COASTAL AND SEA USE PLANNING: AN APPROACH FOR SUSTAINABLE COASTAL DEVELOPMENT

Rokhmin Dahuri*

Abstract

Coastal and marine resources have been considered as a new source of economic growth in supporting Indonesia sustainable economic development to achieve a just and prosperous society. However, the management of coastal and marine resources development in Indonesia's from sustainable development perspectives is at the cross road. On the one hand, there are large coastal and marine areas which are underdeveloped. On the other hand, some coastal and marine areas, such as the North Coast of Java, the Strait of Malacca, and South coast of Sulawesi, are under increasing environmental pressures from incompatible development (human) activities compounded by a burgeoning population.

In terrestrial ecosystems, one of the many successful management solutions to resolve such environmental pressures is by implementing spatial planning regulation. However, coastal and marine ecosystems by the very nature are different from their terrestrial counterpart. By considering the dynamic and fluid nature of coastal waters as well as ecological linkages with upland ecosystems, the paper presents a unique coastal and sea use planning model. It incorporates PCU (Preservation, Conservation and Utilization) principles with ecological linkages occurring among ecosystems within the coastal zone and between the coastal zone and upland areas.

I. INTRODUCTION

From sustainable development perspectives, coastal zone management in Indonesia is at the cross-road. On the one hand, it is widely believed that Indonesia possesses rich coastal and marine resources which can be tapped as new sources of growth to sustain further Indonesia's economic development. Given the fact that terrestrial resources are becoming scarce or difficult to develop, the coastal and marine environment has been regarded by many Indonesian planners and decision makers as one of the last frontier of the country's economic development.

* Director of Center for Coastal and Marine Resource Studies, Bogor Agriculture University (IPB)

This is a reasonable expectation because Indonesia is the largest archipelagic state in the world where two-third of its territorial area is covered by the marine waters. In addition, the coastal and marine environment is blessed with abundant and rich natural resources as well as environmental services (amenities) as a basic asset for the growing tourism industry

The impetus to increase the utilization rate of coastal and marine resources has even gained a momentum during the ongoing economic crisis. This is especially true for living resources (fish, mollusks, crustaceans, seaweed, etc) because their selling price is much higher than the cost of producing or harvesting them, particularly for exported commodities.

However, the ever increasing population growth and industrialization in some coastal areas, such as the North Coast of Java, the Straits of Malacca, the South Coast of Sulawesi, Balikpapan and Bontang bays of East Kalimantan, and some parts of Bali, have led to their over-use and degradation, and to the overexploitation of their resources to the extent which is beyond their carrying capacity. If such development pattern and trend were to continue, coastal and marine resources could not be used to support Indonesia's sustainable economic development.

Based on its natural and social characteristics of the coastal zone, the sustainable development of coastal and marine resources is generally can only be achieved through the implementation of integrated coastal management (ICM). One of many management tools embodied in the ICM is spatial planning (zonation) technique. However, the origin of spatial planning is from terrestrial ecosystems, while the characteristics of coastal zone is very much different from its terrestrial (upland) counterpart. Thus, most failures in implementing spatial planning approach in the coastal zone has probably been due to the direct application of terrestrial spatial planning techniques in the coastal zone without necessary adjustments.

II. CHARACTERISTICS OF THE COASTAL ZONE RELEVANCE TO SPATIAL COASTAL PLANNING

The coastal zone, which is the interface (ecotone) between land and sea, is a unique geological, ecological, and biological domain of vital importance to an astounding array of terrestrial and aquatic life forms including humankind. It is a dynamic habitat where energy, nutrients, and population of plants and animals are mixed and recycled. Such processes result in some of the most productive areas on earth characterized by complex food chain that maintain high production potential.

As the coastal zone consists of two major ecosystem realms, the dry side (coastal land) and the wet side (coastal water), spatial planning of the coastal zone should cover both the characteristics of terrestrial and marine ecosystems as well as the transitional characteristics of the coastal zone.

There are three main characteristics which make spatial planning of the coastal zone should differ from that of terrestrial environment.

