that the present rate of deposition is 20%, as estimated in studies by ECI, then the volume of Citanduy sediment filling the lagoon is about 2.63 x 10^6 t (3.80 x 10^6 m^3) annually (ECI 1987).

Water circulation in the main body of the lagoon, except in the eastern part, is driven mainly by tidal energy from the western inlet and by freshwater discharge from Citanduy River and other rivers. In the eastern and southeastern parts of the lagoon, tidal energy that enters both the lagoon from the western outlet and Cilacap plays an equally important role in driving the water movement. During flood tide, the tidal energy pushes considerable water masses through the western entrance. The water masses are spread over the main body of the lagoon. The fastest water movement occurs in the lagoon entrance (Table 2.6). After the water masses reach the lagoon entrance, water spreads in all possible directions into the lagoon. The velocity of the water masses decreases as they travel farther into the lagoon where their initial tidal energy is also spread. Water masses that travel to the eastern part of the lagoon meet with those pushed westward by tidal energy from Cilacap. At the nesting point of the water masses, the horizontal velocities go to zero, and the horizontal water movement is limited at the northern and northeastern parts of the lagoon, especially in the vicinity of the area where tidal currents

*This is pointed out so that it is clear why the estimates vary. Nevertheless, the estimates for sediment load and deposits in the lagoon are critical for determining management measures for the lagoon and were made for that purpose while realizing the potential inaccuracies. (The editors)

Table 2.6. Peak flow rates and velocities in ocean and lagoon entrances under various tidal conditions (ECI 1987).

Type of tide and tidal range (m)	Tidal direction	Ocean entrance Flow rate (m^3/s)	Ocean entrance Velocity (m/s)	Lagoon entrance Flow rate (m^3/s)	Lagoon entrance Velocity (m/s)
Spring (1.50 m)					
	Ebb	2,350	0.55	2,200	0.70
	Flood	1,650	0.35	1,500	0.50
Neap (0.20 m)					
	Ebb	700	0.20	650	0.25
	Flood	500	0.15	450	0.20

from the western outlet meet freshwater discharges from Cibeureum and Cikonde Rivers. During ebb tide, water recedes to the ocean through both the eastern and western entrances.

The general sedimentation patterns within the lagoon are dictated by the water circulation patterns. If the energy, which is reflected in the horizontal movement of the water mass, is high, then the sediment will stay suspended and move with the water mass. If the water movement slows, such that the energy is not strong enough to keep the sediment suspended, then it starts falling and deposition occurs. Moreover, the energy of the water movement will also act to sort the size of sediment that will be deposited along the path of the flows.

As a consequence of sediment deposition taking place in the lagoon, Segara Anakan's morphology has and is being changed. As soon as the bottom of the lagoon is shallow enough, there is normally an accretion of mangroves over the area. ECI (1987) compiled the shoreline changes and the growth of mangrove forest since 1903 when there were only three islands, all in the southeast corner of the lagoon (Fig. 2.10). The large island, called Sebilas, was 61 ha in

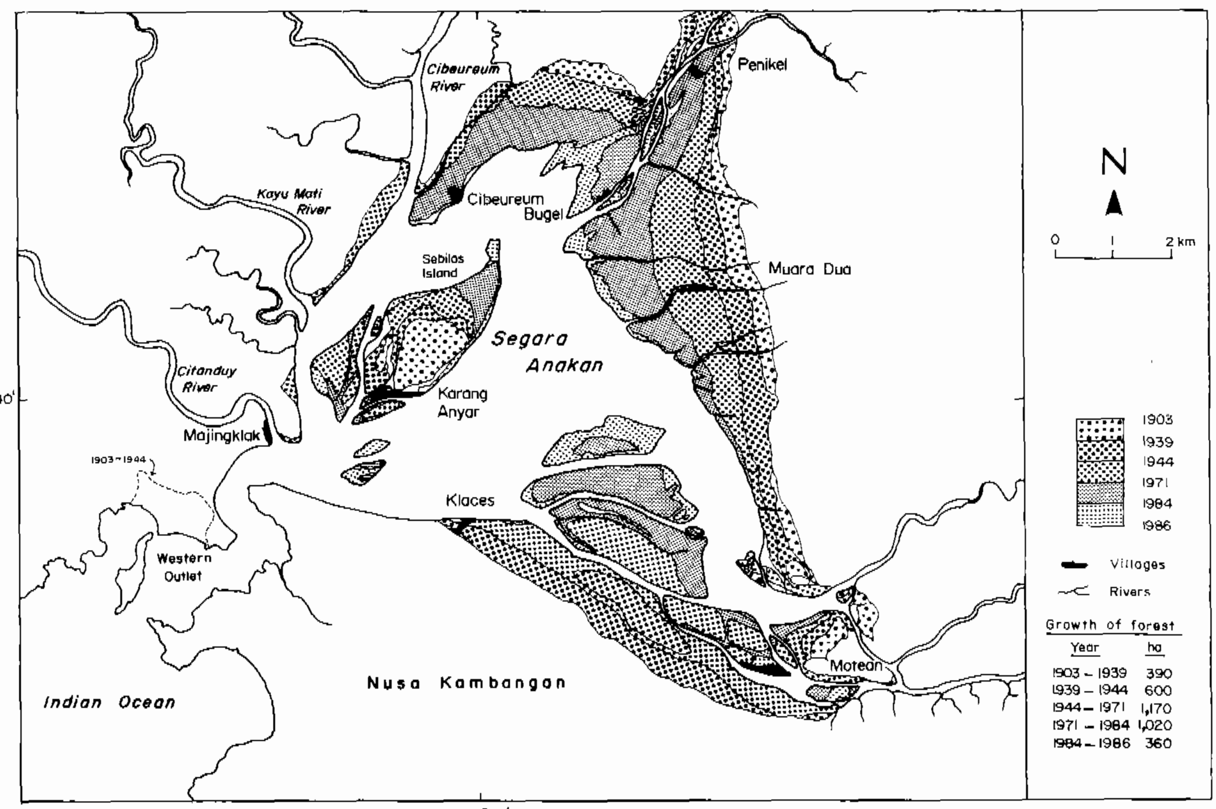

Fig. 2.10. Shorelines and mangrove forest growth from 1903 to 1986 (ECI 1987).

the surface area. The seven villages (Karang Anyar, Klaces, Motean, Muara Dua, Bugel, Penikel and Cibeureum) were built over the water. The mudflats, which were to become the large island at Karang Anyar, were just forming. The surface area of Segara Anakan at high tide was 6,450 ha, excluding the seven villages, which covered an area of about 33 ha by 1986.

By 1939, six new islands had appeared and Sebilas grew appreciably. About 390 ha of new mangrove forest were established. The northern and eastern shores advanced and the western and southern shores remained unchanged. From 1939 to 1944, large amounts of accretion to the southern and eastern shores added some 500 ha of mangrove forest. From 1944 to 1971, the forest had an increase of 1,170 ha in the lagoon and from 1971 to 1984, of 1,020 ha. Much of these increases were new islands between Klaces and the eastern shores.

From 1903 to 1986, the total sediment deposits onto which new mangroves were established were 3,540 ha. Another 210 ha were converted from lagoon to tidal waterway, leaving the 1986 lagoon with a water surface at high tide of 2,700 ha, which was only 42% of the surface area (Fig. 2.11).

From November 1986 to December 1987, the proliferation of mangrove seedlings and grasses accelerated (Fig. 2.12). Karang Anyar became attached to the northern shore of the lagoon. The Cikonde River extended its mouth in the lagoon by building natural levees. New mangrove seedlings sprouted on both sides of the mouth. This rapid change at the mouth of Cikonde River was due to increased sediment load in the river.

Historic land accretion in the lagoon was also recorded by Ludwig (1985) and is shown in Fig. 2.13, which can be compared with Fig. 2.10. Based on the accretion and the water circulation pattern, the trends of physical shoreline changes of the lagoon were predicted (Fig. 2.14).

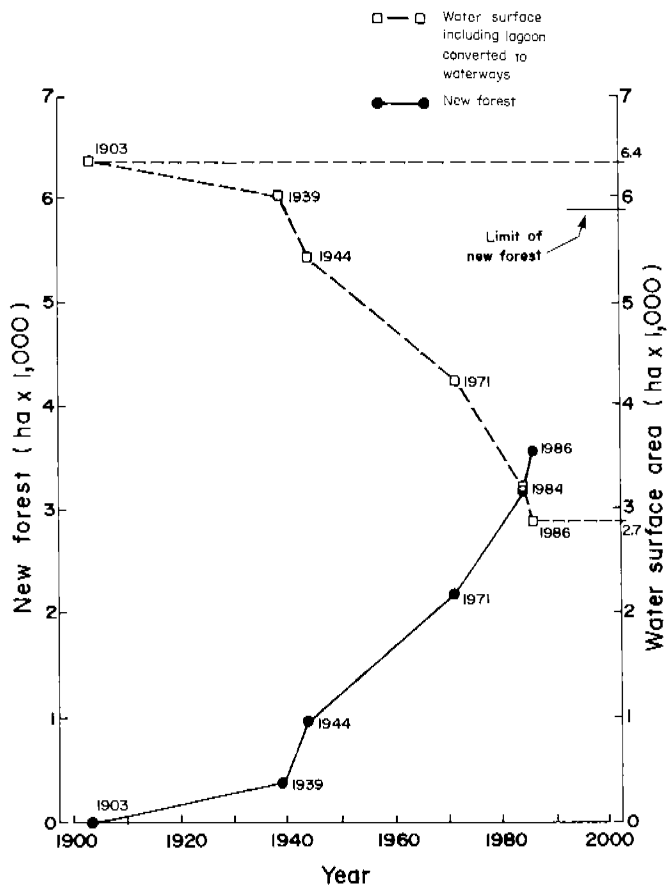

Fig. 2.11. Historical curves of water surface and new forest areas since 1903 (ECI 1987).

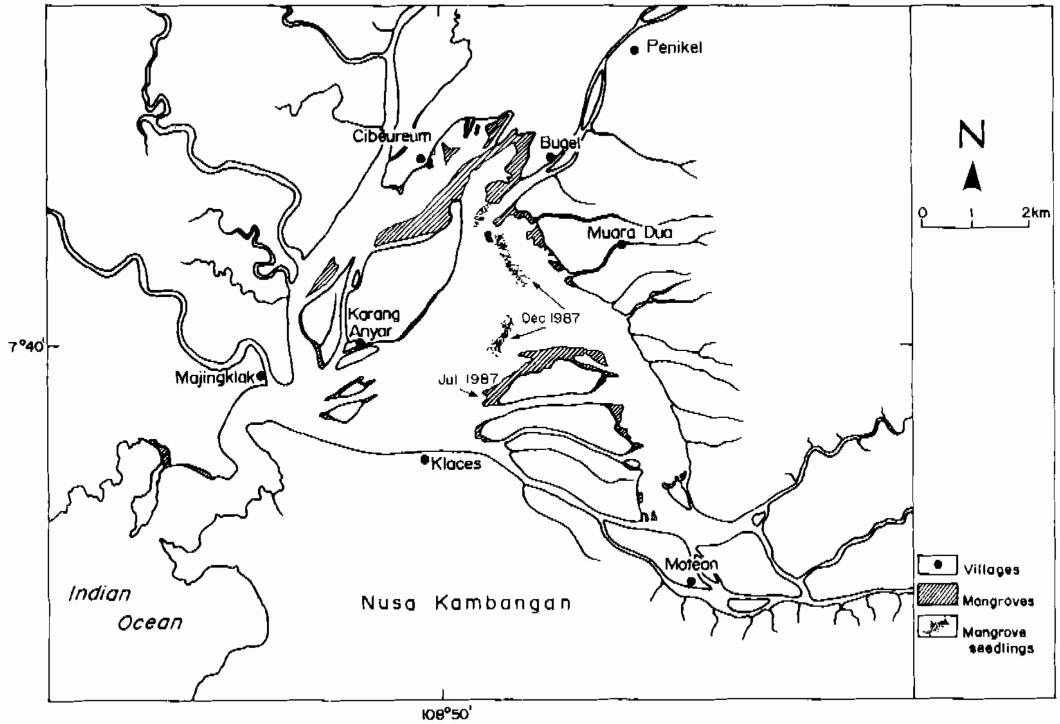

Fig. 2.12. Sketch of new mangrove growth as surveyed in July and December 1987 (ECI 1987).

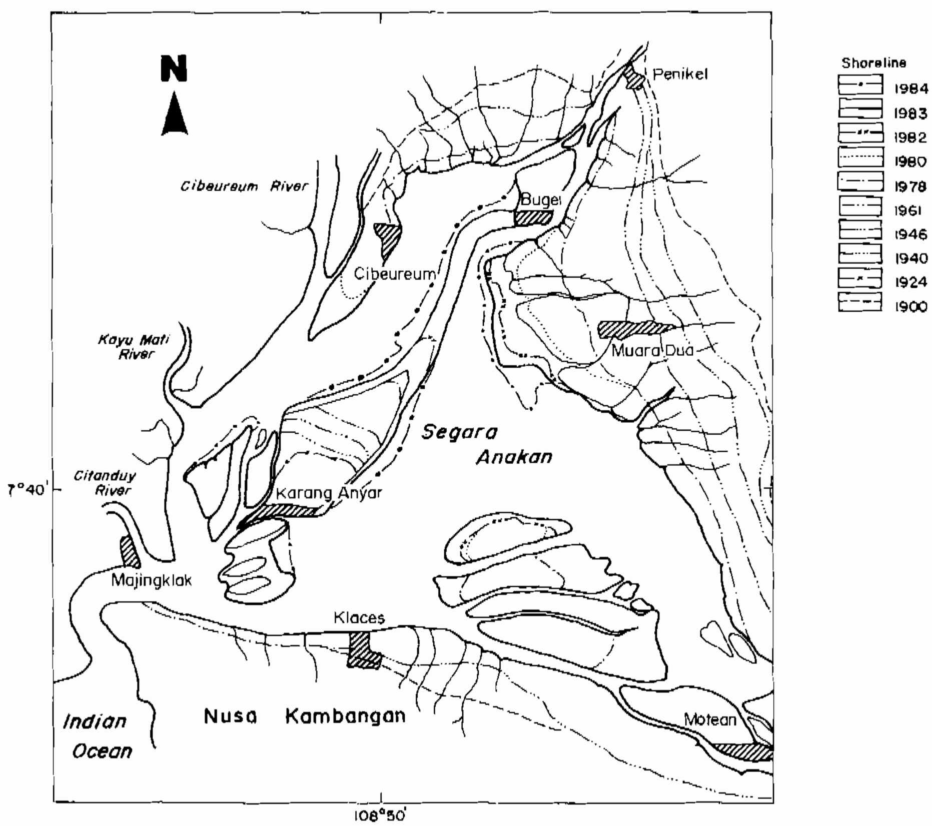

Fig. 2.13. Land accretion since 1900 (Ludwig 1985).

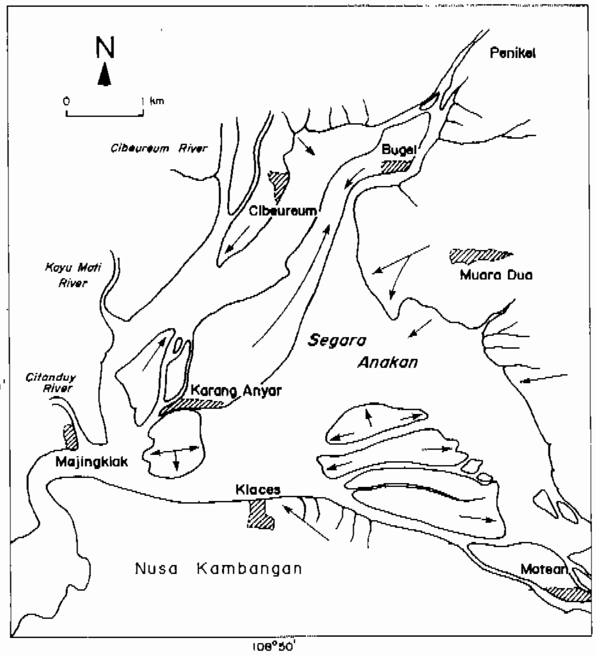

Fig. 2.14. Direction of future shoreline changes (CORD 1986).

The pattern of sedimentation, which resulted in shoreline growth and encroachment of mangrove forest, will continue in the direction of its historic growth since the water circulation pattern and the way the sediment load was introduced and distributed into the lagoon are conducive for such processes to occur. If no action is taken to prevent sedimentation, then it is expected that the lagoon will be filled and only waterways where channels cross will be left. ECI (1987) predicted this future morphology of the lagoon (Fig. 2.15).

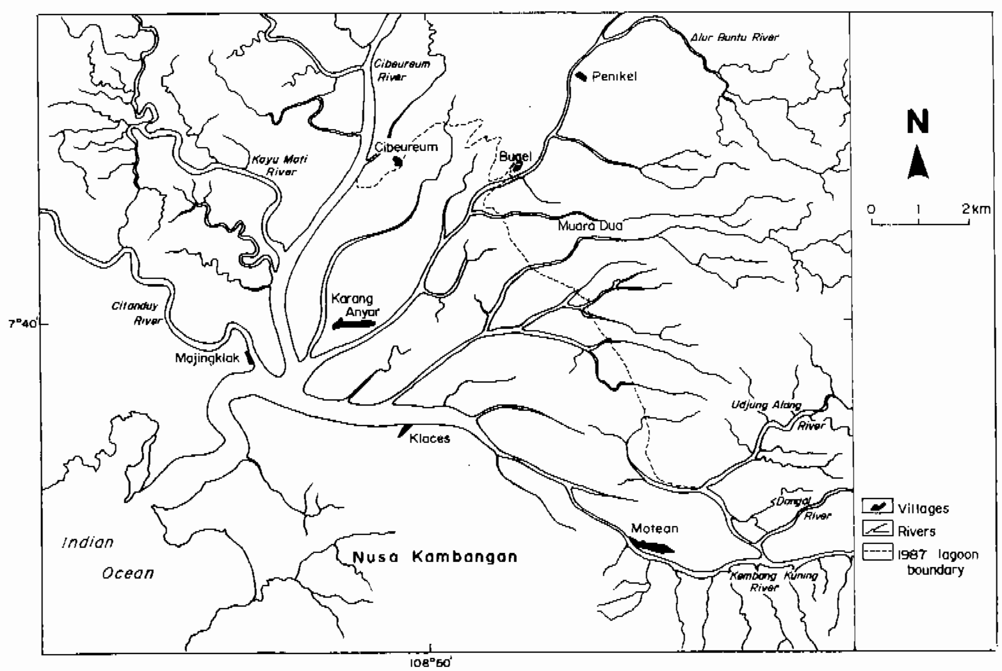

Fig. 2.15. Projected shape of Segara Anakan (ECI 1987).

Several studies have been done to estimate the filling rate of the lagoon--by sediment as well as by the rate of mangrove forest encroachment. Napitupulu and Ramu (1982) computed the filling rate to be 8.8 million m^3/year (1971 to 1976); 3.0 million m^3/year (1976 to 1980); and 6.2 million m^3/year (1971 to 1980). They warned that if nothing is done to stop the filling, then Segara Anakan will be silted in the next five to seven years, leaving only the tidal channels in the lagoon.

ECI (1987) also made a projection on the filling rate of the lagoon, i.e., between 2 and 3 million m^3/year. The rate of mangrove increase has been about 2 km^2/year for the last few years, indicating that without intervention, the mangrove forest will encroach over all the remaining shallow areas of the lagoon by the turn of the century and leave only tidal channels to connect tributary rivers to the two inlets (Fig. 2.15). It is also projected that more or less 500 ha of waterways will remain in what is the 1987 lagoon. This will depend on the balance of tidal energy (currents) and the space for water movement in the channels. The tidal energy concentrated in the tidal channel and waterways will at some point prevent siltation. The width of the tidal channels will be somewhat wider, especially those in the west side of Karang Anyar Island and the main waterway in the south shore of the lagoon (Fig. 2.15).

Chapter 3
Natural Resources

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AND TATANG SUJASTANI

Water

Inflowing rivers

The rivers which empty into the lagoon area are Citanduy, Kayu Mati, Cikujang and Cibeureum in the west, and Penikel, Cikonde, Udjung Alang, Dangal and Kembang Kuning in the east (Fig. 1.1). All carry some mud and silt which are deposited in the estuarine lagoon and river channels or carried out to sea as described in the previous chapter. Segara Anakan is also influenced by tidal currents and intrusion of saltwater which play a major role in distributing the sediments. The velocity of currents is greater during ebb tide and concentrated near the surface. Salinity is higher in deeper water and closer to the sea and lowest in the mouth of Citanduy.

The Citanduy carries mainly soil particles averaging about 193 mg/l in June and 326 mg/l in October. Clay-sized sediment forms the largest fraction, 63-96%; silt, 2-43%; and sand, 1-24% (Sutomo 1982).

The Citanduy River is the longest river with the largest basin and largest discharge into the lagoon and is also the major source of sediment. However, the inflowing water from Kayu Mati and Cibeureum Rivers is also very turbid.

Segara Anakan

Characteristics. The surface and bottom water characteristics of Segara Anakan for May and July 1980 are presented in Table 3.1 while Tables 3.2 and 3.3 show more recent data. These data show that the water quality of the lagoon fluctuates, particularly, salinity and transparency according to tidal and seasonal fluctuations. The salinity of the water in Zone I (Majingklak) ranged from 10 to 25 ppt (mean 20 ppt); in Zone II (Cibeureum/Bugel) 12 to 29 ppt (mean 22 ppt); 18 to 30 ppt (mean 25 ppt) in Zone III (Muara Dua/Motean); and 11 to 31 ppt (mean 23 ppt) in Zone IV (Klaces). Based on salinity, it can be seen that the waters in Zone IV were both affected by the tidal currents and the ingoing freshwater discharge from Citanduy River. This was also indicated by the pH of the water in Zones III and IV, which was relatively stable at pH 8 (Fig. 3.1 and Table 3.2).

The transparency of the waters in Zone I ranged from 22 to 41 cm (mean 33 cm); in Zone II, 20 to 39 cm (mean 25 cm); 27 to 48 cm (mean 35 cm) in Zone III; and 36 to 50 cm

Table 3.1. Values of the surface and near-bottom water parameters of Segara Anakan, May and July 1980 (Birowo and Uktolseya 1982).

