SATELLITE-BASED AND COMMUNITY-BASED COASTAL RESOURCE MAPS: COMPLEMENTARY OR CONTRADICTORY?

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ABSTRACT. Participatory coastal resource assessment, or PCRA, is a coastal management approach that involves the coastal community in the appraisal of natural resources found within its coastal zone. One strategic activity in this approach is the community-based mapping of its coastal resources. In community-based mapping, the leaders and ordinary residents of several communities, which make up the coastal municipality or city, work together to produce coastal habitat maps of their respective communities, relying on local knowledge and technical assistance from other people or groups. However, their lack of training in mapping becomes evident in the output—*e.g.*, shapes and sizes of habitat patches are grossly in error, extent of a habitat patch is wrongly delineated, etc. In contrast, a satellite-based coastal resource map is typically produced by field experts. The accuracy of the map is dependent on the extent and comprehensiveness of ground validation, and experience in image interpretation, among others. The map-making process receives little input from community residents, who are theoretically the most knowledgeable of the area to be mapped. Therefore, satellite-based and community-based coastal habitat maps are, more often than not, not in agreement. This does not imply, however, that one map is accurate while the other map is not. Instead, the paper shows that one map may be enhanced by the other. Using as an example the case for one municipality fronting Davao Gulf, the paper discusses how a more accurate map may be produced from integrating the results of community-based mapping to a classified Landsat 7 ETM+ image of the area.

1. INTRODUCTION

The Philippine coastal zones are under tremendous stress. Fish catch is declining, coral reefs are battered, mangroves are under threat, pollution levels are rising, and growing coastal communities are experiencing increasing poverty (Courtney and White, 2000). Thus, the need for an integrated approach to the management of the Philippine coastal zones--which effectively addresses the social, economic, physical, natural and other factors causing these problems--cannot be overemphasized.

One of the key elements in an integrated coastal zone management approach is the continuing process of scientific data collection on coastal resources. This involves the collection of baseline information and development of a coastal environmental profile to lay the basis for the coastal management plan. In much of the Philippines' experience in coastal management, coastal communities are engaged to participate in this critical activity. The reasons for involving the community in this and other coastal management activities are plenty (Zeitlin-Hale, 1996), but local wisdom and knowledge and community participation seem to be two of the most compelling.

This activity, commonly referred to as participatory coastal resource assessment (PCRA), focuses on resource assessment from the point of view of local users of coastal resources and integrates local wisdom and knowledge with the technical expertise of other people or groups, such as non-governmental organizations, universities, research institutions, and local government staff, who are also involved in planning and management (Walters *et al*., 1998). One of the major outputs of such activity is a coastal resource map, which shows the occurrence, distribution and use of, and access to resources and associated habitats within the economic and cultural domain of the community.

This map is essential in planning and implementing coastal management activities. With this type of map, one is able, among other things, to represent and then analyze the extent and condition of coastal resources and habitats, prepare a coastal use plan, optimize coastal space for infrastructure development and interventions, localize coastal problems, and identify various coastal issues and conflicts.

The same map may be produced scientifically by field experts through the use of satellite remote sensing and related mapping techniques. Through the combined use of data collected from ground validation activities, experience in visual interpretation, the collection of secondary information, and the application of various image processing methods, a coastal resource map may be produced. The literature is replete with cases of the use of remote sensing for mapping coastal resources (*e.g.*, Clark *et al*., 1997; Chauvaud *et al*., 1998) with varying degrees of successes. However, normally, this particular map-making process receives quite little input from community residents, who are theoretically the most knowledgeable of the area to be mapped.

Therefore, satellite-based and community-based coastal resource maps are, more often than not, not in agreement. These disagreements are manifested as differences in shapes, sizes, and lengths of patches, and errors in the positions of such patches, among others. This disagreement does not imply, however, that one map is more accurate and useful than the other map.

The paper attempts to answer the question of whether satellite-based and community-based coastal resource maps are indeed contradictory or complementary. This paper posits the latter. We show that one map may be enhanced by the other. Using as an example the case for one municipality fronting Davao Gulf, the paper discusses how a more accurate and useful map may be produced from integrating the results of community-based mapping to a classified Landsat 7 ETM+ image of the area. The paper also discusses the role of coordination (among participating agencies), cooperation (among field experts and community residents), awareness (of coastal environmental issues), and advocacy in coastal management, in general, and mapping, in particular.