First is that there is less isolation of coastal (marine) ecosystems than one find on land even when the marine habitat differ in appearance. The aquatic medium connecting different places in the sea is itself habitat and provides connectivity among distance locations. Many species spend different life cycle stages in very different habitats and fish move along the three dimensions of the sea (IIRR, 1998). Although they may be physically distinct, ecosystems such as mangroves, seagrass beds, and coral reefs are highly connected to each others and interactive with the surrounding coastal habitats. Laymen may perceive the coastal ecosystems in separate units and not appreciate the level of interaction among them.

Second is that the ecological linkages between land and sea are tremendously significant (Dahuri et al., 1996; Cicin-Sain and Knecht, 1998). From a biophysical point of views, the most important connection between coastal zone and upland areas is the flow of water and silt from rivers, run-off, and underground water to coastal areas. Under natural conditions in uplands, this flow of water and sediments that carry nutrients and other substances would maintain a healthy coastal ecosystem. However, degradation of upland areas, due mainly to deforestation, causes increased erosion and sedimentation, resulting in degradation of coastal ecosystems. Other impacts from the land come in the form of water pollution from industries, cities, settlements, and agriculture.

Third is that most of living resources of the coastal zone are: mobile, underwater, change seasonally and move between different habitats. Such movement is often predictable on a seasonally, monthly or daily cycle, but knowledge of the exact location or size of fish stocks is not easily obtained although local knowledge may be available.

III. GUIDING PRINCIPLES OF SPATIAL PLANNING FOR THE COASTAL ZONE

Based upon characteristics of the coastal zone as previously mentioned, there are three major elements that should be applied in establishing spatial planning of the coastal zone: (1) PCU (Preservation, Conservation, and Utilization) concept; (2) ecological linkages; and (3) tandem use of spatial suitability and carrying capacity.

3.1. Preservation, Conservation, and Utilization Concept

A concept of designation of land by three broad use categories has arisen out attempts to plan for protection of ecologically sensitive areas. While the concepts remain the same, various terms are used for three categories. As use here they are termed preservation, conservation and utilization and the general proposition is termed the PCU concept.

The Florida Coastal Coordinating Council (Clark, 1974) has defined the following use designations for statewide coastal land classification : “Preservation”, no development suitable; “Conservation”, carefully controlled development suitable; and Development", intensive development suitable. The factors utilized in selecting areas for these designation are:

a. Ecological significance of the area and its tolerance to alteration.
b. Water classification of adjacent water bodies.
c. Soil suitability of area.
d. Susceptibility of the area to flooding, both from storm surge and run off.
e. Archeological and historical significance of area.
f. Unique environmental feature that may warrant protection.

Furthermore, "preservation, conservation, and development" are defined according to the following categories :

a. Preservation areas are those which provide invaluable public benefits-such as recreation, aesthetics, economic, and hurricane flood protection-and which are intolerant of development. These are areas which it is recommended should be preserved without any development and protected from degradation. " Preservation " areas include among others the waterways, mangrove, marshes, spawning grounds, and migratory routes which all form critical parts of the same productive and valuable coastal wetlands community.

b. Development areas are those areas which because of physiography, drainage, or other factors are comparatively suitable for development, and which have a reduced ecological, recreational, and public importance. Lands which could be developed directly or with only minor alteration would be classified as "development" (utilization) zone.

c. Conservation areas include the remaining lands, those marginally suitable for development and important but non-critical ecological significance. These serve as a buffer between the preserved and the developed areas. They require special precautions when being developed. Because of flood and drainage problems, development in areas classified "conservation" is generally very expensive, both in terms of initial cost as well as continuing maintenance costs. Developments in these areas are potential hazards to both life and property and require the continual expenditure of public and private dollars to alleviate, prevent, or repair flood damage.

3.2. Ecological Linkages

As described in Section 2 that many critical physical and ecological interconnections extend beyond the coastal zone boundaries, and that the coastal zone can be impacted significantly by human activities and natural processes that occur at great distances away from the coastal zone. The condition of coastal waters, for instance, is obviously influenced by erosion and pollution that may many hundreds kilometers upriver. The watershed of Citanduy- Segara Aanakan Lagoon, for example, included portions of two provinces (Central Java and West

Java), extending well beyond any usual definition (boundaries) of the coastal zone. Yet, soil erosion and pollutants taking place along upland river areas have a major influence on the water quality of Segara Anakan lagoon.