Parameter	Layer Surface (S) Bottom (B)	May 1980 Range	May 1980 Average	July 1980 Range	July 1980 Average
Temperature	S	29.06 - 31.89	30.75	28.71 - 29.95	29.29
(°C)	B	28.89 - 31.10	29.96	25.98 - 29.57	28.74
Salinity	S	13.69 - 28.48	23.11	27.97 - 32.74	30.56
(ppt)	B	16.92 - 32.79	26.04	28.68 - 33.10	30.76
Oxygen	S	3.03 - 5.04	4.09	2.43 - 4.20	3.50
(mg/l)	B	2.77 - 3.87	3.35	2.48 - 4.15	3.48
Phosphate	S	.30 - .51	.39	1.06 - 4.82	2.59
(mg/l)	B	.35 - .93	.56	1.55 - 4.22	2.43
Nitrate	S	.15 - .99	.35	1.82 - 3.40	2.66
(mg/l)	B	.22 - .59	.42	1.86 - 3.27	2.66
Nitrite	S	.03 - .12	.08	.08 - .61	.34
(mg/l)	B	.06 - .18	.11	.14 - .50	.28
pH	S	6.49 - 6.95	6.69	6.85 - 8.40	7.67
	B	6.20 - 6.76	6.47	6.49 - 7.94	7.15
Transparency(m)		.50 - 2.00	.95	.30 - 2.00	1.69

(mean 42 cm) in Zone IV. The water in Zone II was the most turbid, with an average transparency of about 25 cm, due to influences from Kawunganten River, which was quite turbid (70 mg/l), and to tidal movements.

Based on the criteria proposed by Yoshimura (Liaw 1969) and the ratio of Nitrate-N to PO_4-P as stated by Russel and Hunter (1970) and Stumm and Morgan (1981), the zones are classified, thus (Fig. 3.1): Zones I and IV are mesotrophic; and Zones II and III are eutrophic. Similar results are also indicated by the composition and abundance of phytoplankton, zooplankton and benthic communities (Table 3.2).

Some heavy metals, such as chromium, cadmium, copper, nickel, lead, zinc and iron, were detected at very low concentrations. Based on the criteria set in the "Workshop on Marine Environmental Quality" (Anon. 1984), the water condition at that time was not harmful to aquatic life. However, concentration of heavy metals may still increase as the following are likely to occur more in Segara Anakan ecosystem:

- Aggravated erosion and leaching of soil;
- Injection into streams and atmosphere of industrial waste and fuel combustion products; and
- Release of sediment of metal-enriched sewage sludge directly or by dredge-spoil dumping.

Detected in the lagoon were residues of chlorinated pesticides, namely, Aldrin, Dieldrin, Endrin, Lindane and BHC (Table 3.4), but organophosphates were not detected.

Observations on levels of nitrate, nitrite and phosphate during the east and west monsoons showed that their concentrations were quite high especially during the east monsoon of 1980 (Table 3.5) (Winata and Muchtar 1984). The high concentrations were due to river inflows and mangrove litter abundance.

Biological Properties. A typical tropical aquatic system displays phytoplankton densities between 1,500 and 6,500 individuals/l (ind., throughout the text). Segara Anakan is characterized primarily by diatoms in large numbers. Chlorophyceae, Cyanophyceae and

Table 3.2. Physical, chemical and biological characteristics of Segara Anakan (ET 1984).

Month	Zone	Temperature (°C)	Transparency (cm)	Salinity (ppt)	pH	Dissolved oxygen (mg/l)	NO_3-N[a] (mg/l)	Ortho-[b] PO_4-P (mg/l)	SiO_2 (mg/l)	Primary productivity ($mgC/m^3/3$ hr)	Phytoplankton (Taxa)	Phytoplankton (ind./m^3) (10^3)	Zooplankton (Taxa)	Zooplankton (ind./^{3})	Benthos (Taxa)	Benthos (ind./m^2)
	I	27.6	39	9.8	7.4	4.5	0.460	0.126	-	-	-	-	-	-	-	-
June	II	28.6	24	11.7	7.5	5.6	0.610	0.096	-	-	-	-	-	-	-	-
	III	26.8	27	17.7	7.2	5.2	0.610	0.100	-	-	-	-	-	-	-	-
	IV	26.8	36	10.8	7.4	5.2	0.550	0.126	-	-	-	-	-	-	-	-
	I	29.2	41	-	7.6	5.8	0.930	0.051	10.5	212	20	3,520	7	27,800	4	760
July	II	28.3	24	19.8	7.3	5.4	0.114	0.048	19.2	227	18	8,380	5	15,600	6	170
	III	27.3	34	18.5	7.6	6.1	0.158	0.050	7.4	265	17	7,020	5	21,000	3	420
	IV	28.4	43	24.0	8.2	5.4	0.218	0.046	5.0	314	23	6,210	9	100,400	8	140
	I	27.5	32	20.8	8.0	6.3	0.112	0.059	5.9	150	22	1,880	7	23,800	10	1,500
August	II	26.6	39	20.4	7.8	6.3	0.112	0.132	5.1	258	20	5,730	7	28,200	9	500
	III	26.4	48	28.9	8.0	7.5	0.015	0.108	4.2	241	23	2,680	6	12,600	8	200
	IV	26.3	42	29.1	8.2	7.6	0.227	0.084	4.0	191	20	6,740	9	17,800	8	100
	I	26.7	30	25.0	8.2	6.2	0.246	0.022	3.9	255	15	3,560	10	53,500	5	530
September	II	26.4	20	29.3	8.1	6.2	0.263	0.019	4.4	225	18	4,850	9	70,500	8	40
	III	26.2	30	29.1	8.3	6.1	0.158	0.021	4.3	293	16	3,310	10	93,900	6	760
	IV	26.1	41	29.9	8.3	6.3	0.163	0.022	3.1	296	20	7,330	14	51,100	8	340
	I	26.3	22	23.4	8.2	5.8	0.630	0.080	-	-	-	-	-	-	-	-
October	II	26.2	23	28.8	8.2	6.1	0.552	0.030	-	-	-	-	-	-	-	-
	III	24.3	35	24.5	8.4	5.8	0.680	0.025	-	-	-	-	-	-	-	-
	IV	24.0	40	12.6	7.8	5.0	0.345	-	-	-	-	-	-	-	-	-
	I	26.6	35	23.3	8.1	7.0	0.347	0.023	2.2	218	19	940	x	x	x	x
November	II	26.8	22	19.2	7.9	5.9	0.382	0.049	2.3	249	22	2,170	x	x	x	x
	III	26.9	34	30.2	8.2	6.4	0.317	0.044	2.1	233	20	1,700	x	x	x	x
	IV	26.2	50	31.2	8.2	6.6	0.397	0.056	1.7	248	19	1,450	x	x	x	x

[a]Nitrogen in the form of NO_3.
[b]Phosphorous in the form of orthophosphate.

(-) : not measured.
(x) : no data, sample damaged.

Table 3.3. Water quality average conditions based on surveys conducted by IHE-ARD-MPW in Segara Anakan in March, June and October 1983 and January 1984 (Ludwig 1985).

Parameter	Dry season	Rainy season
Conductivity (µmho/cm)	31,125	9,145
Alkalinity (mg/l $CaCO_3$)	71-115	84-146
pH	7.7	7.8
Suspended solid (mg/l)	63-896	100-1,700
Turbidity (mg/l)	59(13-154)	63(12-700)
Dissolved oxygen (mg/l)	5.6(5-7.3)	5.5(3.5-7.8)
Fecal coli (MPN/100 ml)	$2.6 \times 10^{2-}$	9.5×10^2
Total phosphorous(mg/l)	0.2(0.04-0.46)	0.28(0.11-0.70)
Orthophosphate (PO_4mg/l)	0.08(0.04-0.35)	0.12(0.07-0.27)
Total nitrogen (mg/l)	1.0	0.6
Ammonia (mg/l)	0.007(0-0.16)	0.0035(0-0.014)
Ammonium ion (NH_4mg/l)	0.12(0-0.35)	0.09(0-0.20)
Nitrate (mg/l)	0.54(0.14-1.6)	0.11(0-0.65)
Nitrite (mg/l)	0.0035(0-0.006)	0.0033(n-1-0.015)
BOD (higher in dry season)	-	-
COD (mg/l)	18(13-26)	18(5.2-2.8)

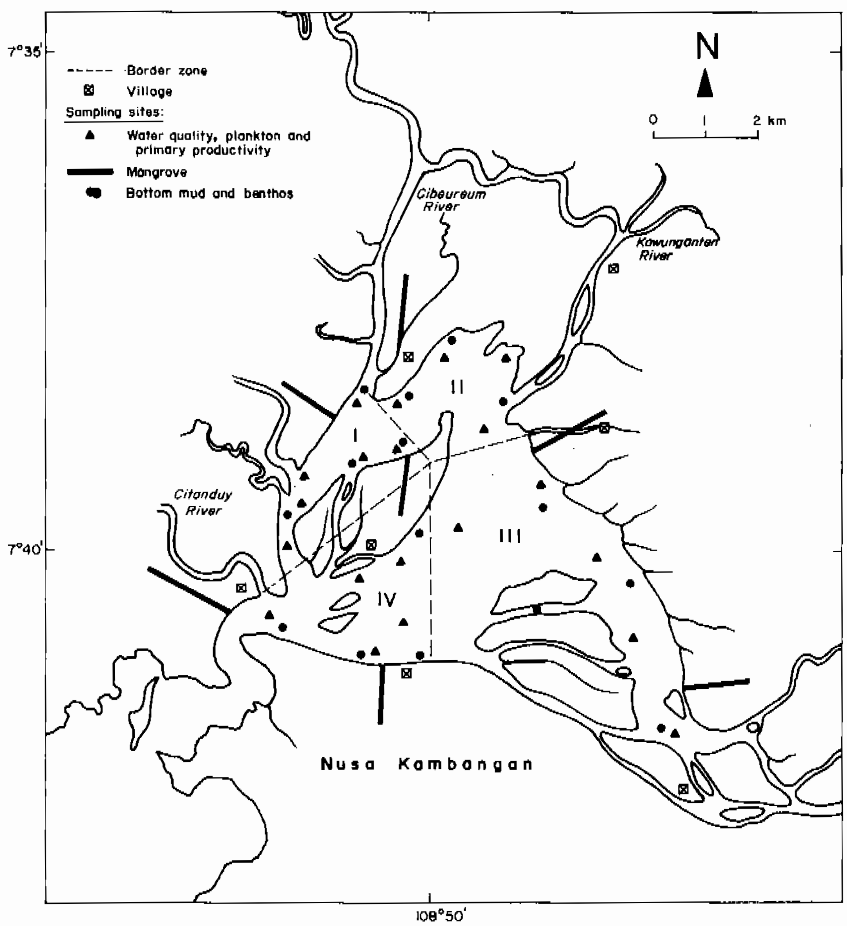


Fig. 3.1. Zonation system (I-IV) and sampling sites for mangrove and natural water resource studies in Segara Anakan (adapted from Rachmat and Setiawan 1984).

Table 3.4. Pesticide residue in water column (µg/l) of Segara Anakan, 1982 (ET 1984).

Zone	Aldrin	Dieldrin	Endrin	Lindane	BHC	DDT	Fenitrothion	Diazinon	Parathion
				Pesticides					
I	0.027-0.109 $\bar{x}$ 0.060	0.222	0.044	0.044-0.162	0.054	0.0	0.0	0.0	0.0
II	0.298	0.044	0.0	0.044	0.0	0.0	0.0	0.0	0.0
III	0.044-0.118 $\bar{x}$ 0.081	0.0	0.0	0.044-0.070 $\bar{x}$ 0.57	0.054-0.340 $\bar{x}$ 0.197	0.0	0.0	0.0	0.0
IV	0.323-1.176 $\bar{x}$ 0.749	0.0	0.0	0.0	0.017-0.027 $\bar{x}$ 0.022	0.0	0.0	0.0	0.0

Source: Statistics from IHE-ARD-MPW.

Table 3.5. The contents of phosphate and nitrate (mg/l) in Cilacap mangrove forest waters, 1980-1982 (Winata and Muchtar 1984).

Specification		Water column Surface (S) Bottom (B)	May			July			October			January 1981/1982		
			Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
1980	Phosphate	S	.30	.51	.39	1.06	4.82	2.59	.08	.38	.21	.10	.97	.55
		B	.35	.93	.56	1.55	4.22	2.43	.09	.47	.32	.10	.85	.85
	Nitrate	S	.15	.99	.35	1.82	3.40	2.66	.12	.38	.18	.08	.98	.53
		B	.22	.59	.42	.86	3.27	2.66	.08	.78	.25	.33	.98	.55
	Nitrite	S	.33	.12	.08	.08	.60	.34	.02	.18	.11	.04	.43	.23
		B	.06	.18	.11	.14	.50	.28	.08	.18	.11	.02	.43	.23
1981	Phosphate	S	.56	1.11	.72	.52	4.39	1.46	.16	3.90	.76	.57	2.91	1.09
		B	.29	1.29	.72	.65	3.52	1.25	.26	1.99	.74	.44	1.96	1.33
	Nitrate	S	1.11	6.33	2.02	.53	3.72	1.85	.56	3.74	1.87	1.12	5.66	1.90
		B	1.06	5.93	1.78	.44	3.48	1.41	.50	3.55	1.48	1.05	5.41	1.78
	Nitrite	S	.02	.16	.10	.18	.75	.40	.05	.16	.10	.02	.14	.09
		B	.02	.145	.08	.32	.75	.47	.08	.18	.11	.02	.14	.09

Dinophyceae are represented by low species diversity but high abundances. Genera encountered in high frequencies were *Cyclotella, Nitzchia, Navicula, Gyrosigma* and *Skeletonema (S. costatum)*. It is difficult to identify the importance of these genera as regards their contribution to primary productivity. The average density of Majingklak-Muara Dua-Motean waters was 5,000-5,500 ind./l, whereas in Cibeureum and Klaces waters, it was about 2,000-3,500 ind./l. High densities noted in Muara Dua-Motean area corresponded to the area's water fertility.

The records on phytoplankton showed a denser community during July to August compared to September to December. The average density for Segara Anakan was estimated to be 3,900 ind./l. The densities varied among water layers and zones, ranging between 2,350-5,450 ind./l. By its standing stock, the zones were ranked in this order: III, I, IV and II. High densities observed in Zone III corresponded to the fertility of the water characterized by high numbers of *Skeletonema* sp.

Diatoms showed the greatest contribution to the primary productivity of Segara Anakan, composing more than 90%. Table 3.6 shows the temporal variations in primary productivity. Zones III and IV were characterized by high productivity during the dry and early rainy seasons. Varying climatic conditions in the upper reaches of the inflowing rivers and the surroundings appeared to affect water conditions of the lagoon. In most cases, production decreases were observed in November in Zones I, IV and III, which were affected by freshwater inflow. In contrast, tidal saline inflow caused an increase in November in Zone II.

Table 3.6. Primary productivity (mg C/m^3/3 hr) in Segara Anakan (ET 1984).

Zone	July	August	September	November
I	212	151	256	218
II	227	258	225	249
III	265	241	293	233
IV	315	191	296	248

Previous studies on the phytoplankton biomass and productivity in May 1980 and January 1982 showed that chlorophyll levels at the surface from 10 stations had values varying between 1 and 66 µg/l. Mean values varied between 2 and 18 µg/l (Nontji and Setiapermana 1982). Low values of less than 3 µg/l were observed near the navigational entrance in Cilacap; moderate levels of 4-6 µg/l at Donan River and the eastern part of Kembang Kuning River; and high values of 12-18 µg/l at the western part of the latter river toward the lagoon.

Measurement of primary productivity, done at one station, showed that the surface values varied between 83 and 216 mg C/m^3/day. This decreased with depth near the bottom to about 10% of the surface values. Phytoplankton was rich in terms of biomass and primary productivity with peak times during the east (July) and west (January) monsoons.

The most common zooplanktons found in 1983 by the Ecology Team consisted of copepods (8 genera), rotifers (5), ostracods (1), rhizophods (4) and penaeids (2) (Table 3.7). Copepods and rotifers were each observed in large numbers ranging from 9,000 to 66,000 ind./m^3. Zooplankton was rich in the area.

The results of another zooplankton study (Sutomo 1982) are shown in Table 3.8. Karang Anyar reached 1,265 ind./m^3 in May 1981. This figure consists of 93% mysids, 4% copepods and 3% crab larvae. Kembang Kuning River produced the highest abundance with copepods forming a major part, followed by crab larvae (29%). The counts in this study were much lower than those of the above study.

Table 3.7. Zooplankton density (ind./m^3), 1983 (ET 1984).[a]

Taxonomic division	Genus	July	August	September
Copepoda (8)	(Nauplius larvae)	12,997	13,850	59,294
	Scaphocalanus sp.	196	-	-
	Microstella sp.	313	47	154
	Oithona sp.	2,651	945	2,428
	Cyclops sp.	-	77	1,063
	Calanus sp.	-	2,369	5,873
	Euterpina sp.	-	612	1,545
	Acartia sp.	-	416	297
	Subtotal	16,157	18,316	70,654
Rotifera (5)		13,256	42	1,033
Ostracoda (1)		-	-	238
Rhizophoda (4)		11,788	463	297
Penaeidae (1)	*Lucifer* sp.	-	89	315
	(Unidentified larvae)	-	-	59
	Subtotal	-	89	374
Others		-	1,669	4,824
Total		41,201	20,579	77,182
Taxa		13	13	18
Index of diversity		2,369	1,425	1,664
Equitability		.640	.366	.399

[a]Modified by editors.

The presence of the two rhizophods, *Difflugia* sp. and *Arcella* sp., in Zone II was significant, since this indicated high organic matter and turbulent waters (James and Evison 1979), leading to the conclusion that the zone was important for zooplankton.

Common macrobenthic invertebrates were represented by 16 genera (Table 3.9). The highest density was observed in Cibeureum-Bugel area with 650 to 1,500 ind./m^3. The community was dominated by the gastropod *Thiara* which is tolerant of low salinity. The larval form of the crustacean *Gammarus* was also common. In general, estuarine-adapted species dominated.

Soils

Comprehensive soil analyses for land suitability of Segara Anakan and its adjacent areas have yet to be done, although a study between Citanduy and Cibeureum Rivers was done by Syukur (1982) in late 1980.

Salt water intrusion and diurnal movement of tidal water dominate the area. The seaward part is a saline or brackish coastal wetland. The land is characterized by mud and water

Table 3.8. Zooplankton density (ind./m^3) observed in Segara Anakan-Cilacap waters, 1980-1981 (Sutomo 1984).

Station	1980 May	1980 July	1980 October	1981 January	Remarks
Citanduy	87	5	126	24	Lagoon
Karang Anyar	7	30	179	130	"
Klaces	50	24	262	12	"
Motean	6	13	-	-	"
Kembang Kuning	24	23	66	430	River
Sapuregel	70	3	1,084	487	"
Donan-Kembang Kuning	38	29	64	281	"
Cilacap (east entrance)	1,714	95	101	1,196	"
Donan	233	36	63	30	"
Jeruk Legi	72	36	126	70	"
Average	230	29	230	296	

Station	1981 May	1981 July	1981 October	1982 January	Remarks
Citanduy	63	333	88	32	Lagoon
Karang Anyar	1,265	894	55	509	"
Klaces	483	192	56	61	"
Motean	531	151	168	94	"
Kembang Kuning	88	334	303	315	River
Sapuregel	23	273	317	129	"
Donan-Kembang Kuning	359	50	406	534	"
Cilacap (east entrance)	272	11	6	118	"
Donan	67	29	178	21	"
Jeruk Legi	70	4	124	13	"
Average	322	227	170	183	

throughout most of the year except for a few places where drying occurs. Shallow groundwater levels, fluctuation of inundating water due to season and tides dominate. There is accumulation of peat and sulfuric compounds and sediments of terrestrial and marine origin.

The soil has a clayey texture and is sticky and firm. Generally, it is undeveloped in the nearshore areas. The opening of mangrove forest tends to stimulate the process of soil ripening with more aerobic microorganisms and decomposition of organic matter. There is poor aeration because of the fine clayey texture, shallow groundwater table and poor drainage. The soil moisture ranges from 40-60% (high) to 61-100% (very high).

Chemical properties

Organic matter content of soil in the nearshore area is low to medium (3.5-17%) with very low level of decomposition (C/N >25). The total nitrogen content is a low 0.1-0.3%. Farther off the coast, the organic matter content and rate of decomposition are somewhat higher.

The low organic matter and nitrogen in the nearshore areas are possibly caused by the quality of the organic sources and the local conditions which don't promote decomposition.

$CaCO_3$ in most areas comprises between 0.2 and 0.5% of the soil. High levels of 0.5 to 1% occur at 13% of the sample points and very low levels at 4%. Generally, sampling has shown that calcium is low except in the nearshore area where values are in the higher range.

Table 3.9. Macrobenthic invertebrate density (ind./m^2) in Segara Anakan, 1983 (ET 1984).

Taxonomic division	July	August	September	Average
I. Gastropoda				
Fairbankia sp.	7	12	5	7
Thiara sp.	704	512	362	526
Assiminea sp.	2	21	22	16
Salinator sp.	5	5	3	4
Stenothyra sp.	-	13	3	5
Laemodonta sp.	-	4	-	2
II. Lamelibranchiata				
Barbatia sp.	-	3	3	2
III. Polychaeta				
Platynereis sp.	20	4	24	16
Cirratulus sp.	-	3	2	2
IV. Diptera				
Hydrophorus sp. (Larvae)	2	7	2	4
V. Crustacea				
Gammarus sp.	678	1,554	1,361	1,197
Gammaropsis sp.	-	9	5	4
Sesarma sp.	52	177	173	134
Chionocetes sp.	8	2	-	4
Asellus sp.	-	2	-	1
VI. Nematoda	5	8	8	7
Total	1,483	2,336	1,973	1,931
Diversity index (Shannon)	0.9967	1.0201	0.7596	1.0479
Total taxa	10	16	13	16

The salt content of the soil as measured by conductivity in the nearshore area is high, greater than 40 mhos/cm. It tends to decrease farther landward to less than 20 mhos/cm in the north area. Landward salinity decreases resulting from translocation of soluble salts upward by the flow of soil moisture. Soil acidity varies from slightly acid (farther inland) to neutral (nearshore area) (pH 5.6-7.5).

The soluble sulfate in the nearshore area is high, around 0.4-0.5%. Landward, it is 0.2-0.3% with increases in vertical distribution. Sulfate content is lower farther from the coast because of the effect of river water and coincidence with the pyrite distribution which varies from 0.1-0.3% (nearshore) to 0.3-0.9% (landward).

The oxidation acidity shows a tendency of having a reverse relation to pyrite. The nearshore soils possess values of around pH 3.5-4.5, whereas farther landward, of pH 2.5-3.5.

In summary, the data on acidity, soluble sulfate and pyrite show that acid-sulfate soil has not formed in the study area except for small landward sections.