2. METHODS

2.1 PCRA

Community-based mapping is a fairly straightforward process. Each municipality or city designates an officer from the Municipal or City Agriculturist's Office to facilitate the coastal resource assessment activity in the different communities (called *barangay*s) that make up the coastal municipality or city. The municipal or city officer normally provides a base map over which the community residents sketches various types of information such as habitats, resources, water uses, environmental issues, and other features. The base map, normally plotted at a scale of 1:100,000 for lower-class municipalities, shows political boundaries and features such as landmarks, shorelines, and roads. Being typically prepared from topographic maps produced by the national mapping agency, this allows for comparison with existing maps produced by mapping experts. Different methods are employed in depicting map elements on the base map. For example, a habitat is expressed as a patch of varying colors. Living resources such as sea mammals or fish are tagged as Arabic numerals placed over locations where these resources are reported to exist.

After some initial mapping has been conducted, the PCRA map is refined by undertaking field visits. Being a group exercise, peer pressure and group consultation often lead to a better understanding of the map-making process and consequently, to a more accurate location of map elements. Also, years of experience in fishing and farming, or even living in the community, help in the identification of features that are not distinct in aerial photographs (from which most topographic maps are derived) and satellite images.

These procedures were implemented by the residents of the coastal municipality of Banaybanay in Davao Oriental, situated in southern Mindanao on the eastern side of Davao Gulf. This was undertaken during the first quarter of 2001.

2.2 Analysis of satellite images

A Landsat 7 ETM+ image of Davao Gulf and adjoining cities and municipalities (path = 112, row = 55), acquired on 26 May 2000 was used in the study (see figure 1). Routine preprocessing procedures, including geometric correction and radiometric calibration, were applied to the image. Ground-truth data were collected during site visits conducted in May 2001 by mapping and fishery experts from the University of the Philippines and the Bureau of Fisheries and Aquatic Resources respectively. The boatman served as their only field guide.

The study area was limited to the region bounded by a three-kilometer buffer zone offshore and a variable distance inland. After this mask had been applied, the scene was plotted at a scale of 1:100,000 and visually interpreted for coastal land uses and habitats. Multispectral classification of the image using the maximum likelihood algorithm was then performed.

2.3 Integration of information from the two maps

Only a qualitative assessment of accuracy of the two maps--satellite-based and community-based--was performed. This was done by a visual correlation approach. Observations are made on the two maps regarding the shape, size and length of coastal resource patches, the location of these patches, and the correspondence of their identities, *i.e.*

if a patch in one map is identified as the same in the other map. Any observed differences are noted and subsequently translated onto the satellite-based map using one's best judgement.

3. RESULTS

Assigning the Landsat bands 4, 3, 2 to red, green and blue respectively, we find that vegetated areas appear in red tones, built-up areas in blue-green tones, coral reefs in blue to light blue tones, and mangroves in red tones (please refer to figure 1a). Fishponds also appear distinctly in the image as regular patches of dark and light green. It is context which distinguishes fishponds and mangroves from other coastal resources and habitats which exhibit,more or less, similar spectral responses. Interestingly, bagnets—a fishing implement—appear as dark green patches in several locations along the coast.

Figure 1b shows the PCRA map for the municipality under study produced by the community residents. The coastal habitats and resources within the municipality that have been identified are sandy beach, seagrass beds, coral reefs, mangroves, and fishponds and fish cages. Water uses—mostly fishing-related—such as fish sanctuary, fish shelter, fish corrals and bagnets, are also indicated in the map.

Figure 1c, on the other hand, is the generalized classified Landsat image of the area. About 93 percent of the training pixels (n = 8,975) have been correctly classified to one of six classes, namely coral reefs, mangroves, fishponds, marine zone, terrestrial zone, and bagnets (see table 1). However, immediately noticeable are the misclassification of mangrove pixels to terrestrial zone pixels, and of marine zone pixels to coral reef pixels. The former is due to spectral confusion between mangroves and other types of vegetation. The latter is due to spectral confusion between coral reefs and shallow water. Submerged seagrass beds are difficult to detect from the image. Some categories in the PCRA map are not identifiable from the image.

Table 1. Error matrix from the classification of the Landsat 7 ETM+ image of the study area.