It is, therefore, of highly important to arrange the types and intensity of development activities along upland river of the watershed according to the assimilative capacity of the receiving coastal waters in neutralizing sediment (silt) and pollutants. Since the assimilative capacity of a coastal water is defined according to its designated uses (e.g. for aquaculture, fisheries, recreation, or ,conservation), then the total loads of sediment and pollutants flowing into the coastal water should be limited according to the environmental quality requirements of those uses.

3.3 Tandem Use of Spatial Suitability and Carrying Capacity

Two ideas are central in this discussion of techniques for developing coastal spatial plans (Ortolano, 1984) . One is that hydrologic, geological, biological, and other features, when viewed collectively, yield insights into the type of use "intrinsically suitable" for a particular parcel (unit) of land. A Second important concept is "carrying capacity" the limits to how much growth an area can accommodate without violating environmental quality goals. Analyses of carrying capacity and the intrinsic suitability of land for certain uses provide systematic ways of utilizing environmental information to guide planning.

The map overly technique is a procedure for synthesizing the spatial data used in (coastal) land use planning. It involves four steps ; (1) identify factors to be included in the planning exercise, for example, potential earthquake hazard, erosion pattern, and soil permeability; (2) prepare an "inventory map" for each factor showing how it varies over the study area; (3) create composite maps by overlaying two or more inventory maps ; and (4) analyze the composite maps to make inferences relevant to land use planning.

There is little uniformity in terminology for describing how a carrying capacity analysis is conducted. Two useful terms are growth variable and limiting factor. A growth variable can represent either population or a measure of human activity, such as number of new housing units per year or the number of park visitors per day. Limiting factors include natural resources, physical infrastructure and other elements that, because they are not available in infinite supply, may restrain growth. Limiting factors used frequently in carrying capacity studies can be grouped into three categories.

Environmental Biophysical characteristics including measures of air and water quality, ecosystem stability, and soil erosion.

Physical The capacity of infrastructure systems, including highway, water supplies, wastewater treatment plants, and soil waste disposal facilities.

Psychological Parameters concerning the way individuals perceive their surroundings: for example , he sense that an area is overcrowded.

To conduct a carrying capacity analysis, a maximum (or minimum) value must be set for limiting factor.

The maxima (or minima) for environmental limiting factors are often derived from either political process or the judgments of experts. For example, acceptable limits of water quality in the Indonesian provinces are often based on national ambient water quality standards. When biological or geological parameters are employed, the limits are frequently set using professional judgement. The maxima for physical limiting factor are often taken as the existing capacities of the relevant infrastructure systems: for example, the dependable yield of a community's water supply. The limits for psychological factors are determined either by professional judgement or by survey of individuals in the study area. Typically, only a few limiting factors are examined since the time and effort required for analysis increase in proportion to the number of factors considered. Those conducting carrying capacity studies must make judgments about which factors are likely to place the most stringent constraints on growth.

To estimate carrying capacity, it is necessary to estimate what a maximum (or minimum) value for each limiting factor means in terms of growth. Quantitative links must be made between limiting factors and growth variables. The difficulties in establishing such connections frequently turn out to be the major impediments to conducting carrying capacity studies.

When quantitative relationships between limiting factors and growth variables can be established, they are often based on either mathematical models or expert opinion based procedures. For example, suppose the dissolved oxygen (DO) of a particular stream in the study area is a limiting factor. If the minimum acceptable value of dissolved oxygen is 6 mg/l, and its current level is 7 mg/l, there is 1 mg/l available to accommodate growth. Suppose, further, that the study area is a suburban community with no major industrial or commercial effluent, and that the growth variable is population. A quantitative link between the population and the acceptable limit for DO can be found by estimating how much wastewater results from a particular increase in population. This requires assumptions about the amount of waste generated per person and the proportion of the waste removed by treatment prior to discharge. Once these assumptions are made, standard-engineering formulas can be used to compute the maximum value of population that can be accommodated by the 6 mg/l limit on dissolved oxygen.