Mineral Resources

The most important mineral of Cilacap area is iron sand, the presence of which was determined in 1910. Hence, exploitation has been attempted several times with commercial mining beginning in 1971 (Rahardjo 1982). A state mining enterprise has signed a contract to deliver 300,000 t of iron sand concentrates annually to Japan. The site is along the beach northeast off Cilacap City.

Limestone, next in importance, is mined for industrial purposes in Nusa Kambangan for the Nusantara Cement Factory. Attempts are being made now to exploit miocene-limestone in the vicinity of Karang Bolong.

Andesite and basaltic flows and breccia outcrops in Gunung Selok and Gunung Srandil are potential sources of crushed stone for surfacing roads. The economic importance of bituminous shale in Manguweni Village in the eastern side of Cilacap requires further study (Rahardjo 1982).

Coastal Forest

The Cilacap mangrove forest habitat covers an area of about 24,000 ha (Fig. 3.2). The largest portion (21,185 ha) is in the immediate shore surrounding Segara Anakan, with an intertidal swampy forest of around 14,100 ha (Sunaryo 1982). The Ecology Team reported 21,750 ha of mangrove habitat, 12,610 ha of which are tidally affected and form the dominant vegetation mass.

The mangrove ecosystem varies from place to place due to differences in topography, tidal fluctuation and sediment transport patterns. The mangroves observed are of four types, according to zone, due to differences in salinity and sedimentation.

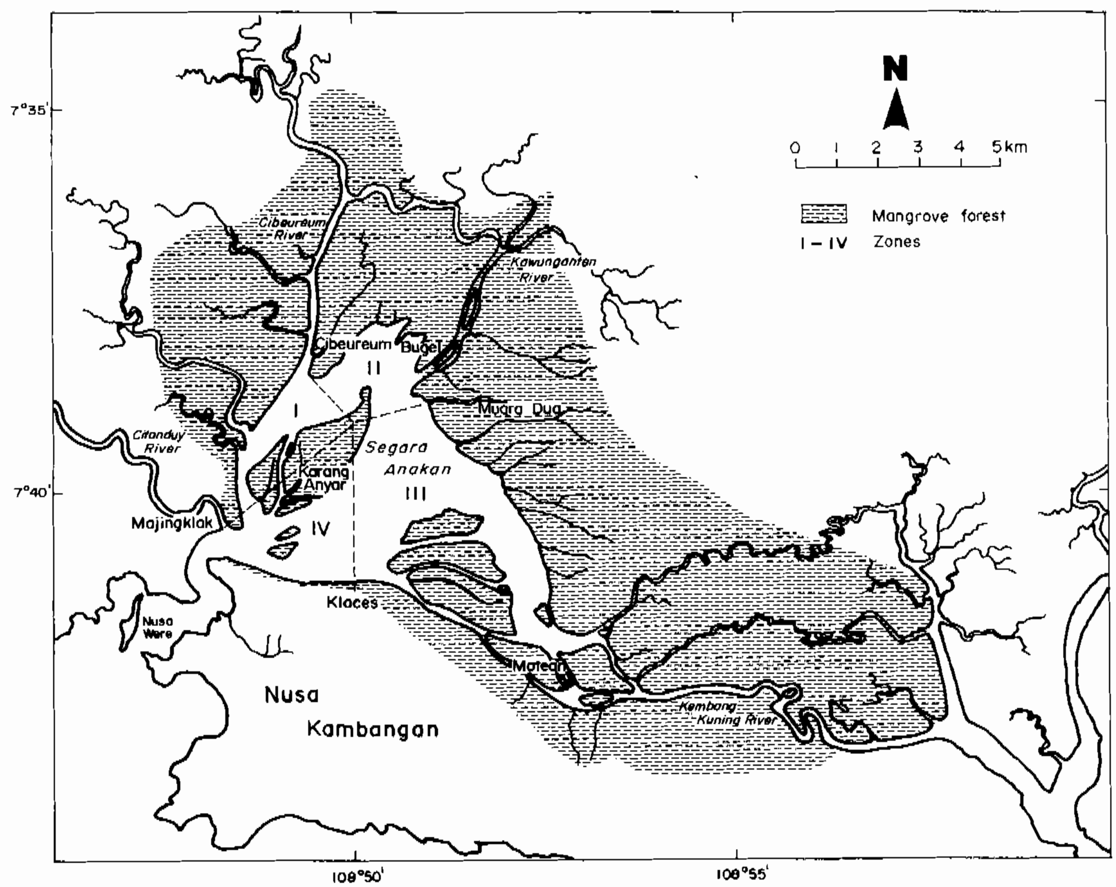


Fig. 3.2. Mangroves in Segara Anakan-Donan watersheds (ECI 1987).

Zone I (Fig. 3.2), from Majingklak to Cibeureum River, includes 2,155 ha of mangroves (Table 3.10). The area is elevated, and only a relatively small belt is affected by high tide. The mangrove area north of Karang Anyar Island is most frequently exposed to high tides and also affected by freshwater inflow.

Zone II has about 3,380 ha of mangroves in two subareas (Table 3.10). The area north of Cibeureum Island is considerably elevated, and the mangrove belt affected by high tide is about 360 m wide. The mangrove area east of Cibeureum Island is gently sloping, with an area of about 1,000 m wide affected by the prevalent high tide. Sediment accumulation in these subareas originate mostly from Citanduy River, and partly from Kawunganten River. Consequently, the depth of the water column in front of the mangrove area is relatively shallow, averaging about 0.5 m. Kampung Bugel is in this zone.

Table 3.10. Estimated mangrove area (ha) affected by exceptionally high tide (ET 1984).

	Zone				
Area	I	II	III	IV	Total
Coastal mangrove	2,000	2,920	5,540	155	10,615
Island mangrove	155	460	920	460	1,995
Total	2,155	3,380	6,460	615	12,610

Zone III comprises the area south of Kampung Muara Dua to Motean, and from Motean westward to Kampung Klaces on Nusa Kambangan. The mangrove area is about 6,460 ha, the largest in the lagoon. The mangrove area from Muara Dua to Motean is on gently sloping land, thus, covering a wider belt of 1,000-2,000 m. This zone is not affected by the western or eastern tidal current, as these currents meet at a point near Motean, south of the area.

Zone IV goes west of Klaces along the shoreline of Nusa Kambangan, and includes a part of Karang Anyar Island. It contains about 615 ha of mangroves. This zone is significantly affected by tidal currents flowing in from the western passage. The lagoon bordering the mangrove forest on Nusa Kambangan is the deepest part, with prevailing strong currents. Sedimentation is relatively low, with the exception of the area around Karang Anyar. The mangrove belt affected by high tides seldom exceeds 100 m wide.

Mangrove community

In 1983, the mangrove forest covered a total area of about 21,750 ha, of which 12,610 ha were tidally affected. This forest represents the dominant vegetation mass of the Segara Anakan ecosystem. The ecosystem is affected by seawater inflow through the eastern and western passages and freshwater inflow from basin runoff, creating conditions suitable for mangrove growth.

The survey in 1983 recorded 26 species, three of which were abundant in the seven transects and considered commercially important. These three were *Rhizophora apiculata, R. mucronata* and *Bruguiera gymnorrhiza*. *Rhizophora* spp., with an average diameter of 7 cm at breast height (DBH), and a height of 6 m, were common, while tree densities with DBH greater than 5 cm varied between locations.

Three species associations were observed: pure stands, paired associations and mixed associations. Pure stands were limited to specific environmental conditions and consisted of:

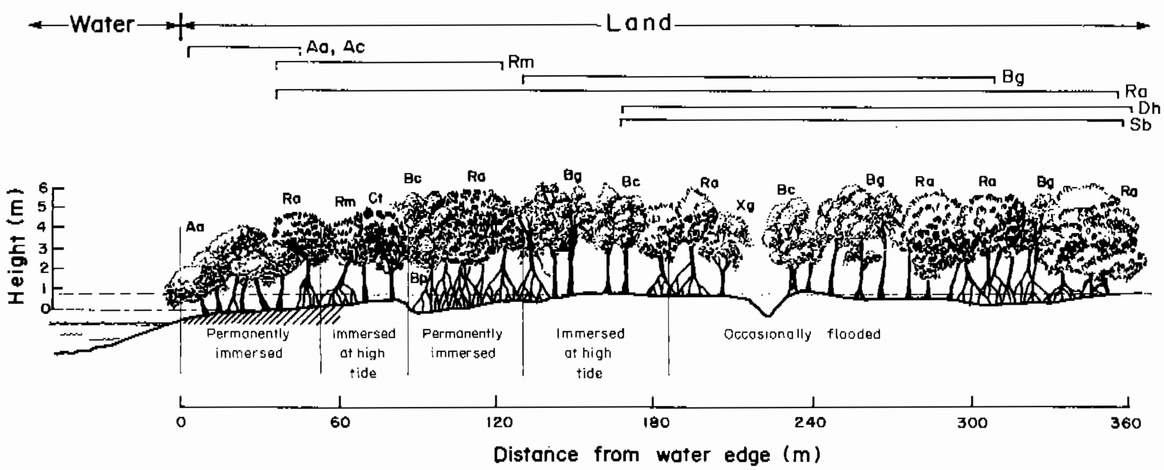
1. *Avicennia marina* and *A. alba* found along the seaward fringe, directly affected by saline water;
2. *R. mucronata,* found in the interior and along flowing, tidally affected creeks;
3. *Ceriops tagal,* found more landwards and along flowing, predominant freshwater creeks; and
4. *Aegiceras corniculatum,* found along the seaward fringe, river mouths and flowing creeks.

Tide levels and soil and drainage conditions may result in the formation of a typical paired association, as noted for *Avicennia officinalis* and *Sonneratia caseolaris* which formed a paired association in high tidal flats. *A. alba* and *Aegiceras corniculatum* were typical at levels exposed to high neap tide along flowing creeks. An inland transition forest with some abandoned swampy or wet/dry wasteland was found to be occupied by bushy shrubs such as *Phragmites karka.*

The Zone I mangrove community had 14 species; the dominant and most important were *R. apiculata* and *B. cylindrica.* In the Karang Anyar area, *R. apiculata* and *R. mucronata* dominated; although *A. alba* occupied a large area. *Derris heterophylla* dominated the lower strata in the south of Majingklak, while *Acanthus ilicifolius* dominated Karang Anyar (Figs. 3.3 and 3.4). In Zone II, *R. apiculata* was the most important and dominant, particularly in areas about 360 m landwards. This was followed by *X. granatum, B. gymnorrhiza* and *A. corniculatum* (Fig. 3.5). In the transition zone, bordering the *R. apiculata*-dominated area and the more inland wetlands, *N. fruticans* was dominant (Fig. 3.5).

Zone III was primarily occupied by *R. apiculata* and *A. alba.* The dominating species of the lower strata were *D. heterophylla* and *A. ilicifolius* (shrubs) (Fig. 3.6). *Rhizophora* spp. dominated the mangrove community and the lower strata in Zone IV.

Frequently inundated mangrove areas constituted the largest part (about 45%) of the mangrove forest. This indicates that the largest part of the mangrove area of the Segara Anakan system is suitable for species tolerant to or dependent on high salinities and/or frequent inundation.



Aa - *Avicennia alba*
Ac - *Aegiceras corniculatum*
Bc - *Bruguiera cylindrica*
Bg - *B. gymnorrhiza*
Bp - *B. parviflora*
Ct - *Ceriops tagal*
Dh - *Derris heterophylla*
Ra - *Rhizophora apiculata*
Rm - *R. mucronata*
Sb - *Sarcolobus banksii*
Xg - *Xylocarpus granatum*

—— (Exceptionally high tide) = 190 cm
—·— (High tide) = 167 cm
---- (Low tide) = 49 cm

Fig. 3.3. Diagrammatic profile showing the species zonation with respect to environmental gradient in the trees (*R. apiculata, B. gymnorrhiza, B. cylindrica*) and undergrowth communities (*D. heterophylla, S. banksii, B. gymnorrhiza*) of South Majingklak area of aquatic Zone I (ET 1984).

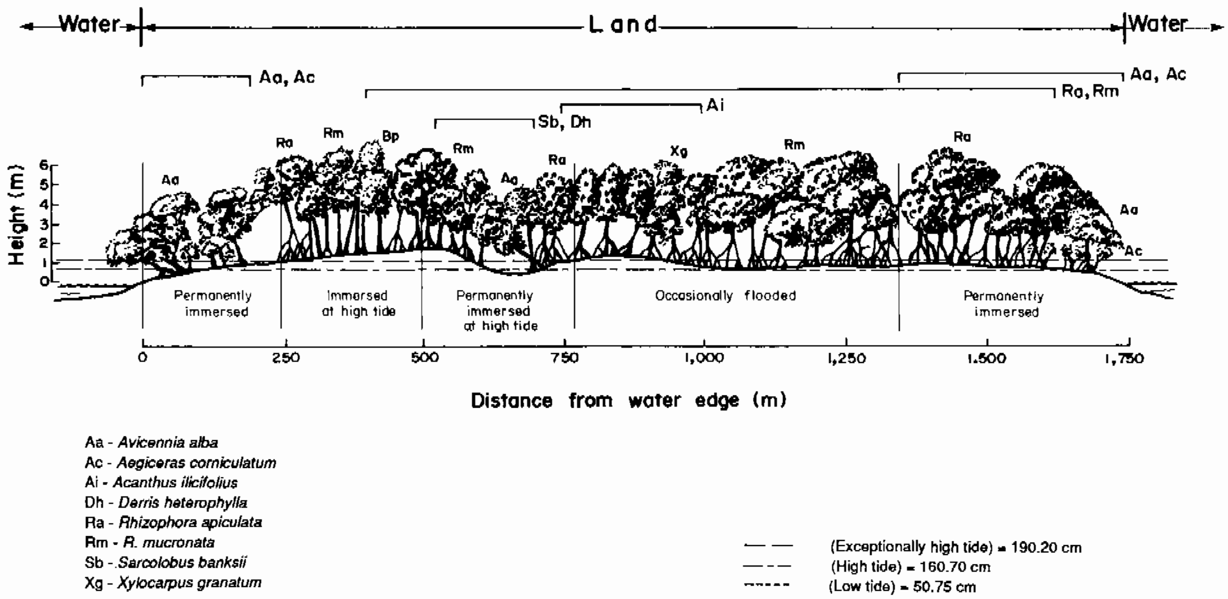


Fig. 3.4. Diagrammatic profile showing the species zonation with respect to environmental gradient in the trees (*R. apiculata, A. alba, R. mucronata*) and undergrowth communities (*A. ilicifolius, R. apiculata, A. alba*) of Karang Anyar area of aquatic Zone I (ET 1984).

Furthermore, mangrove zonation closely corresponded to the effects of submergence, salinity and length of inundation period. Two typical zonations observed in the Segara Anakan system are presented in Figs. 3.3-3.6. The decreasing diversity and size of mangroves found in each zonation type illustrated the typical change of ecological condition from the seafringe to the more inland areas.

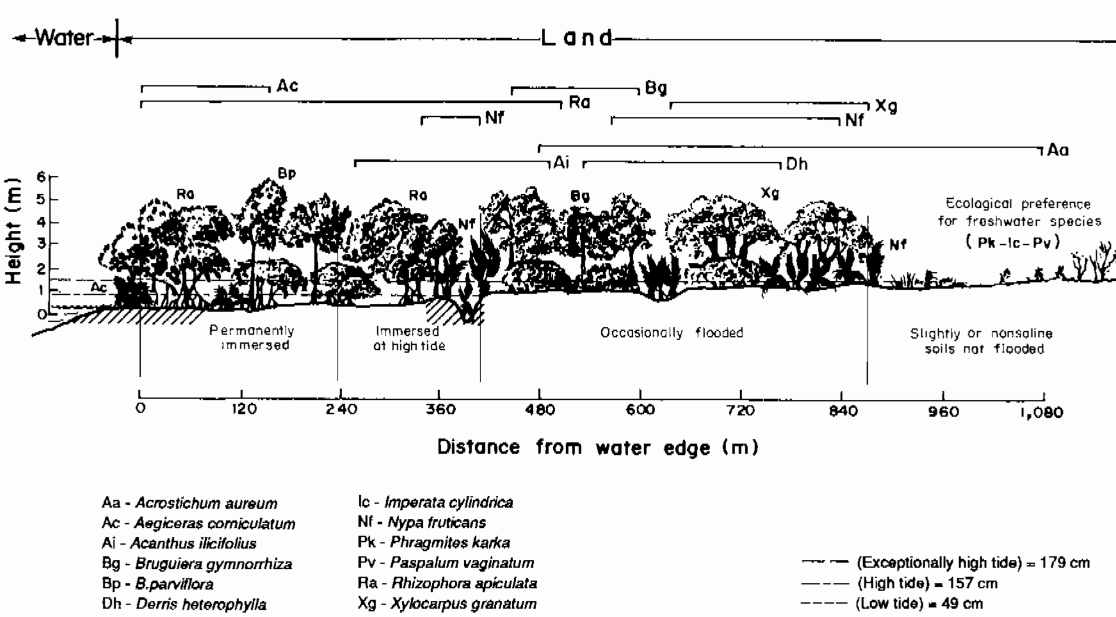


Fig. 3.5. Diagrammatic profile showing the species zonation with respect to environmental gradient in the trees (*R. apiculata, X. granatum, N. fruticans*) and undergrowth communities (*D. heterophylla, A. aureus, A. ilicifolius*) of Cibeureum area of aquatic Zone II (ET 1984).

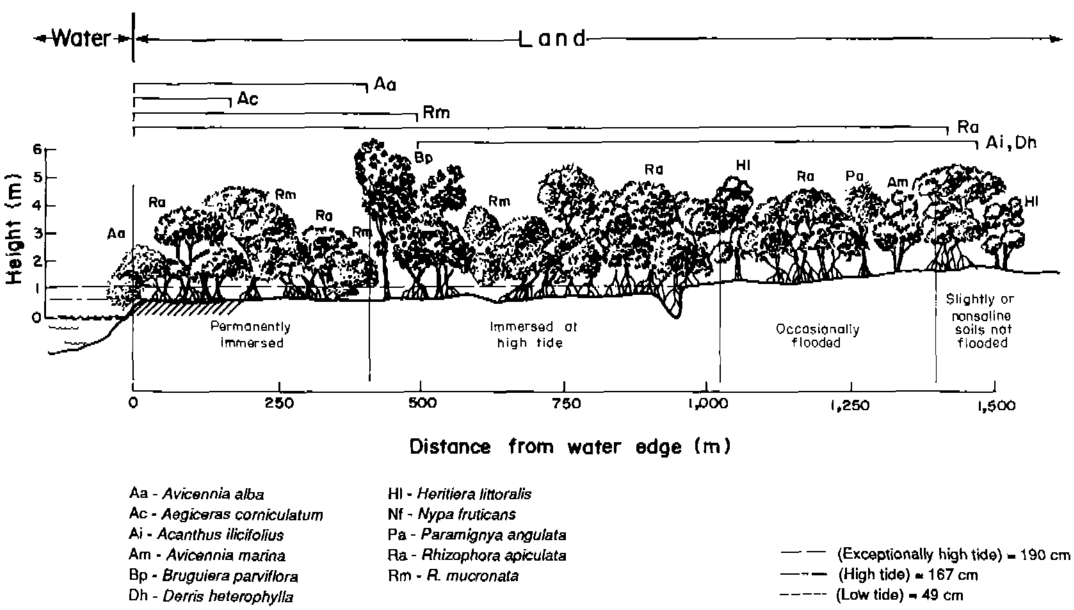


Fig. 3.6. Diagrammatic profile showing the species zonation with respect to environmental gradient in the trees (*R. apiculata, A. alba, R. mucronata*) and undergrowth communities (*D. heterophylla, A. ilicifolius, N. fruticans*) of Muara Dua area of aquatic Zone III (ET 1984).

Critical to the perpetuation of the mangrove system are:

1. Water supply, both freshwater and saline;
2. Nutrient supply, adequate to support mangrove growth, carried into the system from the upper reaches and its surroundings and from the marine system; and
3. Stability of the substrate.

In summary, the seven transects made by the Ecology Team recorded 26 species, while Sunaryo (1982) noted 23 species and 14 families (Table 3.11).

Invasion of mangrove species is predictable and not diverse on newly formed land in Segara Anakan (Pudjoarinto 1982). Pioneer species typically consist of *A. alba, Sonneratia alba* and *S. caseolaris;* and in some locations, *A. corniculatum* and *R. apiculata.* The dominance of particular species varies with the geographical area as shown by Soeryowinoto et al. (1979), Pudjoarinto (1982) and Hardjosoewarno (1984).

The combined actions of waves, tides and currents contribute to the spread of seeds. Certain species benefit from this mode of transport and are the first to colonize newly formed land. This may be the case in Segara Anakan where the forest is advancing seaward as sediments build up.

A general zonation of the area described by Hardjosoewarno (1982) included three different localities relating to environmental conditions: (1) the accretion area of Pekalongan and Bondan Rivers; (2) the nonaccretion area in the east of Segara Anakan near Cilacap; and (3) the polluted area of Donan River by the oil refinery plant.

In the accretion area, a distinctive zonation could be observed of species depending on the increasing contents of dissolved salts and pH. In the nonaccretion area, zonation did not exist and the dominant genera were evenly distributed. The soil parameters were uniform. In the presumed polluted area of Donan, there was a tendency of decreasing vegetation of the lower strata on the west of the river. The oil content of the inflow ranged from 0.7-4.2 ppm, and on the west bank, 44-194 ppm, thus, the decrease in vegetation cover in this area.

Table 3.11. Mangrove species found within the transects (Sunaryo 1982).

Trees :	Apocynaceae	-	*Cerbera odollam*
	Meliaceae	-	*Xylocarpus granatum*
	Myrsinaceae	-	*Aegiceras corniculatum*
	Palmae	-	*Nypa fruticans*
	Rhizophoraceae	-	*Bruguiera cylindrica*
		-	*B. gymnorrhiza*
		-	*B. parviflora*
		-	*Ceriops tagal*
		-	*Rhizophora apiculata*
		-	*R. mucronata*
	Sonneratiaceae	-	*Sonneratia alba*
		-	*S. caseolaris*
	Sterculiaceae	-	*Heritiera littoralis*
	Verbenaceae	-	*Avicennia alba*
		-	*A. officinalis*
Shrubs:	Acanthaceae	-	*Acanthus ilicifolius*
	Polypodiaceae	-	*Acrostichum aureum*
	Graminae	-	*Imperata cylindrica*
		-	*Paspalum vaginatum*
		-	*Phragmites karka*
Liana :	Asclepidaceae	-	*Sarcolobus banksii*
	Asteraceae	-	*Wedelia biflora*
	Leguminoceae	-	*Derris heterophylla*

Productivity

The potential biomass was estimated using the dominant species found in the Segara Anakan mangrove system (Tables 3.12 and 3.13). Of the nine species, seven were represented in Zone I, which contributed a total biomass of about 160 m^3/ha, with *R. apiculata* and *R. mucronata* amounting to about 20% and 22%, respectively (Table 3.13). *R. apiculata* and *B. cylindrica* had the highest density. Represented in Zone II were *R. apiculata* and *X. granatum* which had similar densities, followed by *B. gymnorrhiza*, and then, *B. parviflora*. These four species contributed a biomass of about 240 m^3/ha, with the largest (49%) from *B. gymnorrhiza* and then *R. apiculata* (38%).