	CR	**MN**	**MZ**	**TZ**	**BN**	**FP**	**Total**
CR	638	0	9	2	0	13	**662**
MN	0	534	0	170	3	2	**709**
MZ	0	0	3296	3	0	0	**3299**
TZ	0	137	0	2553	3	170	**2863**
BN	0	1	0	3	306	22	**332**
FP	22	9	0	39	4	1036	**1110**
Total	**660**	**681**	**3305**	**2770**	**316**	**1243**	**8975**

Notes: CR = coral reefs, MN = mangroves, MZ = marine zone, TZ = terrestrial zone, BN = bagnets, FP = fishponds. Overall accuracy = 93.18 percent.

While similar in some respects, several disagreements between the PCRA and satellite-based maps may be observed. These disagreements, as well as the possibility for improving the satellite-based map based on PCRA inputs, are discussed in the following section.

4. DISCUSSION

One difference in the two maps is in the shape of the coastal resource and habitat patches. For example, labeled ‘A’ at the center of figures 1b and 1c is a stationary bagnet. It is rectangular in shape in the community-based map while irregular in the satellite-based map. Another difference in the two maps is in the size of the patches. Labeled ‘B’ near the top of figures 1b and 1c is a coral reef patch. While similar in length, the coral reefs in the satellite-based image are represented as being wider in extent.

Another difference is in the location of the patches. Labeled ‘C’ at the left side of figures 1b and 1c is another coral reef patch, the location of which grossly differs in the two maps. Another type of differences in the map is miscorrespondence of patches. Examples are those marked ‘D’ and ‘E’ near the bottom of figures 1b and 1c. Seagrass in the community-based map is misidentified as a coral reef patch (‘D’) while the terrestrial zone in the community-based map is misidentified as either mangrove or fishpond patches (‘E’).

Nevertheless, despite these differences, a potential exists for improving the satellite-based maps using information derived from community-based maps. Shapes, sizes, lengths, and locations of patches may be reliably obtained from classified satellite imagery. However, information on the identity of patches may be more reliably obtained from community-based maps because of the high reliability and validity that may be attached to local wisdom, knowledge and experience. A better map may be produced by integrating the best features from the two maps. For example, information on the location of seagrass beds in the PCRA map, which is absent in the satellite-based map, may be transferred to the other map. Also, other coastal resources or habitats shown in PCRA maps, but not easily detectable in satellite imagery, may also be depicted in the improved map. Figure 2 is an enhanced coastal resource map produced by integrating information from the two maps.

Many problems in the integration of the two maps may be avoided by maintaining quality throughout the map-making process. In most instances, to do so not only requires strictly following mechanical procedures in mapping but also seeing to it that the social dimensions of mapping are adequately addressed.

One such dimension is coordination among agencies or entities that have a stake or a significant role to play in coastal resource mapping. The community-based and satellite-based maps were produced by two different groups at two different times, but for the same national project. It would have been great savings of time, energy, and money had the production of the two maps been coordinated. Another important social dimension in mapping is cooperation among field experts and community residents. This paper has shown that local wisdom and knowledge are invaluable as far as map-making is concerned. Cooperation cuts on time for, and consequently, on costs for fieldwork. More importantly, it gives the community residents a deep sense of involvement in the process and, somehow, a sense of ownership over the output map. Awareness of coastal environmental issues is another important social dimension of mapping coastal resources and habitats. For example, knowing that coral reefs are essential in supporting marine life could encourage community residents to continually seek out this habitat, add the location of significant coral reef patches to their mental map of their coastal zone, and find ways to protect them. The fisherfolk of Banaybanay instinctively know where their coral reef regions are and they deliberately avoid passing their boats to those regions or, if it is not at all possible, they naturally slow down to avoid causing damage. Finally, community residents and field experts must adopt a "management" attitude towards coastal resources, or an advocacy for coastal management. This attitude attaches importance to mapping because of the significant role that it plays in making policies and decisions related to coastal management.

5. CONCLUSIONS

The study sought to answer the question of whether satellite-based and community-based maps were complementary or contradictory. While disagreements between the two types of maps exist, it has been shown that they play more of a complementary role, in that one map may be improved by the other. The study took two coastal resource maps—one prepared by community residents and the other prepared by field and remote sensing experts—and observed differences between the two. These differences were mainly on the shape, size, length, location, and identity of the different elements on the map. The differences notwithstanding, a better map was produced by integrating the best features from the two maps, although this was done using the mapping experts' best judgement. An accurate and reliable map must be one of the goals of coastal management from the very start. To this end, the social dimensions of mapping, namely coordination (among participating agencies), cooperation (among field experts and community residents), awareness (of coastal environmental issues), and advocacy in coastal management, play a crucial role.