Using reasoning similar to that above, it may be possible to estimate the restriction on the growth variable imposed by each limiting factor. The bounds will be different for each factor.

Continuing the illustration, suppose the availability of DO constrains the area's population to 100,000 people and the are two other limiting factors in the analysis, traffic congestion and water supply. Table 1. indicates hypothetical carrying capacity analysis result for this example. It shows that water supply provides the tightest restraint on growth by restricting the area's population to 80,000. This bound is not fixed for all time. If new water supply investments were made or if residents used the existing supply more efficiently (for example, by implementing water conservation measures) the constraining effect of water supply could be removed. If this occurred, traffic congestion would establish the carrying capacity at 90,000 people. This constraint is also changeable by making investments in new facilities and by influencing driving patterns. Furthermore, even the limits imposed by dissolved oxygen could be changed, for example, by lowering the minimum allowable DO to 5 mg/l instead of 6 mg/l, or by building more efficient wastewater treatment facilities. The is, of course, some point at which it is not practical to continue relaxing the constraint imposed by the limiting factors, and this establishes the carrying capacity for a particular setting. However, because there may be modifications in the circumstances affecting carrying capacity, it is a numerical bound that may change with time.

No.	Limiting factor	Maximum Population Consistent with Limiting Factor
1.	Stream dissolved oxygen	100,000
2.	Water supply capacity	80,000
3.	Traffic Congestion	90,000

Table 1. Using Sets of Limits in a Carrying Capacity Study

Innovative applications of the carrying capacity approach involve its use in conjunction with land suitability analysis. A case study of planning in the Lake Tahoe area demonstrates the tandem use of both analytic procedures. The "Tahoe region" is defined by a compact between California and Nevada. The region consist of about 500 square miles, roughly 39% of which is by covered by the lake. As a result of land development during the late 1960s, the quality of Lake Tahoe was significantly degraded. The soils in the region are very susceptible to erosion. Extensive land development increased the rate at which sediments were eroded and transported to the lake. The nutrients carried by the sediments fostered the growth of aquatic plants that diminished the lake's aesthetic quality.

In the early 1970s, the U.S. Forest Service, in cooperation with the Tahoe Regional Planning Agency (TRPA), undertook a lad suitability analysis based on the region's natural characteristics. This study, referred to by the Forest Service as a "capability analysis," included the following factors: frequency of floods, landslide hazard, water table elevation, soil drainage, soil erodibility, and the fragility of flora and fauna. After considering these factors, both individually ad in various combinations, the land in the region was divided into seven "capability levels." Table 2. Indicates how the levels were defined using various landform and soil characteristics. The study results provided the basis for a TRPA ordinance that established, for each capability level, a maximum allowable percentage of the land that could be covered with buildings and other physical facilities. For example, the ordinance indicated that at most 1% of the land classified as capability level 1 could be covered.

In the mid-1970s the California Tahoe Regional Planning Agency (CTRPA) undertook a carrying capacity investigation for the California side of the Tahoe studies needed to be supplemented. They reasoned that TRPA's population projections for the Tahoe region were based largely on the physical capability of land to accommodate different uses. These projections did not consider regional air and water quality goals, nor did they account for limits on water supply and high capacity. The CTPA study was undertaken to integrate environmental quality goals and the limits imposed by physical infrastructure into its planning and decision making.

The CTRPA analysis focused on the following questions (Grove, 19978,p.l):

- How much activity can the Lake Tahoe basin accommodate white maintaining desired levels of environmental quality?
- What is the ability of the region's natural and societal resources to support further activity?
- What are the interrelationships among the various natural and society system?
- What will it cost to increase the carrying capacity of the region to accommodate the population and development presently allowed by CTRPA's regional plan.
- What are alternative ways to ensure the carrying capacity of the region is not exceeded?