All dominant species, except *B. cylindrica*, were represented in Zone III. This complex mangrove system contributed a total biomass of about 590 m^3/ha, the highest among the zones (Table 3.13). In Zone III, *B. parviflora* gave the largest (31%) biomass, followed by *B. gymnorrhiza* (26%) and *A. marina* (21%). Zone IV gave the smallest biomass (2.7 m^3/ha). *R. apiculata* and *R. mucronata* were high in density contributing 56% of the total biomass (Table 3.13).

The influence resulting from man-induced disturbances such as cutting or clear-felling for firewood and timber and agricultural activities were ignored in these estimates. Nevertheless, these conditions indicate that the biomass potential, and therefore, litter produced closely correspond to the area occupied by the mangrove community (Tables 3.13 and 3.14).

Considering the factors and conditions described above, it is concluded that:

1. *R. apiculata* contributed a significant role in all zones in biomass potential, and *Rhizophora* spp. were generally important in the total biomass in tidally affected areas;

Table 3.12. Net primary production of litter in Segara Anakan as estimated from observations of marked shoots, 1983 (ET 1984).

Aquatic zone	Mangrove zonation Dry matter ($g/20\ m^2/day$) I	II	III	Total
Zone I (Karang Anyar)	Ac, Ra, Rm, Aa, Sc, Bg, Xg, Bp	Aa, Bg, Rm, Ra, Bp, Rm, Xg	Ac, Rm, Xg, Aa, Bp, Ra, Bg	
Leaves, bud scales	520	720	420	
Buds, flowers	18	20	15	
Branches	2,500	2,750	2,000	
Subtotal I	3,038	3,490	2,435	8,963
Zone II (Cibeureum)	Ra, Ac, Bg, Xg, Bp	Bg, Ra, Bp, Bp, Xg	Xg, Bp	
Leaves, bud scales	620	320	105	
Buds, flowers	20	15	5	
Branches	3,500	1,500	250	
Subtotal II	4,140	1,835	360	6,335
Zone III (Muara Dua)	Aa, Ao, Sc, Ac, Ra, Am, Rm	Ra, Bg, Sc, H, Xg	-	
Leaves, bud scales	575	120	-	
Buds, flowers	15	10	-	
Branches	2,575	1,750	-	
Subtotal III	3,165	1,880	-	5,045
Zone IV (Udjung Alang)	Ra, Rm, Aa, Am	Ra, Rm, Bg, Bp	Bp, Xg, Bg	
Leaves, bud scales	750	350	150	
Buds, flowers	25	19	15	
Branches	3,500	2,500	1,750	
Subtotal IV	4,275	2,869	1,915	9,059
Total	14,618	10,074	4,710	29,402

Notes:

Aa - *Avicennia alba*
Ac - *Aegiceras corniculatum*
Am - *Avicennia marina*
Ao - *Avicennia officinalis*
Bg - *Bruguiera gymnorrhiza*
Bp - *Bruguiera parviflora*
Ra - *Rhizophora apiculata*
Rm - *Rhizophora mucronata*
Sc - *Sonneratia caseolaris*
Xg - *Xylocarpus granatum*

2. *Bruguiera* spp. replaced the rhizophores in areas predominantly affected by freshwater currents, which were observed in Zones II and III.

It was thus noted in the Ecology Team's study that the observed conditions affect litter production, decomposition, mineral intake and organic matter transfer which, in turn, create

Table 3.13. Estimated tree stem density (N) (trees/ha) and biomass (B) (m^3/ha) of dominant mangrove species in the four zones, excluding those on islands (ET 1984).

Species	I		II		III		IV	
	N	B	N	B	N	B	N	B
R. apiculata	33	32.36	15	89.13	63	26.30	57	0.66
R. mucronata	19	34.67	-	-	47	33.11	43	0.87
B. cylindrica	32	29.51	-	-	-	-	-	-
B. gymnorrhiza	26	22.39	10	117.49	7	151.37	6	0.38
B. parviflora	3	22.91	4	22.91	10	181.97	-	-
A. alba	13	15.14	-	-	50	28.84	3	0.25
A. marina	-	-	-	-	37	125.89	-	-
A. officinalis	-	-	-	-	20	38.02	4	0.26
X. granatum	2	1.23	15	7.94	7	2.69	3	0.29
Total	128	158.21	44	237.47	241	588.19	116	2.71

Table 3.14. Net primary production of litter of some mangrove species in Segara Anakan, 1983 (ET 1984).

Species	Dry matter (g/m^2/day)		
	Leaves, bud scales	Buds, flowers	Branches
A. marina	4.155	6.750	10.250
A. officinalis	3.417	3.200	11.125
A. alba	3.517	3.150	9.750
R. mucronata	6.850	10.350	15.750
R. apiculata	7.167	12.115	19.350
B. gymnorrhiza	7.825	14.150	16.750
B. parviflora	5.625	11.375	20.150

significant contributions to fish, substrate-dependent organisms and wildlife. Further, the nutrient-organic matter cycles, resulting from the potential biomass produced by the mangrove system, are an indispensable link to many life forms found in the mangrove system, its substrate and adjacent water system (Fig. 3.7).

The most frequently inundated areas form the largest portion (45%) of the mangrove forest in Segara Anakan. Thus, the most dominant species are adapted to high salinity and dependent on inundation. Provided the system is intact within this habitat, an amount of litter will be produced and degradation will occur, resulting in detritus important as the primary energy source for the aquatic faunal community.

Contribution to fisheries

The supposed interaction between mangrove ecosystems and fisheries resources has been stated by Odum and Heald (1972), thus: that the organic matter produced by mangroves, particularly in the form of fallen leaves, is transformed into detritic particles by bacteria, microalgae, protozoans and permeated fungi, which are eventually transported into surrounding waters by tide flushing runoff. These detritic particles, including various life forms found within them, will be utilized as food by larger consumer organisms such as fish, shrimp and crabs (Fig. 3.8).

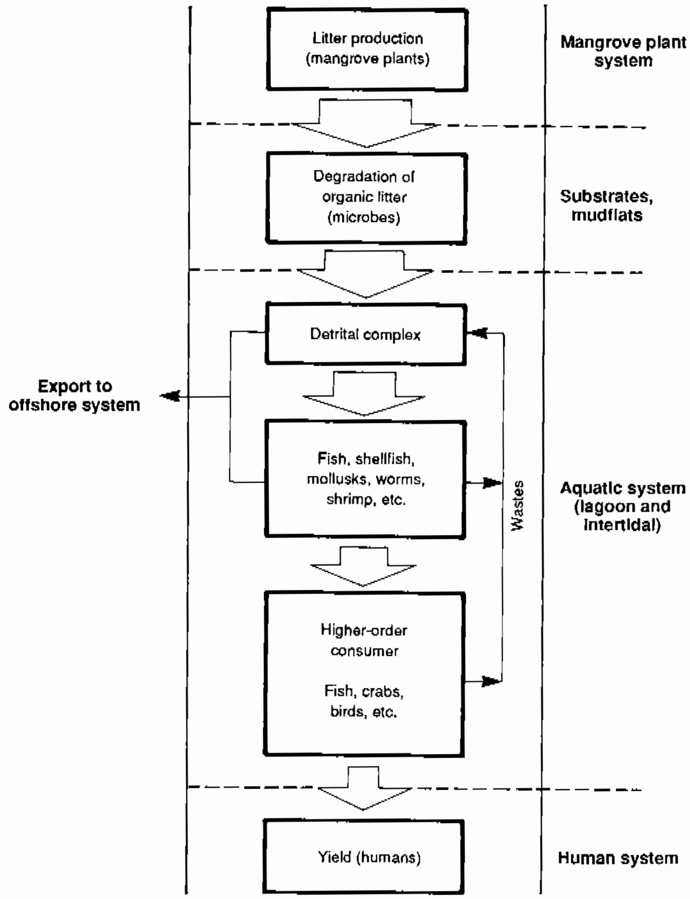


Fig. 3.7. Simplified energy flow in Segara Anakan ecosystem (ET 1984).

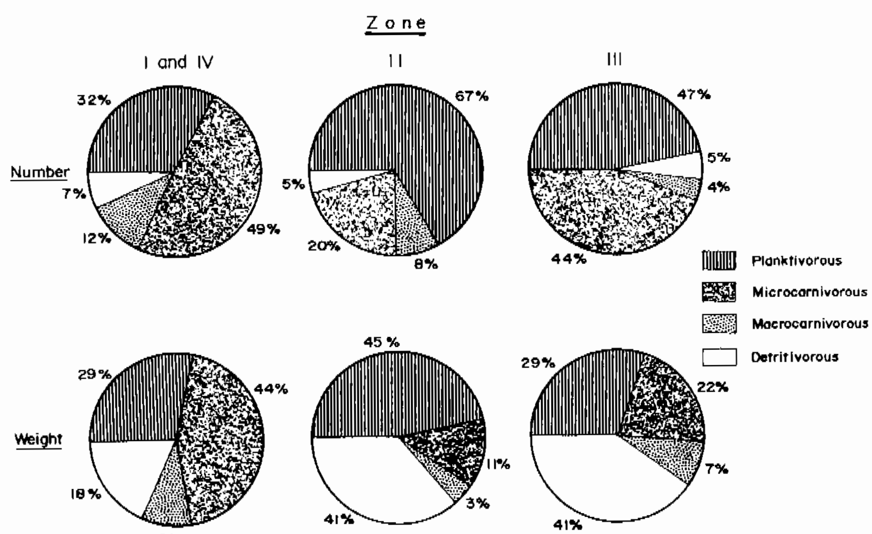


Fig. 3.8. Composition of ichthyo community structure in Segara Anakan, 1983 (ET 1984).

The net primary production of litter provided by Rhizophoraceae was 5-7 g/m^2/day in terms of leaves and bud scales, while Verbenaceae, 3-4 g/m^2/day (Table 3.14). Protein, from 6 to 20%, was observed as *Rhizophora* sp. leaves were kept in seawater for six months. These leaves were also found to be most preferred by the juvenile shrimp *Metapenaeus monoceros*.

The potential biomass productivity varied from one zone to another. The average total litter production ranged from 5,045 to 9,059 g/20 m^2/day (Table 3.12). Zones I and IV provided higher average of litter production compared to Zones II and III, which provided larger potential biomass. This condition was due to the higher degree of homogeneity observed in Zones II and III. In spite of the difference, Zones II and III might still make a larger contribution in providing litter because the mangroves here covered a substantial area, with their contribution indicated by the highest organic matter content (3%) in Zone III soils.

Two dominant detritus feeders, *Mugil* sp. and *Cynoglossus* sp., in the detritus-rich area indicated the importance of organic matter to fisheries. About 46% of the fish encountered were microcarnivorous or detritivorous. Both feeding habits largely depended on organic matter transferred or accumulated on the water substrate. The significance of the organic matter produced and thus of the mangrove vegetation is shown by these conditions. Also, the abundance of larvae of various fish and shrimp in the water systems adjacent to mangrove areas supports the significant role of organic matter in the food chain (Table 3.15).

Table 3.15. Composition (number and percentage) of fish and shrimp larvae found in the mangrove habitats in the four zones, 1983 (ET 1984).

Taxonomic division	I		II		III		IV	
	Majingklak	%	Cibeureum	%	Muara Dua	%	Klaces	%
Fish								
Apogon aureus (*serinding*)	-	-	112	7.14	-	-	-	-
Saurida tumbil (*bloso*)	-	-	2	0.13	2	0.35	-	-
Tetraodon reticulatus (*buntal kelapa*)	-	-	1	0.06	-	-	-	-
Others	279	60.52	1,180	75.26	186	32.92	434	48.17
Shrimp								
Penaeidae	12	2.60	133	8.48	97	17.17	9	1.00
Sergestidae	24	5.21	4	0.26	10	1.77	5	0.55
Others	146	31.67	136	8.67	270	47.79	453	50.28
Totals	461	100.00	1,568	100.00	565	100.00	901	100.00

Human uses

Mangrove trees are commonly used for construction, staking fish nets and traps and firewood by the local residents. Clearing also occurs whenever land is needed for aquaculture or small-scale farming. Some areas, especially on the inland fringe of the mangrove forest, have been heavily cut or totally cleared for rice farming or in some areas, for tree plantations. The extent of these uses has not been quantified. Nevertheless, general observation in early 1988 indicated that sizeable portions of the mangrove forest are affected by sporadic and selective cutting for various uses. Clear-cutting is restricted to areas near villages and in the upland sides of the forest which border ricefarms and other agricultural areas.

General Fauna

Table 3.16 lists the most common mammals, birds, fish, crustaceans and mollusks found in the mangrove areas of Cilacap. The crab, *Uca;* mollusk, *Nerita;* and fish, *Periophthalmus,* were most common in the lagoon. Djohan (1982) notes 20 species from 17 sites with the highest diversities at Cigintung, Selok Jero and Karang Anyar areas, and the lower diversities at Bugel, Citanduy, Kembang Kuning and Donan. The highest densities of these animals were in Selok Jero, Donan, Karang Anyar and Kembang Kuning. However, there were no good explanations given for the variations of diversity and density among the sites.

The distribution of common fish was not equal. Variation in mud substrate, water clarity and mangrove vegetation may explain the range of the diversity index (0.74-1.48). The high values occurred in Selok Jero, Cigintung and Karang Anyar, while the low ones, in Bugel, Donan and Kembang Kuning.

Table 3.16. Common animals found in Cilacap mangrove forest, 1980 (Hardjosoewarno et al. 1982).[a]

Taxonomic division	Species	Taxonomic division	Species
Mammalia	*Sus vitatus*	Mollusca	Bivalves
	Macaca fascicularis		*Anadara*
	Presbytis pyrrhus		*Saxidomus* sp.
			Anomia corugata
Aves	*Ardea purpurea*		*Lucina* sp.
	A. cinirea		*Pedalion* sp.
	Ibis cinereus		*Littorina scabra*
	Ciconia episcopus		*L. carinifera*
	Egretta alba		*Nerita exuvia*
	Bubulcus ibis		*N. violacea*
	Dendrocygna sp.		*Assiminea brevicula*
	Amauornmis sp.		*Chicoreus* sp.
	Anhinga melanogaster		*Alectrion taenia*
			Telescopium telescopium
Pisces	*Periophthalmus* sp.		*Nassa mitralis*
	Mugil sp.		*Cerithidea cingulata*
Crustacea	*Pagurus* sp.		
	Grapsus spp.		
	Uca sp.		
	Ocypode sp.		

[a]Modified by editors.

In the coastal area of the lagoon at Motean, a mudskipper was dominant with a density of 34 ind./m^2. The muddy soil was soft, bare, flat and 50-70 cm deep. The dominant mollusk was *Cerithidea cingulata.*

In the south of Karang Anyar, the steep mudflat slope was colonized by mangroves. The mudskipper, *Periophthalmus scholosseri,* was also abundant with a density of 28 ind./m^2. The diversity index was high at 1.5.

At the mouth of Citanduy River, several mudskippers were recorded, including *P. scholosseri,* some *Grapsus* crabs and several gastropods. This site had the lowest diversity index (0.87) with a density of 35 ind./m^2. The soil was soft with a mud depth of 20-40 cm and a soil salinity of 0.133%. There were no mangrove plants but there were seedlings of *Derris,* indicating that the low diversity index was due to freshwater influence. In the east of Bugel, where the soil was very soft with a mud depth of 70-150 cm, there was also a very low species diversity.

In Selok Jero area, more marine species in higher densities were encountered. The water current and quality seemed more favorable for various species.

In the west bank of Donan River, in front of the oil refinery, 7 species were found, giving a diversity index of .88. The soil was relatively firm, with a mud depth of 5-30 cm of bare land. Mudskippers and *Uca* crabs were abundant with 198 ind./m^2.

On the west of the east bank of Donan River and in the northern area off the refinery, species diversity was relatively low, and the water temperature was noted to be slightly higher than normal at $36^{o}C$ in the west. Otherwise, no particular anomalies were noted except that the hermit crab, *Pagurus*, was commonly inhabiting Cerithid shells at the latter site.

Eleven species were noted at Cigintung, indicating a relatively high diversity. Abundance was average to low. The soil was relatively soft, with a mud depth of 10-40 cm. Currents were slow, and the area was covered with mangrove trees and saplings.

It was noted by Wahyuni and Nuraini (1982) that several mollusks *(Anadara* and *Saxidomus)* were abundant in the mangrove areas. On the west coast of Nusa Kambangan, the oyster, *Crassostrea*, was abundant.

Fisheries

A comprehensive study on fisheries resources in Segara Anakan was conducted in July to September 1983 by the Ecology Team. Reported were 45 species in 37 families: 17 migrating and 13 residential species and 16 occasional visitors (Table 3.17). Found in Zones I and IV were 44 species; 31 in Zone II; and 40 in Zone III. Based on their food habits or trophic levels, these fish were classified into four groups, namely, planktivorous (plankton feeders), microcarnivorous (benthic feeders), macrocarnivorous (piscivorous) and detritivorous. The ichthyo community structure in Segara Anakan is presented in Table 3.17 and Figs. 3.8 and 3.9.

Migrating species, which were well-represented in all zones (Table 3.18), consist of riverine, freshwater and marine species. With the exception of eels *(sidat, Anguilla* sp.*)* and soles *(ikan lidah, Cynoglossus lingua,* and *ikan sebelah, Crossorhambus azureus),* most of the migrants enter the estuary to feed. These species occupied specific habitats in the estuary in completing certain stages in their life cycles. The role of the Segara Anakan mudflats as feeding grounds or food organism-producing system is presented in Table 3.18. Mollusks, worms, crustaceans and fish (also in larval forms) are substrate-dependent organisms and feed on degraded plant debris produced by the upper-strata mangrove community. These trends, however, were not shown in the case of *petek (Leiognathus* sp.*)*, a pelagic marine species, as it is by nature a plankton feeder. The Segara Anakan aquatic system was, thus, shown to be a potential plankton "producer" that could support offshore fisheries.

The presence of migratory species is made possible through the interconnecting tidal creeks and major water channels that link the lagoon to the ocean and inflowing rivers. The role of the accessways on their distribution is represented by the distribution of occasional visitors, which were also in Zones I and IV (14 species) and III (13 species), with similar abundance and biomass. This condition shows that these zones provided relatively suitable conditions to equally sized visitors.

On the other hand, the conditions of Zones I and IV, although closer to main rivers or the ocean, were less suitable to migratory species, as indicated by smaller values of relative abundance and biomass (Table 3.17). Relative frequency of occurrence and abundance would also lead to the conclusion that the existing environment in Zones I, IV and III would support

Table 3.17. Ichthyo community in the four zones in Segara Anakan, July-September 1983 (ET 1984).

	Migratory								
	I and IV			II			III		
Feeding habit	n	N	W	n	N	W	n	N	W
Plankton feeders	6	60	5.7	5	189	28.4	5	314	23.3
Microcarnivorous (benthic feeders)	8	86	15.4	4	23	5.3	7	228	8.8
Macrocarnivorous (Piscivorous)	1	13	0.6	1	7	0.1	1	7	0.1
Detritivorous	2	3	0.2	1	6	0.2	2	16	0.4
Total	17	162	21.9	11	225	34.0	15	565	32.6
Relative frequency of occurrence	14.8			9.6			13		
Relative abundance		10.7			14.8			37.3	
Relative biomass			9.0			14			13.4

	Residential								
	I and IV			II			III		
Feeding habit	n	N	W	n	N	W	n	N	W
Plankton feeders	1	2	0.8	-	-	-	-	-	-
Microcarnivorous (benthic feeders)	8	74	8.5	5	26	0.9	8	64	3.0
Macrocarnivorous (Piscivorous)	2	22	5.2	2	14	1.7	2	14	3.7
Detritivorous	2	25	12.7	2	12	28.6	2	21	40.6
Total	13	123	27.2	9	52	31.2	12	99	47.3
Relative frequency of occurrence	11.3			7.8			10.4		
Relative abundance		8.1			3.4			6.5	
Relative biomass			11.1			12.8			19.4

	Occasional visitors								
	I and IV			II			III		
Feeding habit	n	N	W	n	N	W	n	N	W
Plankton feeders	7	72	14.3	6	29	3.8	6	53	6.0
Microcarnivorous (benthic feeders)	6	45	8.1	4	15	1.6	6	47	10.5
Macrocarnivorous (Piscivorous)	1	14	1.1	1	4	0.2	1	10	3.4
Detritivorous	-	-	-	-	-	-	-	-	-
Total	14	131	23.5	11	48	5.6	13	110	19.9
Relative frequency of occurrence	12.2			9.6			11.3		
Relative abundance		8.7			3.2			7.3	
Relative biomass			9.7			2.3			8.2

Notes: n = no. of species encountered; N = ind./effort; W = biomass (kg/effort).

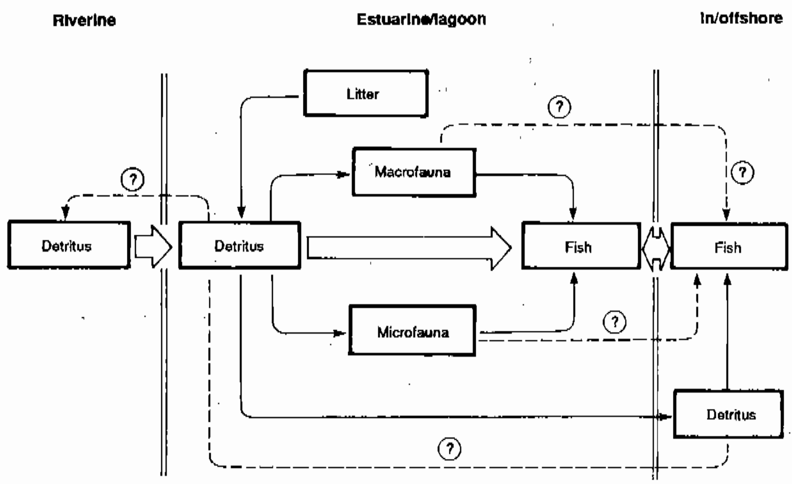


Fig. 3.9. Schematic diagram of possible organic matter transfer in food web in Segara Anakan (ET 1984).