6. ACKNOWLEDGEMENTS

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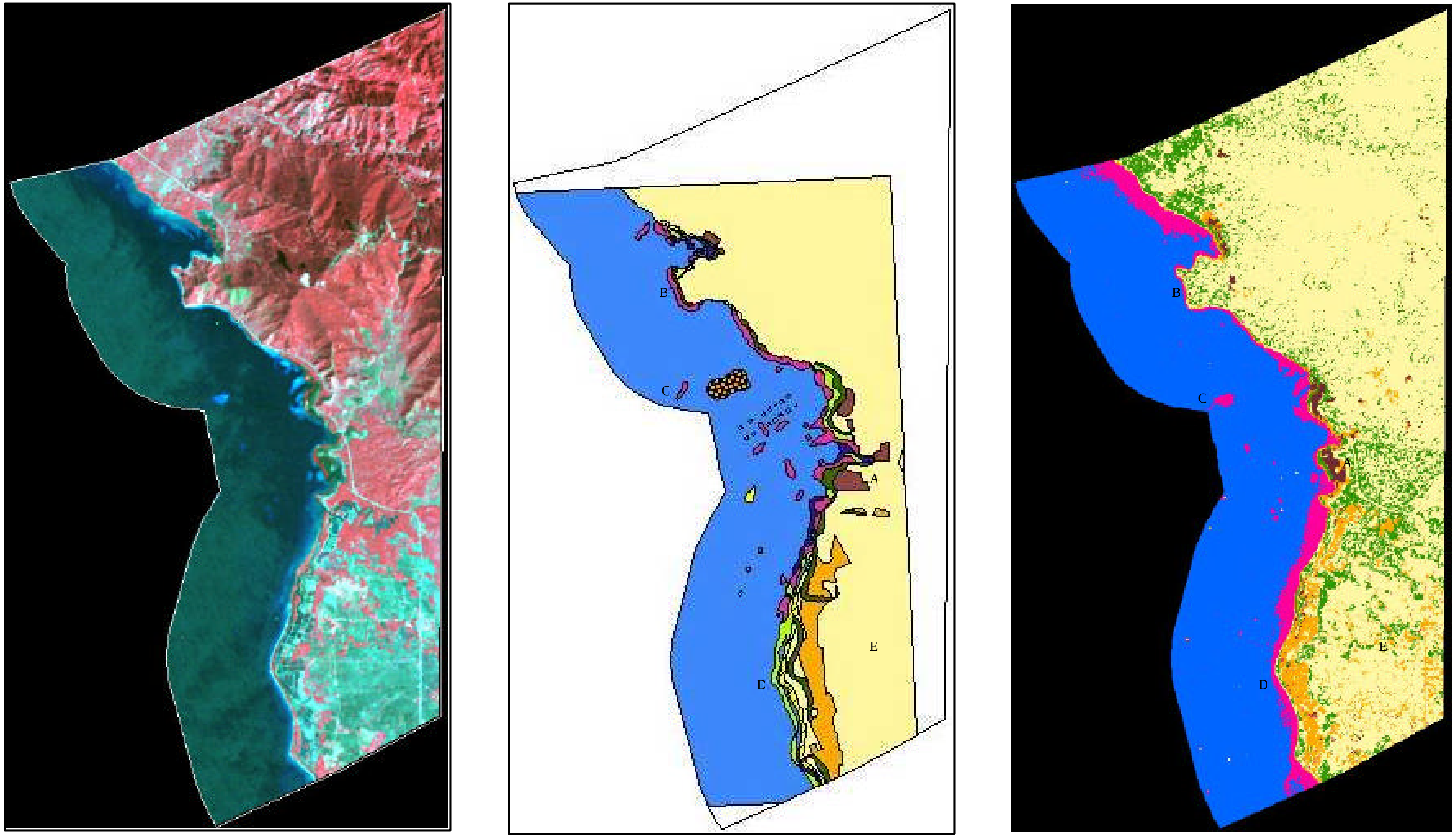

Figure 1. 1:180,000-scale plots of: (a) the Landsat 7 ETM+ image of Banaybanay, Davao Oriental in southern Philippines acquired on 26 May 2000 (RGB=432); (b) the PCRA map for the same municipality produced by the residents of the coastal municipality (see figure 2 for legend); and (c) the generalized classified Landsat 7 ETM+ image of the municipality (see figure 2 for legend).