Capability Levels	Tolerance for Use	Slope Percentage	Relative Erosion Potential	Runoff Potential	Disturbance Hazard
7	Most	0 – 5	Slight	Low to moderately low	Low hazard lands
6		0 – 16	Slight	Low to moderately low	
5		0 – 16	Slight	Moderately high to high	
4		9 – 30	Moderate	Low to moderately low	Moderate hazard lands
3		9 – 30	Moderate	Moderately high to high	
2		30 – 50	High	Low to moderately low	
1a	Least	30+	high	Moderately high to high	High hazard lands
1b		Poor natural drainage			
1c		Fragile flora and fauna			

Table 2. Land Capability in the Lake Tahoe Region

Table 3. Summarizes results from the CTRPA carrying capacity analysis for the 15 limiting factors included in the study. For each factor the table shows the peak population sustainable under conditions existing in the mid-1970's. The circa 1975 peak population of 145,000 exceeded the carrying capacity based on seen factors including air and water quality. The CTRAPA also estimated how much it would cost to increase the population that could be accommodated by some of the limiting factors.

Although investments of various type can increase the Tahoe region's carrying capacity, there is a bound on how much the capacity can be augmented. This is especially true for water quality. Past decisions permitting the development of roads, house, and commercial establishments have decreased vegetative cover, increased erosion, and transformed drainage patterns in ways that are hard to change. The increased nutrient flows to Lake Tahoe resulting from these modifications cannot be easily reversed. Moreover, leaching of nutrients from septic tank drainage fields (now no longer in use) is an additional source of nutrients to the lake that cannot be easily contained. For these reasons, the water quality goals established for Lake Tahoe provide a practical limit on population growth for the region.

The CTRPA carrying capacity study broached a subject that is only beginning to receive serious attention, namely, the connections among limiting factors. Such linkages are significant since a change in the ability of the most limiting factor to accommodate growth can indirectly influence the effects of other limiting factors. For example, suppose wastewater treatment plant capacity provided the most stringent restriction on growth and that relaxing this constraint by adding treatment capacity would lead to an increase in the Tahoe region's housing stock. Grove (1978) observes that the "increase in housing would also require increased water supply, generate additional sedimentation, increase travel, and generally require other infrastructure and services. He emphasizes that interdependencies can be important even when capacity is augmented for a factor that is not restricting growth. Such an expansion could lead to increased political pressure to enlarge the factor that is the growth constraint. The interconnections among factors can be quite complicated, and they are difficult to analyze in a systematic fashion.

Limiting Factor	Seasonal Peak Population That Can Be accommodated
Environmental Quality	
Air quality	Inadequate
Land capability	175,000
Water quality	Inadequate
Noise	Unknown
Natural Resources	
Water supply	223,000
Energy supply	
Electricity	Inadequate
Natural gas	185,000
Infrastructure and Services	
Sewage treatment	167,000
Solid waste disposal	Inadequate
Transportation	Inadequate
Health care	185,000
Education	227,000
Police protection	Inadequate
Justice	145,000
Fire protection	Inadequate

Table 3. Carrying Capacity Estimates for the California Portion of the Lake Tahoe region

Although both the CTRPA's carrying capacity report and the forest Service's land capability study had an influence on the CTRPA's 1980 land use plan, the two analyses were not synthesized in a formal way. Each study contributed to increasing people's awareness of the implications of continued growth in the Tahoe region. As more citizens recognized the adverse environmental effects of continued growth in he region, appointed and elected officials became increasingly willing to impose potentially unpopular restraints on growth. A reflection of the usefulness of the CTRPA carrying capacity study is given in the 1980 bistate compact for the Lake Tahoe area. It called upon the Tahoe Regional Planning agency to extend the CTRPA study by analyzing carrying capacity for the entire region.

IV. CONCLUSION

1. The most failures in implementing spatial planning approach in the coastal zone has probably been due to the direct application of terrestrial spatial planning techniques in the coastal zone without necessary adjustments.
2. There are three main characteristics which make spatial planning of the coastal zone should differ from that of terrestrial environmental: (1) There is isolation of coastal (marine) ecosystems than one find on land even when the marine habitat differ in appearances; (2) The ecological linkages land and sea are tremendously significant; (3) That most of living resources of the coastal zone are : mobile, underwater, change seasonally and move between different habitats.
3. There are three major elements that should be applied in establishing spatial planning of the coastal zone: (1) PCU (Preservation, Conservation, and Utilization) concept; (2) ecological linkages; and (3) tandem use of spatial suitability and carrying capacity.

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