Table 3.18. Stomach content (% volume) of dominant fish species in Segara Anakan, 1983 (ET 1984).

Genus	Fish food substances (%)							
	Detritus and plant debris	Phyto-plankton	Zoo-plankton	Mollusk	Crustacean	Worm	Insect	Fish
Mugil sp. *(belanak)*	36.0	5.4	56.0	-	-	2.6	-	-
Sillago sp. *(boyor)*	26.3	-	-	-	46.1	7.6	10.0	-
Johnius sp. *(tombol)*	8.7	-	-	6.7	-	-	84.6	-
Trachiphalus (susur-wedi)	-	-	-	1.6	-	-	-	98.4
Cynoglossus sp. *(lidah)*	98.3	-	-	-	-	-	1.7	-
Setipinna sp. (lea)	-	-	-	-	97.8	2.2	-	-
Leiognathus sp. *(petek)*	-	27.3	72.7	-	-	-	-	-

greater variety and larger numbers of fish. A simplified model of organic matter transfer, based on the most probable prevailing feeding habits and water movement in Segara Anakan, is shown in Fig. 3.9.

Table 3.17 shows that the plankton feeders and microcarnivorous species were evenly distributed among zones with the exception of *ikan oleng (Rataboura bicolor), krekekan (Pomadasys hasta)* and most migratory species feeding on microcarnivores. Migratory species feeding on plankton made deep incursions as far as Zone II which was more brackish and also through the east-west passage to Zone III. Great abundances were observed in Zones II and III due to the high occurrence of *ikan oleng* indicating its high tolerance to turbid waters which was not the case for *ikan serinding (Apogon aureus),* which was only found in Zones I and IV.

Macrocarnivores were restricted to Zones I and IV which indicates that they intruded the lagoon system and preyed on the larval stages of the existing faunal community (Fig. 3.9) at the entrance of the lagoon. The macrocarnivores were also not as tolerant of turbid waters as the other species encountered.

Two species of soles *(Cynoglossus lingua* and *Crossorhombus azureus)* and two species of mullets *(Mugil cephalus* and *M. buchanani),* which were residential, represented the detritivores. Their distributions were widespread in all zones, indicating their ability to adapt to the lagoon's environmental conditions.

These discussions lead to the conclusion that Segara Anakan aquatic system:

1. Serves as a potential food-producing system for migratory species, both riverine and marine, with those encountered forming 63% of the ichthyo-fauna;
2. Has important habitats in the completion of life cycles of economically important species such as soles and eels, aside from penaeids and metapenaeids encountered in larval forms on the mangrove floor; and
3. Has accessways to the ocean and bordering freshwater and brackishwater systems (rivers and swamps) which have important roles as migratory pathways, in particular, the east-west passage and the channel connecting the western channel from Plawangan to the north, up to Cibeureum.

These statements are not definite, though. More in-depth investigations are needed to verify the lagoon dynamics in relation to the development of a sound CRM plan.

Catch

Fish made up about 25-40% of the lagoon catch; the rest were mostly crustaceans consisting of more than 10 species of penaeids, mysids, palaemons and crabs (TEM 1986). Naamin (1982) noted that the latter catch reached 400 t/year. The shrimp catch consisted of more than 20 species, six of which were economically important. In decreasing order of importance according to size and price, some of these species are:

- Banana or white shrimp *(jerbung)*, consisting of *Penaeus merguiensis, P. chinensis, P. monodon* and *P. semisulcatus;*
- Endeavor shrimp *(dogol)*, consisting of *Metapenaeus ensis, M. elegans* and *M. affinis;*
- Mixed small shrimp *(krosok)*, consisting of *Parapenaeopsis coromandelica, M. dobsoni* and *Solenosera crassiconis;* and
- Sergestidae and Mysidaceae.

Sujastani (1982) listed 21 species of demersal fish in Cilacap waters and 12 species of pelagics. Total species reported in catches were over 60 (TEM 1986).

Annual fish yields from the lagoon declined from 1,017 to 199 t during the period 1977 to 1980, followed by increases thereafter (Table 3.19). Increasing fishing effort leading to overfishing coupled with decreasing fishing area and water depth caused by sedimentation explained the drastic decline in catch. In recent years, fishing effort has decreased due to poor catch, thus, lessening slightly the problem of overfishing.

Common gear in use varied with the prevailing currents and depths. In Majingklak, Klaces and in the inshore waters of Muara Dua-Motean, gill nets, trammel nets, lift nets, traps and lines were commonly used. In the central area of the lagoon, gill nets were most used. Lift nets and lines were used in Cibeureum. The number of gill nets used declined from 1980 to 1982 (FSC 1983) due to decreasing depth and sedimentation of the lagoon.

Based on the Ecology Team's study, monthly fish yields varied cyclically with the seasonal differences in river discharges. The offshore landing variation was related to the lagoon's seasonal variation in the flushing of food material to the offshore waters. The link of Segara Anakan with offshore waters as a food source was shown by the preference of *Metapenaeus monoceros* juveniles to decomposed leaves of *Rhizophora.* The presence of two dominant detritus feeders of the genera *Mugil* and *Cynoglossus* in the detritus-rich areas also indicated the importance of organic matter to local fisheries. About 46% of the fish encountered were planktivores and detritivores, which feeding habits depended largely on organic matter transferred or accumulated on the water substrate.

Of the total catch, migratory species were about 60%; resident species, about 35%; and the rest, occasional visitors. The ratio of migratory to resident species was 4 to 1; of the 45

Table 3.19. Fisheries production (t) from Cilacap, 1966-1984.

Year	Shrimp TEM	Fish TEM	Fish and shrimp from Segara Anakan TEM	ET's study	Remarks
1966	82	1,993	628		
1967	155	4,426	364		
1968	79	2,087	663		Pretrawl fishing
1969	84	3,519	-		
1970	113	2,319	495		
1971	195	1,419	391		
1972	3,798	1,780	-		
1973	2,487	7,771	-		
1974	2,911	12,127	-		
1975	3,005	10,362	-		
1976	3,054	13,278	664	474	Trawl fishing
1977	4,900	13,414	1,017	937	
1978	5,205	16,523	622	516	
1979	5,242	16,329	282	182	
1980	1,614	3,870	199	99	Trawl ban-
1981	903	1,803	236	136	October 1980
1982	1,114	2,249	248	148	
1983	866	3,622	399	-	
1984	775	2,978	362	-	

Sources: TEM 1986; Cilacap Fisheries Service Office; and the Ecological Team's (ET) study.

species, 10 to 15 were represented in daily catches. Eight species of economic importance were mullets, mackerels and carangids. Although some of the marine species were caught throughout the year, there were definite seasons for most species, depending on the monsoon changes. Peak fishing seasons occurred in April and September.

In an attempt to show the potential fish yield and productivity of Segara Anakan, the Ecology Team estimated the primary productivity of the water system to be 387 mg C/m^2/day. This was in accordance with the findings of Nontji and Setiapermana (1982) who gave a range of 0.20-0.50 g C/m^2/day. The team then showed that 1.5-6.3 million ind./m^3 of phytoplankton and 20,000-47,000 ind./m^3 of zooplankton would be able to provide a fish yield of 1.12 t/year and 256 t/year of shrimp. These yield estimates would lead to a daily catch estimate per fisherman of 3.5 kg. This was higher than the 0.5 kg/day/fisherman figure arrived at from official fisheries data but lower than the crude census data result of 4.8 kg/day/fisherman. The estimated annual production from the latter source was 752 (517-1,010) kg/ha/year and for shrimp, 172 (37-233) kg/ha/year.

Sujastani (1982) estimated the maximum sustainable yields (MSY) for fish in Cilacap traditional offshore fishing grounds to be 10,500 t/year and for shrimp, 5,500 t/year. Naamin (1982) stated that the MSY for shrimp in the south coast of Java ranged from 4,177 to 5,792 t/year.

The above data and projections on sustainable fisheries yields indicate that the most ecologically and economically important aspect of Segara Anakan is its capacity as a nursery ground for marine fish and shrimp. Although the lagoon fisheries are important to the local residents, the real value of fisheries production is reflected in the coastal and offshore waters of Cilacap. To the extent that the lagoon contributes ecologically to offshore fisheries, it merits sustainable management to maintain its functions.

Chapter 4
Population, Socioeconomics and Land Use

TATANG SUJASTANI

The area of Segara Anakan consists of many small islands surrounded by dense mangrove forest. The first dwellings in the islands were probably established in 1835 when the Dutch government built custody stations there to protect navigational channels. These sites later developed into villages, the smallest units of government.

In 1982, there were three villages, collectively known as Kampung Laut, which were divided into seven subvillages: Udjung Gagak with the subvillages of Karang Anyar and Cibeureum; Penikel with Muara Dua, Bugel and Penikel; and Udjung Alang, with Motean and Klaces. These villages are administratively under Kawunganten subdistrict of the district of Cilacap, Central Java Province. The village of Majingklak in Citanduy belongs to Ciamis District, West Java Province (Fig. 4.1).

Most of the information in this chapter was derived from the work of the Economic Team of the Faculty of Economics, Padjadjaran State University in 1983. Since the lagoon is in a state of rapid physical change which has a direct impact on the livelihoods of the village residents, the information included herein should be viewed with caution.

The villages in Segara Anakan are accessible only by canoes and small boats in rivers and tidal channels. The larger towns of Kalipucang and Pangandaran (15 and 30 km west, respectively) in west Java; Sidareja (15 km northwest); Kawunganten (10 km northeast); and Cilacap (30 km southeast) are not included in this demographic survey.

Demography

The Segara Anakan area is sparsely populated in contrast to other areas in Central Java where living conditions are better. Kampung Laut is part of the subdistrict of Kawunganten, which is relatively less developed than the other villages in this administrative area. The population decreased from 1975 to 1983 by 8.4% or 692 individuals, giving a -.88%/year rate of growth. This local outmigration to urban areas around Cilacap and other rural areas was probably a result of declining livelihood options in the area (Tables 4.1 and 4.2).

Transmigration was suggested for the area but 80.7% of the inhabitants rejected the idea. However, during 1979 to 1983, 1,889 individuals mostly from Udjung Gagak were transmigrated or about 20% of Kampung Laut population (Table 4.3). Although the motivation for transmigration was not strong, those who moved realized that their productivity as fishermen decreased and that other areas offered better opportunities.

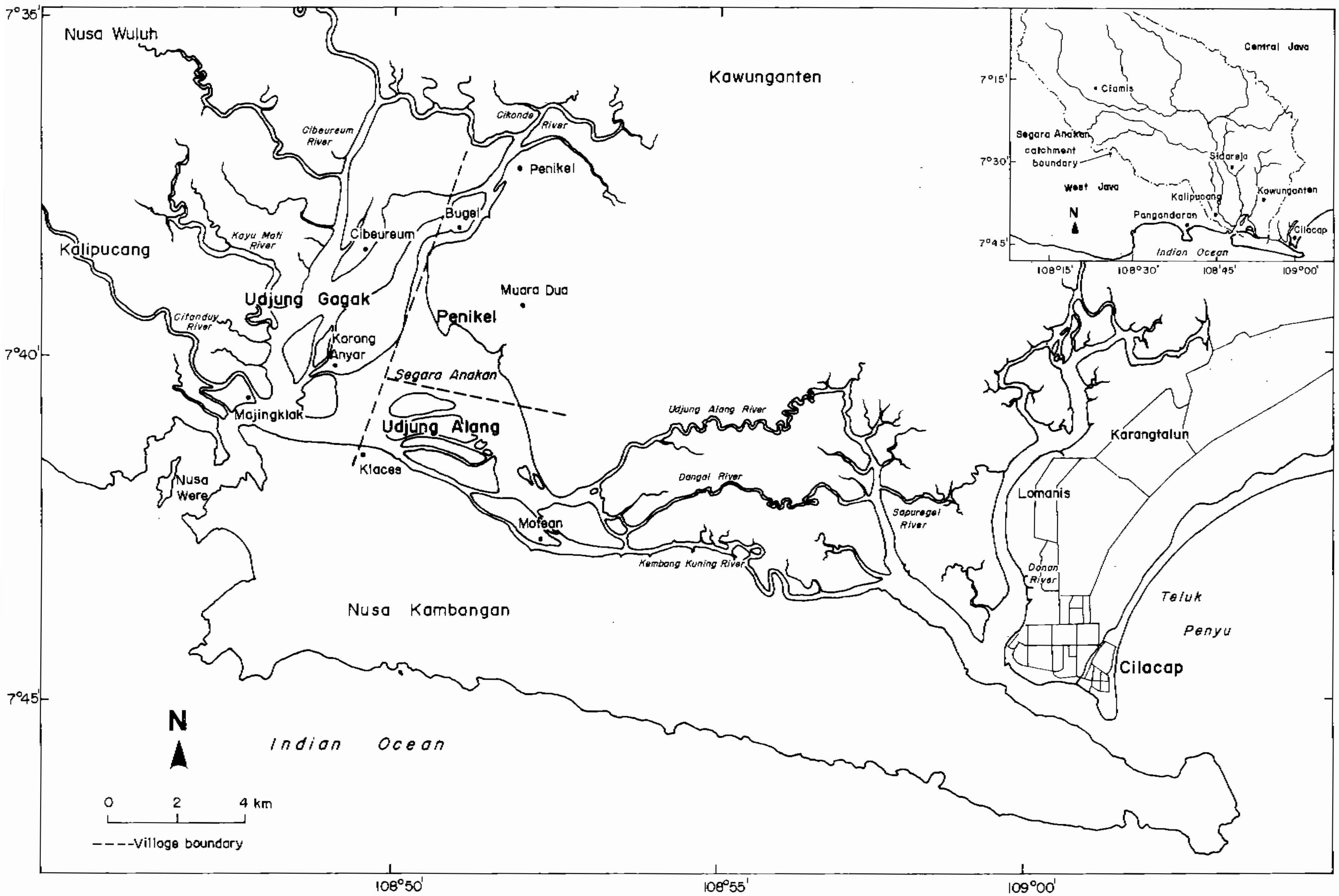


Fig. 4.1. Villages in Segara Anakan and Cilacap area.

Table 4.1. Population of Kampung Laut, 1975-1983 (ECT 1984).

Year	Udjung Gagak	Penikel	Udjung Alang	Majingklak	Total
1975	3,058	1,585	3,274	351	8,268
1976	3,058	1,581	3,364	363	8,366
1977	3,083	1,595	3,396	371	8,445
1978	3,069	1,589	3,507	381	8,546
1979	3,092	1,602	3,570	389	8,653
1980	2,583	1,473	3,445	376	7,877
1981	2,552	1,396	3,229	350	7,527
1982	2,467	1,113	3,447	348	7,375
1983	2,499	1,079	3,606	392	7,576
1986	2,454	1,241	3,868	91	7,654

Table 4.2. Population density (ind./km^2) of Kampung Laut villages, 1983 (ECT 1984).

Village	Area(km^2)	Population	Density
Udjung Gagak	25.15	2,499	99.4
Penikel	7.50	1,079	143.9
Udjung Alang	25.00	3,606	144.2
Majingklak	-	392	-
Total	57.65	7,576	

Statistics showed that immigration to Segara Anakan area was very low and did not affect population growth. About 93% of the inhabitants were born there. Some of the few immigrants were former inmates of the Nusa Kambangan Penitentiary. Intermarriages among the villages had also occurred.

In 1983, 35% of the population was under 15 years old with a variation of 27% in Udjung Alang to 44% in Penikel. The proportion of the age class under 15 has decreased since 1979. People were considered economically independent between 15 and 65 years old. The burden of dependency in Udjung Gagak in 1979 was 68% (Mantra 1982); in Kampung Laut, 83% in 1980 (Hardoyo 1982), which was higher than the average for Indonesia (81%) in 1976 (Table 4.4).

Table 4.3. Number of transmigrants, 1979-1983 (ECT 1984).

Year	Udjung Gagak	Penikel	Udjung Alang	Total
1979	62	-	-	62
1980	576	117	-	693
1981	227	464	251	942
1982	158	-	-	158
1983	34	-	-	34
Total	1,057	581	251	1,889

Table 4.4. Population distribution by age, 1983 (ECT 1984).

Age group	Udjung Gagak No.	%	Penikel No.	%	Udjung Alang No.	%	Total No.	%
0-4	353	14.1	155	14.3	286	7.9	794	11.1
5-9	392	15.7	209	19.4	335	9.3	936	13.0
10-14	303	12.1	113	10.5	342	9.5	758	10.6
15-59	1,419	56.8	587	54.4	2,479	68.8	4,485	62.4
60+	32	1.3	15	1.4	164	4.5	211	2.9
Total	2,499	100	1,079	100	3,606	100	7,184	100

Health and Water Supply

The quality of health in the area is poor. Malaria, cholera and skin diseases are common due to lack of potable water, malnutrition and poor housing and sanitary facilities. In 1984, only 1% of the households had decent facilities for washing and bodily needs. There were few toilets or outhouses in the villages.

Public health centers were inadequate and,until 1983, the villages were dependent on the center in Cilacap town. Now, Karang Anyar, Klaces and Motean each has a clinic which is a branch of the main center. The clinics are administered by nurses and midwives who visit the area twice a week. Otherwise, untrained personnel are on duty.

Except for Klaces on Nusa Kambangan and Motean, the villages have no fresh groundwater. During the wet season, rainwater is collected and stored for daily use. During the dry season, freshwater is brought from Nusa Kambangan. In 1983, the price per 20 liters was about Rp25.*

Analysis of drinking water in October 1985 indicated that: (1) the water in the reservoir in Udjung Alang was contaminated both from the reservoir condition and the source; (2) the water in Klaces was contaminated from the surrounding environment; and (3) the water in Karang Anyar was relatively clean since its source was rain, although an ammonia content of 0.05 mg/l deviated from the normal health standard. In general, the quality of water in the area posed a serious public health problem (Table 4.5).

Table 4.5. Results of physical, chemical and bacteriological examination of drinking water, October 1985 (adapted from TEM 1986).

Parameter	Units	Results		
		Udjung Alang	Klaces	Udjung Gagak
Taste	-	Salty	Tasteless	Tasteless
pH	-	8	7.3	7.5
Solid materials	mg/l	1,270	252	243
Chlorides	mg/l	483.10	15.46	11.59
Ammonia	mg/l	0.10	0.03	0.05
Nitrite	mg/l	0.17	0.07	-
Electrical conduct	umho/ml	1,150	375	-
E. coli	MPN/100 ml	-	800	2
Coli-feces	MPN/100 ml	-	4,800	26

*US$1.00 = Rp1,770 (as of June 1989).

Education

There was generally a low level of formal education in the area. Illiteracy was 60% in 1980 (Table 4.6) due to cost of education and transportation and lack of nearby schools (Hardoyo 1982). In 1984, the Economic Team indicated that the number of children who attended school decreased (Table 4.7). In 1983, every subvillage had an elementary school, but in Bugel and Penikel, the buildings collapsed. Motean, Klaces and Karang Anyar each have two elementary schools. But, there are no secondary schools in the vicinity so that potential students need to travel to Cilacap or other towns and pay lodging.

The dropout rate among elementary pupils is high since parents often take their children out of school to work with the family.

Table 4.6. Level of education in Kampung Laut, 1980 (Hardoyo 1982).

Level of education	Udjung Alang No.	%	Udjung Gagak No.	%	Penikel No.	%	Total No.	%
No schooling	2,558	63.9	1,369	52.8	920	62.5	4,847	60.1
Primary (dropout)	1,350	33.7	1,146	44.2	510	34.4	3,006	37.2
Primary (graduated)	70	1.8	55	2.1	29	2.0	154	1.9
Junior high	17	0.4	14	0.5	7	0.5	38	0.5
Senior high	10	0.2	9	0.4	7	0.5	26	0.3
Total	4,005	100	2,593	100	1,473	100	8,071	100

Table 4.7. Level of education of 166 sample respondents in Kampung Laut, 1983 (ECT 1984).

Level of education	Udjung Gagak No.	%	Penikel No.	%	Udjung Alang No.	%	Total No.	%
No schooling	28	16.9	24	14.5	59	35.5	111	66.9
Elementary (dropout)	29	17.5	1	.6	25	15.0	55	33.1
Elementary (graduated)	-	-	-	-	-	-	-	-
Total	57	34.4	25	15.1	84	50.5	166	100.0

Housing

Prior to 1969, most houses in the area were built over water on piles. Hence, shorelines have accreted to such an extent that most houses are constructed directly on land. About 80% of the houses in Kampung Laut have been restructured since 1980. Replacement of roofing and wall materials is common in Karang Anyar, Klaces and Motean due to cheaper supply of building materials available through regular ferry services from Cilacap and Kalipucang (Hardoyo 1982).

Houses are generally built with bricks and plaster throughout. People prefer a permanent-type construction of bricks and stuccos if they could afford it. Most houses have dirt floors although a few have concrete floors. Roofing materials vary from leaves of marsh nipa (thatched) to zinc plate and tile. Zinc plate has become more popular because of its durability and price.

About 93% of the families had their own house in 1984. The others either lived with their parents or rented. The high rate of ownership was because of the tradition of mutual help in constructing houses among friends and family in the community.

Employment

In 1983, almost all people in the area worked and were employed in some capacity, but underemployment was still a problem. Fishing was the most common livelihood, but this was seasonal and depended on the weather and environmental conditions. More than 90% of the workforce were full-time fishermen while others were traders (5%), farmers (2%) and civil servants and laborers (Table 4.8). Some fishermen, in their spare time, engaged in community mutual help activities or worked as traders or laborers. Thus, it was difficult to strictly classify people by occupation.

The accretion of land and subsequent growth of the islands allowed more farming and gardening activities. Small-scale farming augmented food supply for local consumption but contributed little in income generation. A small fishpond was built in Karang Anyar. But most people lacked the capital to sustain it. In Klaces, aquaculture and rice-cum-fish culture have increased significantly since 1984 but the number of people involved is not known. Small stores are more common with improved transportation to main towns (Table 4.9).

Table 4.8. Main occupations of the heads of households in Segara Anakan, 1983 (ECT 1984).

Occupation	Number	Percentage
Fishing	150	90.4
Trading	8	4.8
Farming	3	1.8
Civil service	2	1.2
Artisanship	1	0.6
Others	2	1.2
Total	166	100.0

Table 4.9. Sources of additional family income in Segara Anakan, 1983 (ECT 1984).