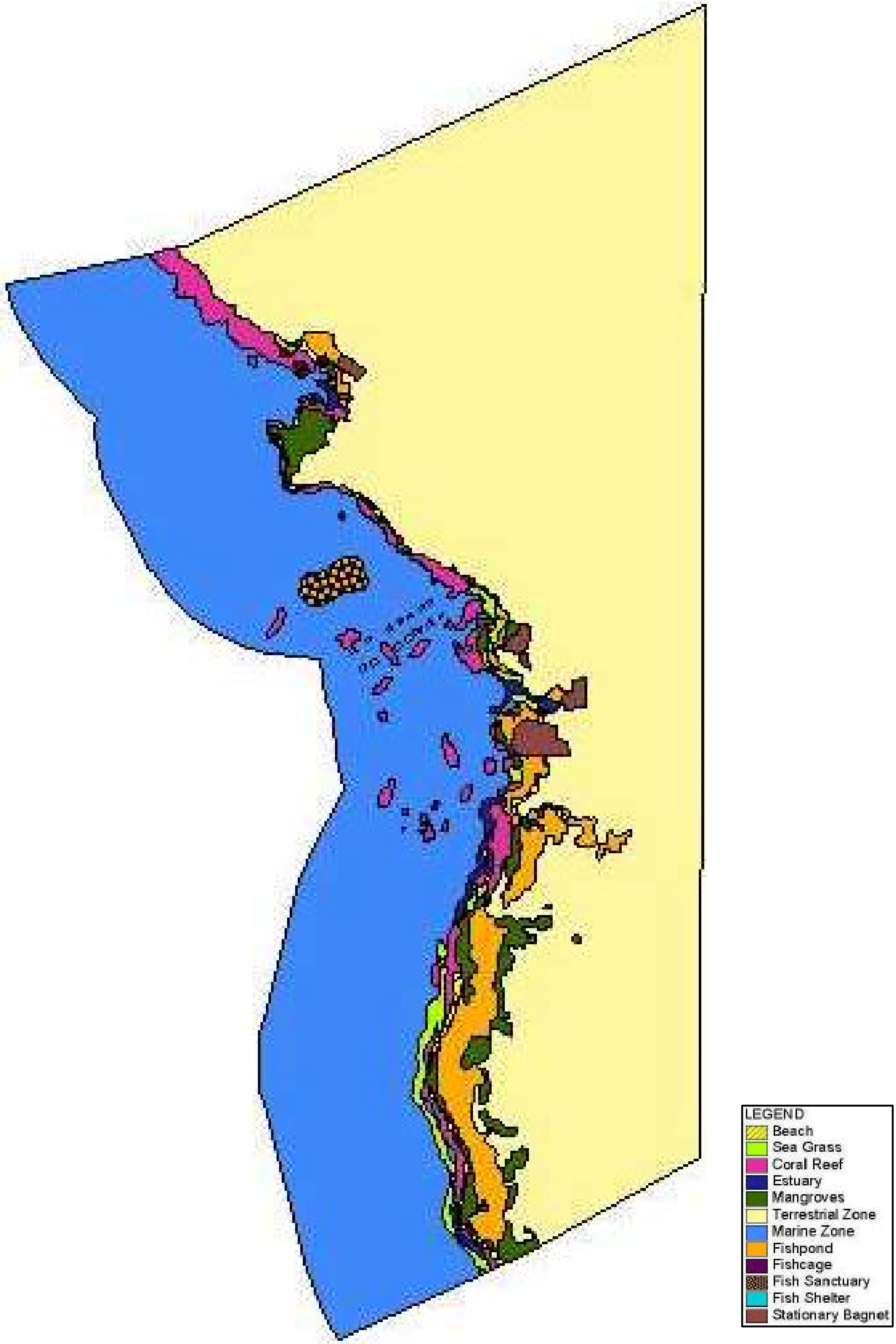

Figure 2. A 1:100,000-scale coastal resource map of Banaybanay, Davao Oriental integrating results from the satellite-based and community-based maps.