Source	Udjung Gagak	Penikel	Udjung Alang	Total	%
Net fixing	3	-	3	6	3.6
Renting boat	1	2	4	7	4.2
Trading	13	3	7	23	13.7
Artisanship	2	-	7	9	5.4
Labor	1	-	5	6	3.6
Farming	1	-	16	17	10.2
None	36	20	43	99	59.3
Total	57	25	85	167	100.0

Income

Fishing is the main source of income in Segara Anakan area but income is declining along with the catch. Income distribution is unequal. More than 67% of the households earn monthly amounts of less than Rp31,000 and 35%, less than Rp17,000. The average level of per capita household income of the people in the area generally does not meet minimum basic needs. Interviews by Hardoyo (1982) indicated that 50% of the fishermen earned less than Rp180,000 per year, and 40% had income insufficient for their daily expenses.

Sources of income besides fishing are irregular, generally low and thus don't affect income levels significantly. The 10% or less of the population which does other jobs such as trading, poultry breeding, small-scale farming and other businesses earn between Rp37,500 and Rp60,000 per month. The per capita income of Segara Anakan fishermen is only about 10% of that of the sea fishermen and 66% of that of the freshwater fishfarmers of Cilacap.

The low general income level of people in Segara Anakan area poses a serious socioeconomic problem. The people need alternative sources of income. Until this problem is remedied, increasing pressure will be placed on the already stressed fisheries resources and mangrove ecosystem. Furthermore, the decreasing fish catch and size of the lagoon encourage some fishermen to become farmers. But most fishermen are reluctant to change their livelihood as they already view fishing as an inherited activity.

In 1986, about 400 ha of former lagoon area were converted to paddy rice and/or fishponds along the northern coast of Nusa Kambangan. Mangrove forest was converted to aquaculture and agriculture sites. The mangrove forest is also used more intensely for firewood and the making of bricks and tiles for domestic purposes in the area surrounding Segara Anakan. Interviews in 1986 (TEM) noted that majority in the community recognized the usefulness of mangrove forest for firewood (91%) and housing materials (52%). Recognition of mangroves as fisheries resources was only 24%. Conservation awareness was high among fishermen (75%), but low among laborers, traders and other workers.

Transportation, Communication and Infrastructure

Segara Anakan villages are served by four ferry motorboats with an average capacity of 60 passengers each. These operate regularly connecting Cilacap and Kalipucang through the villages. Intervillage transport is provided by many smaller crafts. Each village has a post office. Mail is distributed from house to house, although use of this facility is low because of high illiteracy in the area.

Market places in each village are informal and made without special structures in the streets. Udjung Gagak established a minimarket but it is not well-used.

There are no banks in the villages but some credit is available through the Himpunan Nelayan Seluruh Indonesia (HNSI or All Indonesian Fishermen Association), the Pendidikan Kesejahteraan Keluarga (PKK or Women's Vocational Training) and money lenders. The HNSI generally provides credit for financing the investment and operating expenses of new fishing boats and gears. The PKK gives loans of Rp5,000 or less.

Land Use and Ownership

In 1983, land ownership in the area of Segara Anakan was not clearly defined. Three parties claimed ownership: the State Forestry Authority (Perum Perhutani); local inhabitants; and Nusa Kambangan Prison Authority (NKPA), for the land in the vicinity of Udjung Alang village.

The residents' claim was based on the prescriptive custom (right law or *hukum adat*) which is called *hak ulayat* or the right upon an area. The understanding by tradition is that anyone who first clears the forest or who first occupies or settles on a piece of land is entitled to that land.

The inhabitants claimed that their ancestors were among the first settlers who occupied the area, and that their descendants had been living there for more than three generations. Some residents of Motean claimed that before the year 1900, their ancestors were the landowners of at least some parts of Nusa Kambangan. When the Dutch colonial government converted the island into a penitentiary, their ancestors were forced to move out to Kampung Laut.

The Forestry Authority claimed ownership of the land on the basis that the newly formed lands were tidal forests which were essential for the ecosystem and were part of forest reserves. Segara Anakan proper is within the boundary of the public forest. According to the authority, a committee to identify the appropriate forest boundaries was established in 1932 by the Regent of Banyumas, resulting in the decision that Segara Anakan is within the boundaries of public forest. However, the Agrarian Office of Cilacap (Land Use Authority) argued that the decision of the above committee was only a suggestion to the Regent, thus, resulting in no legal implementation.

The third party to claim ownership in the northern coast of Nusa Kambangan was the NKPA. It argued that the disputed land is part of the island since its emergence was due to landsliding from slopes along the shore. The residents of Udjung Alang argued that the natural boundary of Nusa Kambangan was the rocky shore wherein the newly formed lands used to be the lagoon where they once fished. Consistent to their opinion, the residents claimed all newly formed lands on the north coast and distributed among themselves about 400 ha (about 0.5-0.75 ha per family). However, these residents still need to ask the government of Cilacap for grant letters of land ownership.

In mid-1983, the provincial government of Central Java issued an order to preserve the lagoon and its surrounding area. Furthermore, the possibility that the central government would develop Nusa Kambangan and its surroundings into a tourism area was raised, which complicated the situation. Since granting land titles to the inhabitants would be in disconformity to the possibility, the Cilacap Agrarian Authority could not proceed. But since the residents are desperately seeking assurance of land ownership before undertaking any type of development, a reasonable decision on this matter is required.

There was one case of transfer of land titles to local residents. The Forest Authority empowered the Central Java government to distribute land to farmers cultivating lands of 6,300 ha near the village of Patimuan in the subdistrict of Kedung Raja. There, forestry lands had been cultivated by local people since the Japanese occupation in the 1940s. In 1980, certificates of ownership of 1,300 ha were granted to farmers; and in 1982, there were 5,000-ha grants.

The first land use map of the area was published in 1917 and indicated the following: Segara Anakan was approximately 10 km long on each of its three sides; Nusa Kambangan had no mudflats and the mangroves existed only on the west and east of the lagoon; the government reported a mangrove forest covering an area of 22,987 ha; and the existing villages then were Cibeureum, Karang Anyar, Klaces, Penikel, Muara Dua and Motean (TEM 1986).

Aerial photos taken in 1974 and 1982 describe recent land use, mangrove forest coverage and land propagation. The so-called Segara Anakan area covered 96,000 ha, of which

32,500 ha were the lagoon environs and 63,500 ha, the Sidareja east and north areas. The land use distribution in hectares was: forest and plantation (27,000); upland (11,000); home and garden (11,000); lowland rice (23,000); and mangrove-lagoon (24,000) (Napitupulu and Ramu 1982). Compared to land use in 1972 (Table 4.10), lowland rice culture as well as home gardens had increased. In contrast, upland forest area had decreased.

Table 4.10. Land use pattern (ha) in 1972 (ECT 1984).

Subdistrict	Lowland rice	Upland crops	Home and gardens/yards	Forest	Plantation	Others	Total
Cilacap	1,578	974	2,936	14,379	-	383	20,250
Kawunganten	7,188	3,813	3,674	5,800	1,563	404	22,442
Gandrung Mangga	4,764	3,492	2,170	3,612	-	26	14,064
Kedung Raja	8,093	922	2,861	4,500	-	778	17,154
Jeruk Legi	1,198	3,643	1,432	3,200	-	142	9,615
Total	22,821	12,844	13,073	31,491	1,563	1,733	83,525

Note: In 1982, Cilacap became an administrative city, while the villages in Kampung Laut were transferred to Kawunganten.

Land use in the area changed. Fewer people fished full-time, and more were occupied on land-based activities, especially in Motean and Klaces. The three villages in Segara Anakan covered an area of 7,350 ha: 4% for housing and settlement; 22%, state forest; and 74%, mangroves and water. There were only 0.25 ha of brackishwater fishponds in 1981 and 4 ha in 1983.

Chapter 5
Economic Sector

ECOLOGY TEAM - BOGOR AGRICULTURAL UNIVERSITY
AND TATANG SUJASTANI

Fisheries

Stock

The part of the fish community vulnerable to capture follows the inherent dynamics of the community but is also affected by the fishing gears in operation. In the Segara Anakan system, the greater part of the fish stock consists of migratory/actively moving and solitary/shoaling species. The depth of the water column, surface area and access ways determine the availability of the fish stock. In general, the increase and the decrease of the fish stock are determined by the growth and recruitment rates and the mortality and exploitation rates, respectively. However, since the fish community is migratory in character, the fish stock in the lagoon is determined by the average size of the fish as they enter the lagoon; the length of period they stay in the lagoon; and the amount of food available.

Management considerations for the sustained use of the fisheries are: decreasing water volume and depth of lagoon; inaccessibility to food-rich areas, thus, causing decreasing growth; dynamics of fish movements in the lagoon; and impact of traditional fishermen and their gears.

Fishing gears

Based on the distribution of fishing gears, boats and operators of traditional fisheries in Segara Anakan in 1983 (Table 5.1), it can be deduced that there was greater pressure and abundance of fish in Zone III compared to the other zones.

Fish weirs/traps were the most common, followed by hooks and lines. Gill nets were restricted to Zones III, I and IV because water depths permitted their use. Weirs and traps were apparently effective in these zones due to the water movement conditions. Zone III will receive greater fishing effort as the lagoon decreases in size. Furthermore, fish weirs, gill nets and trammel nets have become less effective as water depths have decreased and channels narrowed. A particular gear problem as the fish stock decreases in size is the use of fish weirs with very fine-meshed net which capture large quantities of juvenile shrimp and fish used by local fishermen.

Table 5.1. Distribution of traditional fishing gears and craft in the four zones in Segara Anakan, 1983 (ET 1984).

Fishing gear	I and IV	II	III	Total
Trammel net				
Jaring ciker	154	36	81	271
Jaring kantong	110	-	62	172
Jaring bangkok	61	-	-	61
Total	325	36	143	504
Gill net				
Jaring gilap	-	-	5	5
Jaring tetek	58	-	-	58
Total	58	-	5	63
Cast net				
Jala	32	19	39	90
Jala otek	-	-	180	180
Total	32	19	219	270
Fish weir/trap				
Waring sodong	250	219	122	591
Wadong	895	82	1,942	2,919
Wide sero	468	50	155	673
Jaring tadah	-	40	235	275
Waring caduk	63	-	-	63
Waring telembuk	-	-	40	40
Waring kambang	-	-	624	624
Total	1,676	391	3,118	5,185
Hook and line				
Pintur	1,230	760	1,185	3,175
Pancing	-	8	24	32
Pancing rawe	28	-	16	44
Total	1,258	768	1,225	3,251
Fishing boats/craft	120	80	228	428
Fishermen	415	287	570	1,272

Yield

Annual fish yields during the period 1977 to 1982 showed a decreasing trend for both shrimp and fish landings. A constant increase was observed in the preceding years (Table 5.2) which may be due to the increasing effort and number of operators and the deteriorating condition of the lagoon environment. In 1983, monthly yield variation in the lagoon in Zones II and III (Fig. 5.1 and 5.2) showed a seasonal variation, apparently affected by seasonal change in water discharge of rivers. The peak in Zone III was reached two months later than that in Zone II, which is located closer to the major river mouth. Comparing these curves to the demersal fish landing of the offshore waters (Fig. 5.3), it may be concluded that the offshore landings variation is related to the lagoon's seasonal variation, and perhaps to the flushing of food material to the offshore waters and hence the abundance of offshore fish.

Table 5.2. Annual fish production (t) in Segara Anakan, 1976-1982 (FSC 1983).

Year	Quarter				Total
	1st	2nd	3rd	4th	
1976	-	155.9	89.9	227.9	473.7
1977	226.2	228.9	257.0	227.5	939.6
1978	44.5	137.6	187.9	146.3	516.3
1979	22.3	116.0	34.7	8.9	181.9
1980	17.3	21.3	31.8	28.5	98.9
1981	62.5	61.1	11.9	-	135.5
1982	10.0	4.6	113.2	15.7	143.5

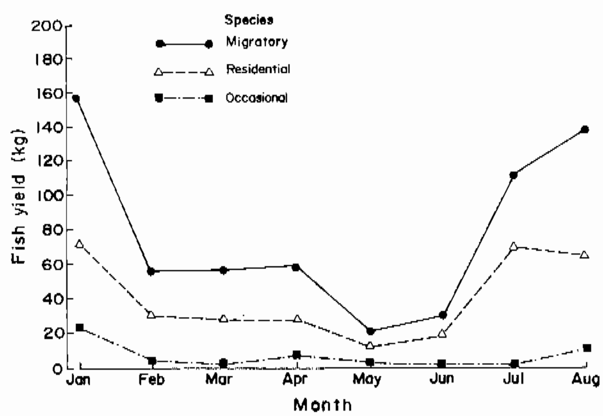


Fig. 5.1. Monthly fish yield variation in Zone III (Motean and Klaces), 1983 (FSC 1983).

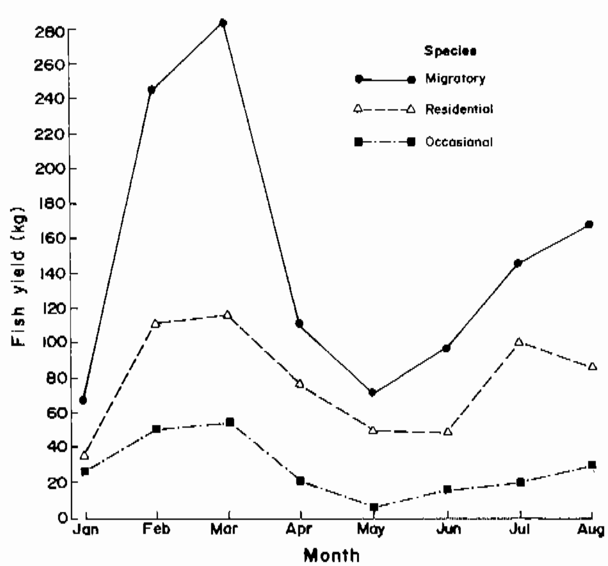


Fig. 5.2. Monthly fish yield variation in Zone II (Cibeureum), 1983 (FSC 1983).

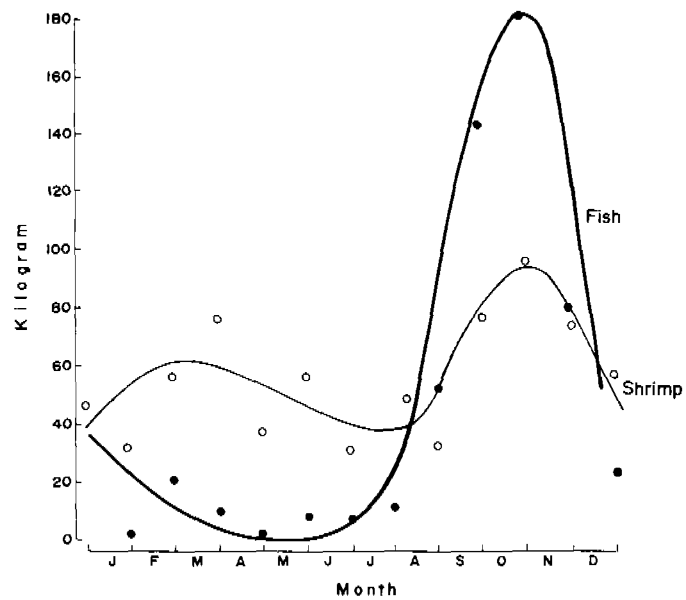


Fig. 5.3. Average demersal fish (gill net) and shrimp (trammel net) production (1981-1983) from offshore waters. Data were obtained from landing station at Pangandaran (FSC 1983).

Quantity and quality of catch

Migratory species constituted about 60%, and resident species, about 35%, of the total catch; the rest were occasional visitors. The ratio between the numbers of migratory and resident species was 4:1.

Of the 45 species encountered, 10-15 were represented in the daily catches. Seasonal variations were distinct for several species, which contributed a small part to the catches. Great variation of daily catches was observed, reflecting diversity and dynamics of the stock present and the effectiveness and selectivity of gears used. Eight species of mullets, mackerels and carangids (all of economic importance and preferred by the local people) were caught in large numbers.

Marine species were encountered throughout the year in most parts of the lagoon. *Tenggiri (Scomberomorus guttatus)* and *tambalan (Lutjanus fulviflama)* and other pelagic and benthic species showed seasonalities corresponding to monsoon changes. Peak seasons occurred in April, while secondary peaks were in September. In the early monsoon, offshore migratory species were caught closer to the central subwater area. Trammel nets and gill nets were nonselective.

Compared to fish, marine shrimp caught made a greater contribution to the local economy. In 1981, shrimp contributed 45% of the production value, while being only 17% of the total volume of fisheries production. Shrimp catches in the past showed considerable annual variations (Table 5.3).

P. indicus and *P. merguiensis,* the most highly priced shrimp, were common in most catches. Of the 26 species of penaeids caught, only 6 were economically important. The species caught may be classified into three groups: (1) penaeids *(udang jerbung);* (2) metapenaeids *(udang dogol);* and (3) sergestids and mysids *(udang rebon)* (FSC 1983).

Table 5.3. Annual production (kg) of and revenue obtained from the fisheries industry in Citanduy River, Segara Anakan, 1968-1973 (FSC 1983).

Year	Fish		Shrimp	
	kg	10^3Rp	kg	10^3Rp
1968	16,725	2,509	5,575	1,115
1969	14,400	2,160	4,800	960
1970	15,000	3,000	5,000	1,250
1971	20,225	5,056	6,725	2,354
1972	23,100	5,775	7,700	3,080
1973	37,000	9,250	15,400	7,700

Potential yields

Table 5.4 shows the fish and shrimp yields as estimated from the fishing success, selectivity and intensity of gear present in Segara Anakan and corrected according to seasonal variation (ET 1984). These estimates indicate that the official statistics were too low. For example, the estimated daily catch per fisherman was 4.5 kg/day when calculated from these values as compared to 0.5 kg/day when calculated from the official data. The former estimate was believed to be more realistic and closer to the average daily catch from the creel census showing 4.8 kg/day/fisherman.

Table 5.4. Estimated annual yield (t) of fish and shrimp from the four zones in Segara Anakan (ET 1984).

Fishing gear	Fish				Shrimp			
	I and IV	II	III	Total	I and IV	II	III	Total
Jaring ciker	121.2	28.3	63.8	213.3	-	-	-	-
Jaring kantong	32.5	-	18.3	50.8	97.4	-	54.9	152.3
Jaring bangkok	9.0	-	-	9.0	27.0	-	-	27.0
Jaring gilap	-	-	0.9	0.9	-	-	-	-
Jaring tetek	12.8	-	-	12.8	-	-	-	-
Jala	14.2	8.4	17.3	39.9	-	-	-	-
Jala otek	-	-	177.1	177.1	-	-	-	-
Waring sodong	129.2	113.1	63.0	305.3	-	-	-	-
Wadong[a]	-	-	-	-	-	-	-	-
Wide sero	138.2	14.8	45.7	198.7	17.2	1.8	5.8	24.8
Jaring tadah	-	41.3	242.8	284.1	-	12.7	74.5	87.2
Waring cadok	16.3	-	-	16.3	4.6	-	-	4.6
Waring telembuk	-	-	5.9	5.9	-	-	-	-
Waring kambang	-	-	322.4	322.4	-	-	92.1	92.1
Pintur[a]	-	-	-	-	-	-	-	-
Pancing	-	3.0	8.8	11.8	-	-	-	-
Pancing prawe	31.0	-	17.7	48.7	-	-	-	-
Total	504.4	208.9	983.7	1,697	146.2	14.5	227.3	388.0
Corrected annual yield estimate	332.9	137.9	649.2	1,120	96.5	9.6	150.0	256.1
Catch/day (t)	1.3	0.6	2.6	4.5	0.4	0	0.6	1.0
Potential annual production (t)	486	201.6	950.4	1,638	140.4	14.4	219.6	374.4
Water surface (ha)	848	390	941	2,179	848	390	941	2,179
Potential productivity (kg/ha/year)	573	517	1,010	752	166	37	233	172

[a]Highly selective to crabs; creel data, erratic.

Economics and tradition

Fishing involves more than 90% of the resident households. Local fishermen work from 5 to 12 hours per day, 15 to 25 days per month throughout the year. Otherwise, they are engaged in sideline jobs, doing small business, gear repairing and having social activities. Fishing boats are generally small, dugout, canoe-type and family-owned; only a few are motorized. Boat rents vary, but in 1983 averaged about Rp3,000 per month. Fishing gears are of indigenous types, consisting mostly of seines, gill nets, weirs, traps or lines.

About 93% of the lagoon-based fishermen fish in Segara Anakan; 3% in Indian Ocean along the southern coast; and 4% in both areas. The lagoon fishing grounds have been traditionally divided into several compartments, each individually owned. The residents of a certain village may only occupy compartments within their village's boundary. If someone wanted to fish in another's compartment, he must pay a fee.

Fisheries production fluctuates from year to year. There was a decreasing trend from 1974 to 1984. Annual average production from 1967 to 1972 was 448 t; from 1979 to 1982, only 140 t.

The decreasing fishing ground in the lagoon is thought to be adversely affecting productivity and catch. This condition is associated with the increasing rates of sedimentation. The production figures shown in Table 5.5 may not include the total catch because of local sales and consumption but nevertheless indicate a drastic decline in catch. Less than 5% of the total Cilacap fish landings originate in Segara Anakan. Most Cilacap fish catch comes from the Indian Ocean. Fluctuations in this fisheries have various causes. The decline in 1980 occurred after the issuance of Presidential Decree No. 39/1980 which banned trawl operations. The production declined most in 1981 and then increased slightly in 1982 and 1983 due to more efforts by small-scale fishermen. In 1982, the government provided capital for the motorization of small fishing boats.

Two main buyers operate in Segara Anakan area, the *bakul* (local collectors) and the *juragan* (fishing boat-gear owners). Traders buy more than 86% of the total catch while the remainder is sold directly to consumers and outside collectors or through auction.

The best fishing season, known as *ngangkat,* occurs between August and December (Hardoyo 1982). During this period, the tidal range is more pronounced, which is thought to affect the catch. The daily catch per fishing unit is 10-15 kg during this season compared to 2-5 kg during *ngember* (lean) period of January to July. The catch is sold fresh to the traders who

Table 5.5. Changes and shares of fish production (t) of Cilacap and Segara Anakan, 1978-1983.

Year	Cilacap	% change	Segara Anakan	% change	% share
1978	15,412.9		516.3		3.35
		-13.		-64.	
1979	13,450.1		181.9		1.35
		-55.		-45.	
1980	6,002.4		98.9		1.64
		-55.		+37.	
1981	2,705.8		135.5		5.00
		+24.		+5.	
1982	3,362.8		143.5		4.27
		+33.			
1983	4,488.0				

Source: Statistics from the Cilacap Fisheries Service Office and the Economic Team's study.

act as creditors providing capital to purchase boats and gears. Repayment is usually made in kind. Fishermen often become caught in debt and are not able to accumulate capital or sell their catch in other outlets. The distance to Cilacap town aggravates this situation.

Fishermen who venture to hire boats for transport sometimes are obligated to sell their catch to boat owners. Because of the relatively small volume, it is difficult to sell the catch in the auction market in Cilacap. These factors, along with the perishable nature of the product, make the marketing situation unfavorable to the fishermen of Segara Anakan.

Prior to 1970, a fishermen's cooperative was in operation to facilitate market sales (Hardoyo 1982). It failed in part because of the larger fish traders who became more dominant in marketing Segara Anakan fish and because of dearth in capital, experience and managerial skill. Attempts to revive the cooperative have failed but new reorganization may still be considered in light of the potential benefits to the Kampung Laut community.

Aquaculture Development

In 1983, a trial aquaculture production project for the residents of Kampung Laut was conducted by the government's fisheries service. Assistance with design, construction and management of *tambak* was provided to farmer groups to set up cooperative management. Near Muara Dua, 2 ha (2 ponds) were established; 1.5 ha (2 ponds) at Karang Anyar; 7 ha (7 ponds) at Klaces; and 9 ha (9 ponds) near Motean (ECI 1987).

The ponds in Karang Anyar were abandoned shortly after construction because of reluctance of fishermen to engage in aquaculture, and because large amounts of suspended sediments in the water caused silting in the ponds (ECI 1987). It is reported that ponds near Muara Dua are still functioning.

At Klaces, the trial ponds are in production by a 20-member group of fishfarmers. Initial attempts to produce milkfish and shrimp in polyculture failed. At present, the ponds produce *Mujair* (*Tilapia mossambica*) and *Tawes* (*Puntius* sp.). After 6 months of culture, 400-500 kg/ha of *Tilapia* weighing 200 g each were reportedly harvested and sold locally for Rp500/kg and Rp1,000/kg in Pangandaran (ECI 1987). These estimates may be high since they are based on impressions only. In addition to the 7 ha of *kelompok* (cooperative) ponds at Klaces, there are 17 ha of *rakyat* (individually owned) ponds. These ponds are not well-managed (ECI 1987).

On Nusa Kambangan at Motean, there are 9 ha of *kelompok* ponds with 20 ha of *rakyat* ponds. About 4 ha (of the former) were abandoned and not so successful as at Klaces due to less community spirit in the other areas. The individual-owned ponds are functioning. Typically, families are granted 0.5 ha for *tambak* development and 0.2 ha for rice cultivation. Fill from pond excavation is used for the house site but the ponds are poorly managed. Local farmers and those from West Java are beginning to move to Nusa Kambangan at Motean because of the relative success of fish culture and rice cultivation (ECI 1987).

Potential

The lagoon area with the largest potential for aquaculture is the north coast of Nusa Kambangan from Klaces to Motean (ECI 1987). The area has a wide expanse (400-500 ha) of relatively well consolidated, intertidal alluvium with tidal or brackishwater culture potential and with some freshwater pond area near the mountain. This area receives relatively little sediment and is adjacent to a deepwater channel (ECI 1987). Most other areas in the lagoon receive far too much sediment causing shoreline accretion which is not favorable for *tambak* ponds (ECI 1987). In addition, *tambak* are normally constructed in or near the intertidal zone which use tidal-influenced and propelled water. Land in Segara Anakan requires clearing of mangrove forest, which is in direct conflict with the traditional users of mangroves and their ecological functions of providing nutrients to the lagoon, among others.

Aside from the environmental constraints to aquaculture potential in Segara Anakan, there are several social considerations. Producer attitudes, knowledge and skills are important in the case of traditional fishermen who know little about pond fish culture. Lack of these skills may be responsible for initial failure of the early pilot aquaculture program. The exception of success at Klaces and Nusa Kambangan may be attributed to cooperation among producers, and some people from West Java with previous knowledge about the more favorable environmental conditions.

Rice-cum-fish (*minapadi*) farming is currently being done in several ponds at Klaces in which little or no pesticide is used (ECI 1987). This practice holds some potential for the Klaces as rice farming becomes more common.

Chapter 6
Institutional and Legal Framework

ALAN T. WHITE AND PURWITO MARTOSUBROTO

Chapters 1 to 5 of this profile brought forth all the ecological relations present in Segara Anakan-Cilacap project site and highlighted some economic issues. The interdependencies of resources and human uses and the highly interrelated ecological systems which include humans have been described. The linkages between and within upland, lowland, coastal and marine systems and the consequent environmental and economic effects of development activities on these systems have also been noted.

The management of coastal systems, such as the mangrove-lagoonal complex of Segara Anakan, is largely in the hands of sectoral agencies which have narrow, single-resource mandates which discourage interaction with other agencies. Current sectoral approaches to the planning and use of this complex system of resources do not provide a viable basis to achieve sustainable development. The staff of the agencies are for the most part not trained in multiple-use management of the complex ecosystems. Often, the policy and management guidelines of one agency are in direct conflict with another over land-use issues, conservational issues and/or methods of implementation. Because of the richness and ecological complexity of the coastal resource base and the multiple-use opportunities it offers, there is a strong case for increased integration of sectoral interests and the coordination of CRM activities.

Implementation of CRM in Segara Anakan-Cilacap will require coordination at the district level and among agency personnel in particular where field activities will be ongoing. The environmental awareness of local officials and their will to implement will influence their decision to cooperate cross-sectorally. Planning of CRM in this context should involve the district- and village-level people so that their inputs can be considered during the process. This process can proceed more rapidly if there is political and financial support from the national government as well.

Legal Acts Affecting CRM

The Environmental Management Act of 1982 (Statute 4) provides general national policy and authorizes the State Ministry of Population and Environment (SMPE) to protect, develop and manage the living, natural, social, economic and human environment of Indonesia. The act emphasizes sustainable use of renewable resources and the environment. There are also sectoral regulations which guide activities such as in fisheries and forestry. At the local level, the society traditionally operates by consensus, stressing mutual cooperation and joint responsibility.

More specific laws which will affect CRM in Segara Anakan include:

1. Agrarian Law (Statute 5/1960) which regulates land use and ownership pertaining to agricultural areas;
2. Forestry Law (Statute 5/1967) which covers coastal forest areas including mangroves which belong to and are to be managed by the State Forest Company (Perhutani); and
3. Local Government Law (Statute 5/1974) which gives the regional chief or *bupati* the authority to plan and develop the region including land use.

Institutions

In Indonesia, there is no single national agency responsible for coastal management or which has jurisdiction over both marine and land areas. For the Segara Anakan area, the Ministry of Forestry (MF) manages the mangroves and the Directorate General of Fisheries (DGF), the lagoon and offshore fisheries. Water quality standards come under SMPE. The Provincial Planning Board of Cilacap (BAPPEDA) is instrumental in formulating, approving and finding support for any CRM plan affecting the area, but real implementation will have to be accomplished by line agencies. Since there is no clear mandate for CRM implementation, the planners will have to work towards such a role for line agencies while identifying key individuals and groups in the process. It may also be appropriate to modify the existing legal framework to allow a suitable agency to coordinate CRM for the area.

Consideration of the organizational arrangements used in the recently completed Citanduy River Basin Development and Watershed Management Project under the Ministry of Public Works (MPW) (Rachlan 1986) is useful because of its similarity in structure to the development of a CRM plan for Cilacap area. Also, the CRM problems are similar. A coordinating committee at the national level is made responsible for overall project direction. This committee has representatives from the various ministries involved and the agencies providing financial and technical assistance. Coordination at lower levels is done through the agencies in the national and provincial governments designated to implement the project components.

The management constraints experienced by the Citanduy project are relevant examples in the formulation of the CRM plan. The most obvious problems resulted from weaknesses of cross-sectoral coordination at the decision- and policymaking levels and lack of cooperation at the programming and field implementation levels. These problems were caused by the lack of clear criteria of achievement and different and/or conflicting management processes and phases and institutional interests and priorities. Weaknesses also existed in linkages within sectoral and intersectoral activities, allocation of budget and systemization of experiences. These problems are all indicative of those encountered when political, geographic, ecological and sectoral boundaries are crossed in order to integrate the management system.

Indonesia is in an early stage in the process of CRM. It is to be expected that many conflicts will arise cross-sectorally when such wholistic management has not been attempted before. Nevertheless, there are examples of CRM in Indonesia under MF which affect specific, small areas such as those mandated as marine parks and reserves and are implemented by the Directorate of Nature Conservation only. The site which comes closest to integrated CRM is that of Pulau Seribu in Jakarta Bay, which has a multitude of uses with which to deal. Thus, the implementing agency must, as a result, liaise with other governmental and nongovernmental organizations (NGOs) to try effective management. The SMPE has also taken initiative to set up coordinating committees for cross-sectoral environmental problems but generally does not implement such programs.

The general organizational structure of the government of Indonesia is illustrated in Fig. 6.1. It can be noted that the government is very hierarchical in nature and provides little natural communication channels among agencies. There is some programmed cross-sectoral communication, although often lacking in practice, through the planning agencies of the National Development Planning Board (BAPPENAS) and the Provincial and District Planning Board (BAPPEDA). Fig. 6.2 provides a more realistic idea of how CRM would be implemented through the existing government structure using agencies directly responsible for coastal areas, natural resources and planning in general. From this figure, it can be seen that the crux of CRM for the District of Cilacap level would need to be coordinated through Bappeda II, Bupati and the line agencies of fisheries, forestry, public works and home affairs, among others, in cooperation with village level authority.

Coordinating Ministries

The central government agency responsible for the formulation of national development policies and programs is BAPPENAS. Final formulation is through an interdepartment committee on the national policy for the development of Indonesia's coastal sector (CIDA 1987). Provinces and districts have planning boards (BAPPEDA) under BAPPENAS that advise and coordinate all planning efforts at these levels. BAPPENAS and BAPPEDA are responsible for the translation of policies and plans into programs. They also implement, monitor and evaluate such programs by coordinating with line ministries and with provincial, district and village governments (CIDA 1987).

The SMPE implements national environmental policy, laws and regulations by coordinating with central line ministries. It has no direct line responsibility. Its role is to provide technical advice and assistance, develop environmental regulations and monitor environmental programs of government departments and agencies (CIDA 1987). In June 1987, SMPE facilitated the beginning environmental impact assessment (EIA) regulations. It also coordinates population management activities and the control of coastal communities or areas affected by coastal activities (CIDA 1987).

Central Line Ministries

Coastal resources management and utilization

The Directorate General of Fisheries (DGF), under the Ministry of Agriculture (MA), is responsible for the administration, management and development of marine and coastal fisheries, inland fisheries and aquaculture (CIDA 1987). The ministry's Agency for Agricultural Research and Development (AARD) and its Agency for Agricultural Education, Training and Extension (AAETE) handle fisheries research and extension, respectively. Two of AARD's three major research institutes, the Research Institute for Coastal Aquaculture (RICA) and the Research Institute for Marine Fisheries (RIMF), focus on the marine and coastal areas.

The Ministry of Cooperatives (MC) is responsible for the development of fisheries cooperatives.

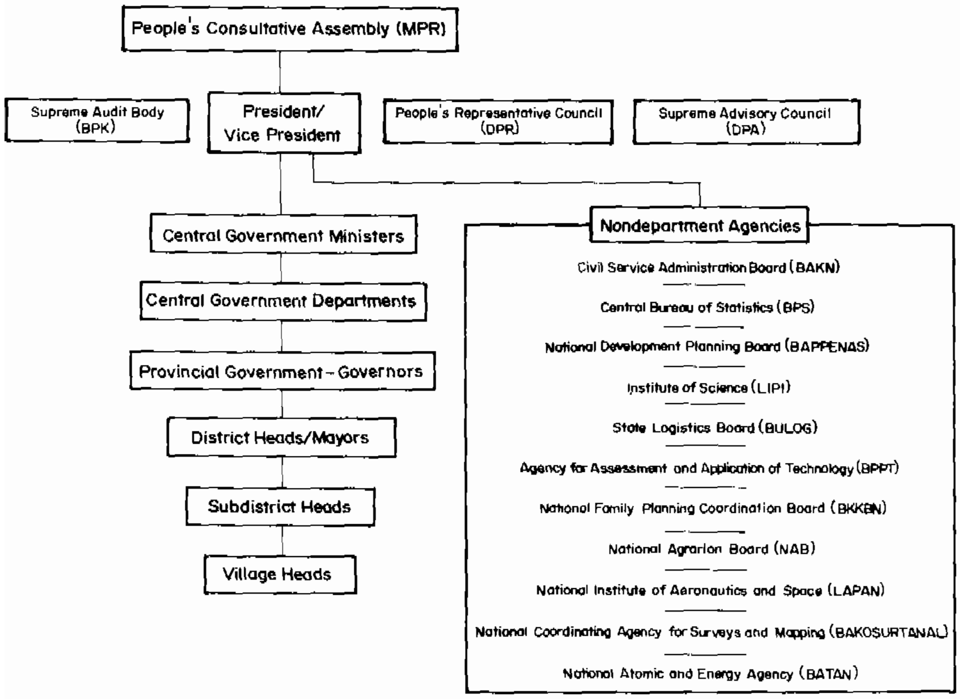


Fig. 6.1. General organizational structure of the Indonesian government (CIDA 1987).

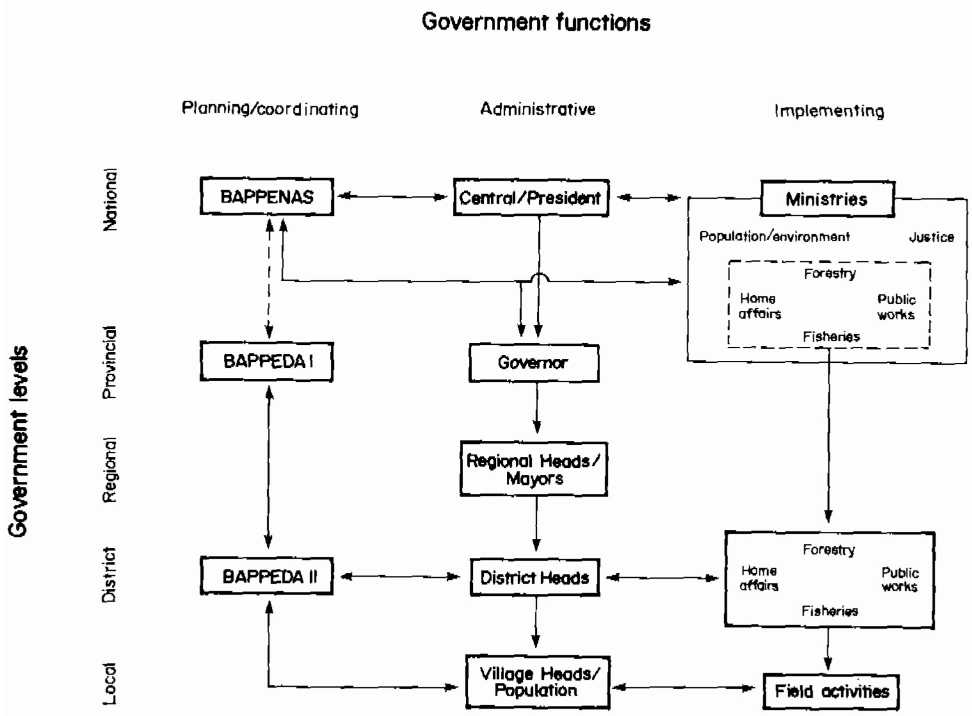


Fig. 6.2. Realistic institutional framework for planning and implementation of CRM in Indonesia.

The Ministry of Public Works (MPW) oversees the development of physical infrastructure in the coastal areas. It is also responsible for swamp reclamation, shoreline erosion control and the development of water resources affecting aquaculture projects in swamplands. MPW also works in river basin infrastructure projects and management and monitors hydrological regimes, river flow and water quality.

The Ministry of Mining and Energy (MME) identifies energy resources in marine and coastal areas. It also sets policies for management and exploitation of these resources.

The Ministry of Forestry (MF) is responsible for all public forest areas, including mangroves and all parks and reserves, terrestrial and marine.

The Ministry of Transportation (MT) is responsible for ports and navigational channels.

Surveillance and education Infrastructure

The Ministry of Defense and Security (MDS) plays a dual role in the coastal sector. It patrols national marine boundaries, protects national sovereignty and aids development activities in marine areas through DISHIDROS (the Indonesian hydrographic service, which is part of the Naval Headquarters of MDS). These activities include surveying and mapping, aerial photography and hydrographic and oceanographic data collection.

The Ministry of State for Research and Technology (MSRT) oversees technology used in the development of the coastal sector and for the research programs of agencies which affect the development of information on marine and coastal areas such as: the Indonesian Institute of Sciences (LIPI) which has, among others, under its direction the National Institute of Oceanology (recently changed to the Centre for Oceanological Research and Development or CORD); and the National Coordinating Agency for Surveys and Mapping (BAKOSURTANAL) which produces base maps; does aerial photography; and coordinates land resource inventories and evaluation surveys.

The Ministry of Tourism, Posts and Telecommunications (MTPT) is concerned with tourism programs located in coastal areas.

The Ministry of Education and Culture (MEC) is concerned with the development of technical training and education activities in the coastal sector.

The Ministry of Home Affairs (MHA) is responsible for policymaking and planning of socioeconomic activities in the coastal areas. MHA affects the provincial, district and village levels and aids development of coastal communities. Other government agencies with programs to support the development of coastal communities include MA, the Ministry of State for the Role of Women, MC and MEC (CIDA 1987).

Universities

Twelve universities in Indonesia have faculties or departments concerned with coastal affairs. There are: six in Java, two in Kalimantan, one in Sumatra and three in eastern Indonesia. There are also many local technical colleges and fisheries schools.

Various Environmental Study Centres have been established at provincial universities and at the Bureaus of Population and the Environment as part of the provincial government structure. These centers provide information and technical support in developing environmental management procedures and in CRM.

Nongovernmental Organizations

Only recently have NGOs been accepted as legitimate organizations for assisting development in Indonesia. Several of the 450 recognized NGOs or People's Self Reliance Development Groups (LPSMs) are relevant to the development of the coastal sector, particularly, the natural resources and coastal communities. These include: Dian Desa, Bina Swadaya, Indonesia Environmental Forum, SKEPHI, Yayasan Swadaya Membangun, Yayasan Pengembangan Masyarakat Desa and Yayasan Indonesia Hijau. To the extent that these NGOs endeavor to work together or alone and develop project initiatives, they will impact directly the future development and management of coastal resources and coastal communities.

Cilacap and CRM

The institutions with direct involvement in CRM in some capacity in Cilacap are as follows:

1. Ministry of Agriculture
   a. Directorate General of Fisheries
   b. Agency for Agricultural Research and Development
2. Ministry of Defense and Security
3. Ministry of Forestry
   a. Directorate of Nature Conservation
   b. State Forest Corporation
4. Ministry of Health
5. Ministry of Home Affairs
6. Ministry of Justice
7. Ministry of Mining and Energy
8. Ministry of Public Works
9. Ministry of State for Research and Technology
10. Indonesian Institute of Sciences
    a. National Institute of Oceanology
11. Ministry of Tourism, Post and Telecommunications
12. State Ministry of Population and Environment
13. Provincial and District Boards of Planning and Development
14. Universities
    a. University of Indonesia, Jakarta
    b. Bogor Agricultural University, Bogor
    c. Padjadjaran University, Bandung
    d. University of Djendral Sudirman, Purwokerto
    e. Gadjah Mada University, Yogyakarta
    f. Diponegoro University, Semarang
    g. University of Satya Wacana, Salatiga
    h. University of Pekalongan, Pekalongan

There is no simple structure or set of relations for institutions to implement CRM plans in Indonesia. For implementation to be possible, careful analysis of the local institutions and their potential role in a CRM plan will be necessary. BAPPEDA at the district level of Cilacap would be the most appropriate agency to coordinate CRM plan implementation. But because there exist some overlaps of responsibilities and jurisdiction among agencies, there will be a need for special agreements and ongoing communication among them. BAPPEDA can help eliminate these overlaps if it is respected at the district level.

Chapter 7
Coastal Resources Management Issues and Plan Formulation

ALAN T. WHITE AND PURWITO MARTOSUBROTO

This coastal environmental profile for Segara Anakan, Cilacap, Java, provides the background and secondary information needed to make a general analysis of management of the area. The overall goals of the ASEAN-US CRMP are to develop and implement a management plan which will ensure sustainable use, development and conservation of coastal resources in the project area; and to upgrade the income of the local population through participatory CRM.

Specific objectives are to:

- Stabilize erosion in the upper watershed and address the high rate of sedimentation in Segara Anakan;
- Regulate the intensity of fishing in the lagoon;
- Protect and conserve the lagoon and the adjoining mangrove forest as a critical habitat for sustaining the productivity of the lagoon and offshore fisheries;
- Promote alternative livelihood options; and
- Develop an institutional framework suited to integrated CRM for the area.

It is intended that these goals and objectives will be achieved by:

- Formulating and implementing sustained-use management strategies for the key coastal resource sectors;
- Reducing existing and potential intersectoral conflicts resulting in poor management and environmental degradation;
- Providing better protection and management for coastal ecosystems, and nursery grounds for offshore and inshore fisheries resources;
- Improving coordination among national and local institutions involved in CRM planning and implementation; and
- Carefully observing and analyzing the current status of coastal resources for planning in consultation with local users and beneficiaries.

The working boundaries for the CRM plan are a seaward limit which is practical and necessary for the management of commercial fisheries off the south Java coast and a landward boundary which includes the immediate environment of Segara Anakan and estuary and surrounding mangrove forest (Fig. 1.1).

Coastal Resources

The most ecologically and economically important aspect of Segara Anakan is its capacity as a nursery ground for marine fish and shrimp. The real value of fisheries production is in the coastal and offshore waters of Cilacap. Past estimates (using trawl data) for maximum sustainable yield (MSY) for offshore fisheries was 25,000 t (19,500 t of finfish and the rest, penaeid shrimp which spend part of their life cycle in the lagoon). The present catch of offshore fisheries is 9,050 t (7,150 t, finfish and the rest, penaeid shrimp). Based on the previous estimate, the fisheries are currently underfished compared to years before 1980, when trawling was allowed. (Nurzali pers. comm.).

The lagoon, in contrast, only produces about 400 t/year of finfish (25-40% of the catch) and crustaceans which form the economically important portion. It should be noted that production is steadily declining as the lagoon size decreases. Migratory fish species are widely distributed in Segara Anakan and economically important species such as soles, mullets and eels complete their life cycle in the lagoon while other species enter the lagoon to feed. Analysis of the lagoon catch composition shows that a high percentage is of economically important species in the offshore fisheries.

Segara Anakan supports the largest single stand of mangrove forest on Java, covering an area of about 24,000 ha. There are 21,185 ha lining the immediate shore of the lagoon while an intertidal swampy forest covers about 14,100 ha. Chapter 3 highlighted the significant ecological/nutrient contributions of the mangrove ecosystem to the fisheries in the lagoon. The high production of organic matter in the form of leaves and debris is deposited into surrounding waters. This nutrient function is also apparent by the predominance of detritus feeders like mullets. Large quantities of larvae are also evidence for the ecological importance of the lagoon in general and the need for nutrient-rich water.

Mangrove trees are commonly used for construction, staking fish nets or traps and firewood by the residents. Mangrove habitat is cleared wherever land is needed for aquaculture ponds or small-scale farms. Some areas on the inland fringe of the mangrove forest have been almost or totally cleared for rice farming. Also, some dry lands have been turned into tree plantations.

Water quality insures the viability of fisheries in the area and will be important to aquaculture as this alternative to capture fisheries takes hold. It is directly dependent on the major rivers which flow into the area and, to some extent, on tidal fluctuation. The Citanduy River discharges the largest water volume and sediment into the lagoon, causing the single most significant impact on the size and shoreline of the lagoon and the water quality.

Management Issues

In an ASEAN-US CRMP Technical Workshop in Indonesia in March 1988, the following were identified as important concerns in CRM planning in Segara Anakan-Cilacap area (Guarin and White 1988):

Sedimentation. The filling rate of the lagoon has increased to such an extent that the surface area is estimated to decrease from the current 1,400 ha to about 550 ha by the year 2000 (ECI 1987). The Citanduy River Basin Management Project has made several proposals to stabilize the lagoon by diverting the Citanduy River, dredging, churning up sediment to facilitate transport, among others. Now, a practical physical management scheme must be decided on while considering the water and sediment dynamics in the lagoon, the economic and ecological values of the lagoon to fisheries, the livelihood of the inhabitants, the use of water channels for transportation and the practicalities and costs involved.

Fisheries. Yields of the lagoon fisheries have been declining because of increasing effort in relation to the real physical decrease in the lagoon and resulting fisheries size. Fishing gears (e.g., fine-meshed nets where currents are strong) extract small organisms which are often immature. These methods need to be regulated; and the increasing effort controlled by directing fishermen to other sources of income.

The value of the lagoon as a nursery and feeding area needs to be quantified to help in deciding on how to manage the sedimentation of the lagoon. A cost-benefit approach will be useful here.

Mangroves. Although many mangrove trees are being cut, there are still some of legal size (10 cm or more) left. Since the ecological role of mangroves is clear, there is now a proposal to zone the area into four: mangrove greenbelt surrounding the lagoon; conservation area; utility (traditional use) area; and conversion area. This zonation plan, if implemented and accepted by the local community, will allow sustainable use but not totally curtail traditional use or conversion to aquaculture ponds and farmland.

Water quality. At present, there is no serious chemical pollution in the lagoon although some domestic wastes, increasing pesticide residues and oil from refinery operations in Cilacap may be problems. The real water quality issue is silt which drastically lowers light penetration and primary productivity in the water column. This problem depends on upland farming, land use practices and flood control measures which, if not addressed, will continue to affect water quality in the lagoon.

Socioeconomic status of local residents. The primary source of income for local people is the lagoon fisheries which have decreased from 628 t in 1966 to 361 t in 1984. There is extreme poverty among the people, and 60% are illiterate. There is engagement in new income sources like farming, mangrove lumber and labor, but the options are limited. Management in the area will have to focus on viable alternative income sources such as appropriate aquaculture (e.g., netcages), offshore fishing, simple farming, animal husbandry and, possibly, homecraft. Land and water tenure is also an increasing concern, especially if the people are to have a hand in the management strategy for limited use and control of fishing methods. The fishing right system and land resource use system for mangroves and farmlands can be developed. Education needs to be an integral part of this process.

Legal/institutional conflicts. In Indonesia, there is no single national agency responsible for coastal management or which has jurisdiction over both marine and land areas. For the Segara Anakan area, Perhutani (under MF) manages the mangroves and DGF, the lagoon and offshore fisheries. Water quality comes under SMPE as do the economics and health condition of the people. BAPPEDA of Cilacap is instrumental in formulating, approving and finding support for any CRM plan affecting the area, but real implementation will have to be accomplished by line agencies. Since there is no clear mandate for CRM implementation, the planners will have to work towards such a role by involving line agencies and identifying key individuals and groups in the process. It may also be appropriate to modify the existing legal framework to allow an agency to coordinate CRM for the area.

Planning. The participation of the local government, NGOs and the community will undoubtedly be a crucial part of the management plan and follow-up activities. This does not preclude participation and support of the national government, but because of the nature of the local resource use conflicts, people must agree to change their ways. Law enforcement cannot be the only means of changing use patterns. The major exception to local decisions making a difference is that of sedimentation. This very large impact on the physical environment will only stabilize with significant national support, planning and coordination with the Upland River Basin Projects and Land Use arrangements.

Information Needs for Management

Research on Segara Anakan and its vicinity under the ASEAN-US CRMP was completed in 1988 and addressed the following information needs for management:

1. Since the life of the lagoon is threatened by sedimentation, accurate data on the rates of sedimentation and filling are required. The water flow dynamics of the lagoon system must be understood before long-term predictions can be accurately made on the accretion of land and lagoon filling. In relation to this need, tidal movement, river inflow and internal lagoon currents have been monitored to give a general view of the lagoon system, sediment movement and accretion of the shoreline. The MPW has accumulated much data in this regard which have been referred to in this profile (ECI 1987). The options presented by ECI (1987) for management of the sediment load entering the lagoon are limited. In order to save the lagoon from complete filling, one of the expensive alternatives--diverting Citanduy River, dredging or churning the lagoon water--will require action by MPW as soon as policy is decided.

2. A general status of mangrove forest from an aerial perspective has been made for proper planning for management through a zonation scheme. However, use patterns by local people still need to be monitored to plan for sustainable use in zoned areas and to minimize conflicts of resource uses.

3. Sediment loads have been determined and the main sources of pollution isolated. Potential pollution from pesticides, domestic waste and oil should also be monitored to determine any serious problems and to suggest mitigating measures for point sources. These field data need to be compared to recommended guidelines for water quality being prepared for Indonesia by SMPE.

4. MSYs have been determined for lagoon fisheries and need translating into a management program for sustainable use. A means of regulating the fisheries must be formulated based on observations on the patterns of fishing and gear used. A study on the dependence of offshore shrimp fisheries on the lagoon as a nursery area has been made. This information needs to be translated into economic values for the lagoon/mangrove ecosystem as a nursery area in addition to the value of the internal fisheries.

5. A general understanding of the socioeconomic situation of Cilacap area will facilitate planning for economic development and job alternatives for the residents of the area. Since income is low, community organization and alternative forms of marketing local products need to be explored. A better understanding of the traditional fishing rights system will contribute to the sustainable management of the fisheries and offer ideas for setting alternative mariculture systems. Finally, the ideas of resource users on solving local management problems need to be considered.

6. Experiments with appropriate culture systems consistent with the local environment are providing new alternatives. The trend for rice-cum-fish culture needs monitoring in the Klaces area as a viable alternative.

7. An understanding of the level of environmental awareness and knowledge of CRM among local residents and government personnel will aid in formulating future education programs. This information is also available and must be translated into action-oriented education programs for local residents and government officials.

8. Knowledge of all the laws affecting the area is necessary before a plan for implementation can be made. Equivalently, information on private institutions in Cilacap area and those in the national government which have jurisdiction over the coastal zone, fisheries resources, coastal forest and others can be used for planning and implementation. Each institution should be contacted and involved in the project, if it will ultimately be concerned with CRM implementation.

Management Planning and Options

The overriding concerns for decisions on CRM in Segara Anakan are the fate of the lagoon size, water quality and forest accretion resulting from continuing sedimentation. ECI (1987) has outlined several alternatives to slow the sediment loads and extend the life of the lagoon based on engineering studies.

The basic options include (ECI 1987): maintenance dredging; selective dredging land reclamation; diversion of rivers or drainage; closure of one or both outlets; provision of new or improved outlets; and enhanced flushing.

These basic options were grouped into three concepts: limited change to the lagoon; alterations to Citanduy River; and closure of the lagoon at the western outlet.

A present-value analysis of costs to perform the above options identified limited change to the lagoon as agitation dredging, conventional dredging and enhanced flushing as the most economically viable options to extend the lagoon life. It might be added that, ecologically, these options are the least disruptive to the lagoon system. Diversion of Citanduy River and closure of the western outlet would both have uncertain outcomes and affect the overall ecology of the area. Even though the limited change options appear to offer the best results, the least disruption and are less expensive, they are still a large-scale undertaking. They will require long-term funding and infrastructure support from the government and must be rationalized in relation to the long-term value of the lagoon to the associated fisheries, and other natural resources which provide livelihood for the local population. In lieu of some kind of action, as has been pointed out, the lagoon will continue to shrink in size until some kind of equilibrium state is reached. This new scenario will be quite different than that of the present lagoon. It will undoubtedly include much more land area for mangrove growth, aquaculture and farming while the fisheries will take a smaller role in the socioeconomics of the area. In any case, the decisions to sustain the lagoon should be made soon. Otherwise, it will disappear and CRM will take on a new face for the area in terms of content. Nevertheless, the CRM process will still be applicable for planning in the area.

The process of CRM planning involves different inputs and the participation of various agencies and individuals at the national, provincial and local levels. Relevant information on the status of coastal resources, their environments and uses is a prerequisite to proper planning. This information and that being generated by field research teams will evolve into CRM plans. The process involving the local government to formulate and evaluate these plans is shown in Fig. 7.1. Fig. 7.2 shows the outputs expressed as: (1) final goals, objectives and management policies; (2) protected area management plans and implementation; (3) issue-oriented action plans for primary sectoral conflicts; and (4) integrated coastal area management plan for Cilacap-Segara Anakan which consists of specific action plans and marine protected area plans and of linkages for large area management.

Figs. 7.1 and 7.2 emphasize the content and process for determining general CRM policy. The process will involve extracting useful management-related data from the coastal profile and primary data by means of working committees. A general zonation scheme for the planning area is shown in Fig. 7.3. Here the important resources are highlighted such as mangrove habitat, fishing areas, water quality areas and agricultural and aquaculture land use zones. This scheme provides a perspective on how an integrated plan--broken into issue-oriented action plans and special area management plans--may look for the entire area.

A management framework for Segara Anakan might look like Table 7.1 to address the zones suggested in Fig. 7.3. Implementation of the various plans could be coordinated by BAPPEDA in Cilacap or there may need to be a special project office designated to coordinate line agency inputs. It is imperative that implementation be handled at the regional level and not only at the national level. The Citanduy II Project made use of coordinating teams at the national

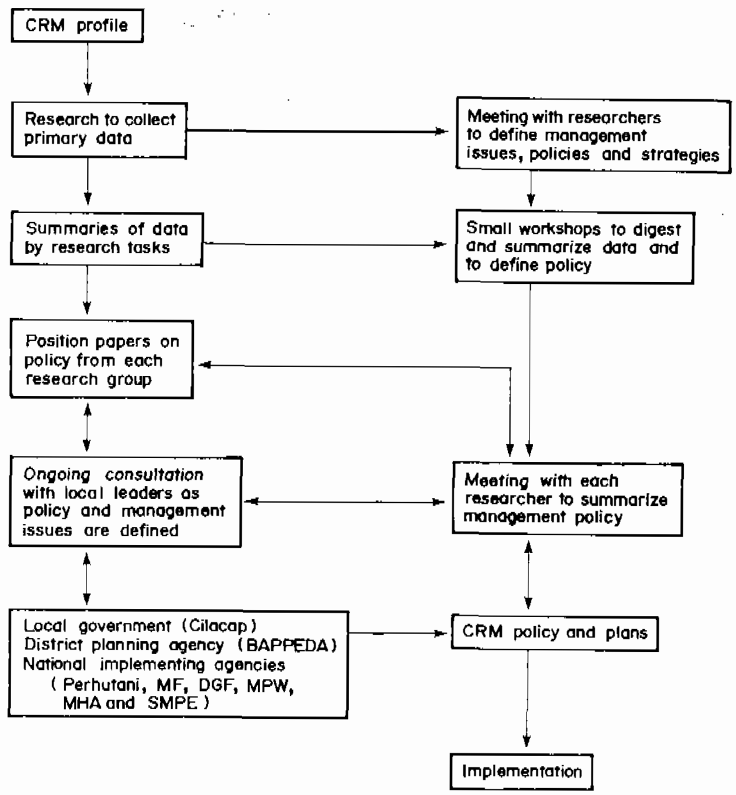


Fig. 7.1. Process involving local government to develop CRM plans for Segara Anakan-Cilacap area.

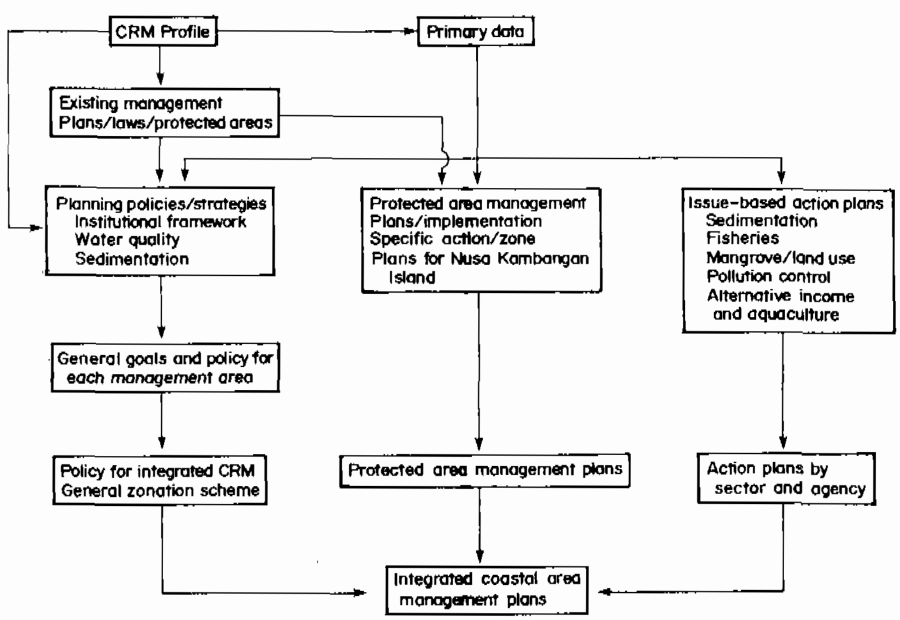


Fig. 7.2. Content of CRM plans for Segara Anakan-Cilacap area.

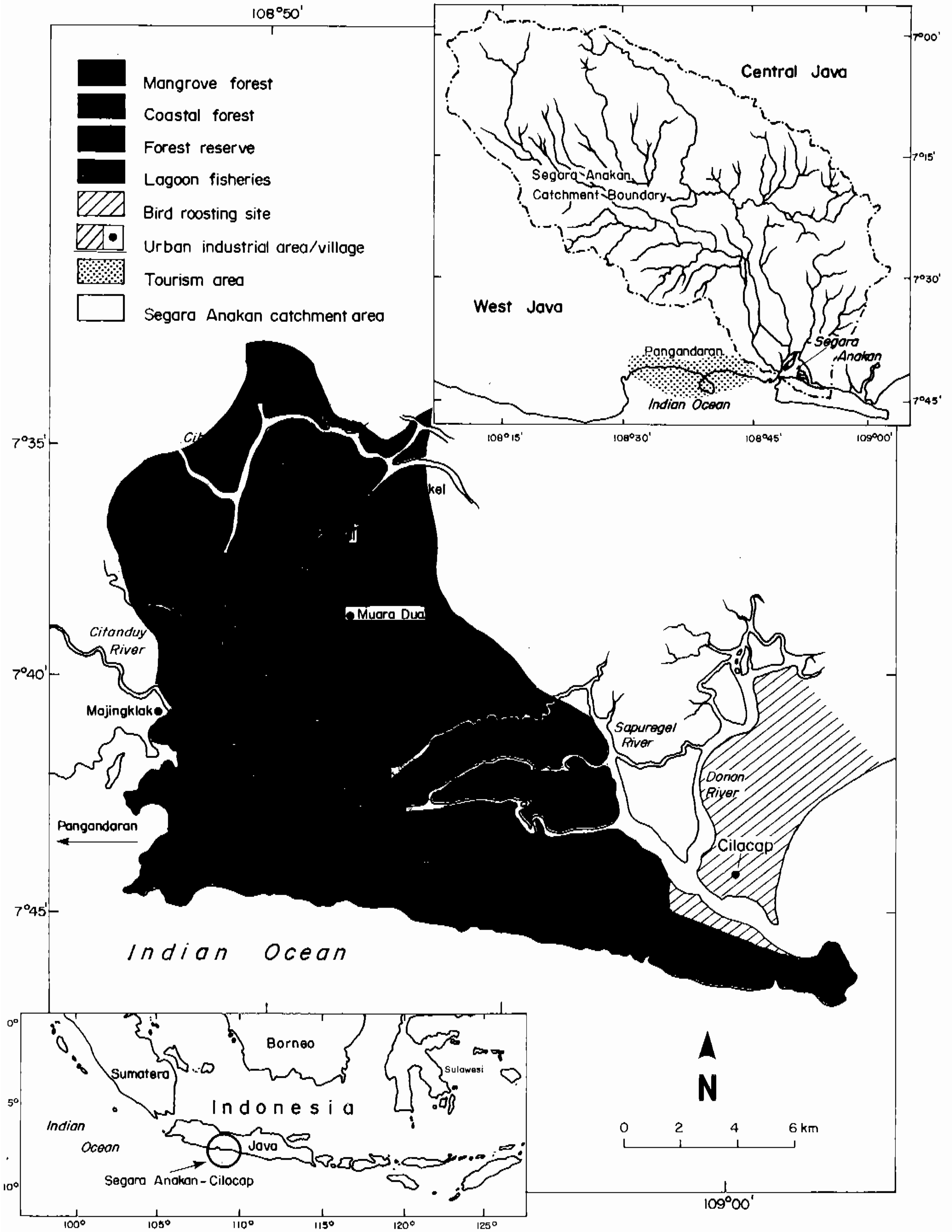


Fig. 7.3. Zonation plan showing resources distribution and general land uses in Segara Anakan.

Table 7.1. Conceptual framework and expected outputs for CRM plans for Segara Anakan-Cilacap area. (Source: ASEAN/US CRMP 1988).

A. Policies and guidelines for issue-based management plans and integrated coastal area management plan
   Objectives:
   - To review existing policies and guidelines and to formulate new ones for sustainable management which assume maintaining the lagoon as a nursery area in the long term.
   - To address present and potential CRM issues to resolve present use conflicts and to ensure proper allocation of future uses through appropriate measures and habitat enhancement.

B. Issue-based management and action plans
   1. Mangrove and general land use management plan
      a. Introduction and situation analysis
         1) Existing policies and guidelines
         2) Conflicts in mangrove and land use
         3) Historical trends of use and extent of resources
         4) Current status of land area and economic value of resources
         5) Institutions and laws affecting land use
      b. Policies and objectives for management
      c. Issues, causes and strategies for management
      d. Zonation scheme for mangrove and all land area which establishes extent and condition of the resources and designates zones for preservation/conservation, production forest, limited use, transition or agriculture and urban/industrial uses
      e. Actions and guidelines to implement zones
      f. Institutions and laws for implementation
      g. Pilot projects, schedule and cost to implement

   2. Fisheries management plan
      a. Introduction and situation analysis
         1) Existing policies and guidelines
         2) Conflicts in use of fisheries resources
         3) Historical trends of exploitation
         4) Current status in terms of stock assessment and economic value
         5) Institutions and laws affecting resource
      b. Policies and objectives for management
      c. Fisheries conflict issues, causes and strategies for resolution
      d. Guidelines on gear restrictions, allowable effort, area extent of effort, alternatives for excessive fishing effort and marketing
      e. Actions to implement guidelines
      f. Institutions and laws for implementation
      g. Pilot projects, schedule and cost to implement

   3. Sedimentation and water quality management plan
      a. Introduction and situation analysis
         1) Factors affecting sedimentation and water quality
         2) Water quality policies/standards for Indonesia
         3) Current proposals for management of lagoon
         4) Historical trends and current status of lagoons
         5) Lagoon size in relation to economic value of fisheries and mangroves
         6) Cost-benefit analysis for lagoon maintenance
         7) Existing pollution sources affecting lagoon
         8) Institutions and projects which affect lagoon sedimentation control and water quality
      b. Policies and objectives for sediment control based on previous studies and analysis of CRMP
      c. Issues, causes and recommended strategies
      d. Actions to maintain the lagoon in its present state based on previous analysis
      e. Actions necessary to prevent increased chemical pollution
      f. Institutions and laws for implementation
      g. Pilot projects, schedule and cost to implement

   4. Socioeconomic alternatives and development plan
      a. Introduction and situation analysis
         1) Current policies on the social well being and economic development in the area
         2) Current status of economic development trends and alternatives
         3) Status of aquaculture as an alternative to fishing
         4) Institutions, laws and projects affecting social problems, programs and alternative livelihoods

Continued

Table 7.1 (continued)

b. Policies and objectives for livelihood development
c. Main issues and causes of poor socioeconomic status
d. General strategies to improve local economies
e. Actions to implement several economic alternatives in the area including aquaculture
f. Institutions to implement socioeconomic programs
g. Pilot projects, schedule and cost to implement

C. Integrated coastal area management plan for Segara Anakan and vicinity
1. Policies and objectives for sustainable management of the resources based on analysis and recommendations
2. Socioeconomic profile with implications for management
3. Status of resources and trends in and conflicts of uses
4. Zonation scheme which integrates issue-based action plans with policies and institutional arrangements for implementation
5. Maps showing zones and linkages for management
6. Actions and administration to coordinate plans
7. Flow chart showing linkages of plans to achieve coordination

and river basin levels. There were problems with this arrangement which suggests that regional level coordination through BAPPEDA Office in Cilacap would be a good alternative. For this to be possible, BAPPEDA capacities would need to be strengthened so that a team would be able to manage the various Segara Anakan plans. For a project implementation to be effective, it should not be directed by a national steering committee which rarely meets and is too far removed from the site (David McCauley, pers. comm.).

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