GIS-AIDED MARINE CONSERVATION PLANNING AND MANAGEMENT: A CASE STUDY IN PHUQUOC ISLAND, VIETNAM

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ABSTRACT

This study aims to apply Geographical Information System (GIS) in identifying areas of high potential for marine conservation. The study started by designing and establishing a spatial database of Phu Quoc, including natural conditions, socio-economic conditions and biodiversity data, which were the basis for the criteria to determine the potential of marine conservation. It identified seven criteria concerning marine conservation: 1) biophysical condition, 2) distribution of seagrass, 3) coral reefs, 4) rare/ precious species, 5) fishery resources, 6) inland planning, and 7) human activities. The potential level for marine conservation was modeled relying on weighting of the criteria. Based on GIS dataset, the multi-criteria analysis in combination with the weighting and scoring for each criterion was applied to generate a synthetic map of potential level for marine conservation. Then that map was overlaid with layers of current planning for selecting and zoning the MPA.

A number of methods were applied in this study including GIS mapping, remote sensing, interview of key informants, field survey and observation, local participatory mapping, stakeholder analysis, institutional analysis and assessment. A seminar-workshop was organized to discuss about seven criteria involving marine conservation potentials, weighting and scoring criteria, and conservation planning. After that, the boundary of MPA has been reviewed and revised as a result of the weighted criteria. Finally, the conservation measures and management was proposed. Major results in this study were the establishment of a GIS dataset, the development of seven criteria to support MPA zoning together with scoring and weighting for each criterion, and suggesting conservation measures. The database is practical and useful for PQMPA and Wetland Alliance Programme. In addition, the identification of the PQMPA boundary, based on GIS application with multi-criteria analysis for determining the marine conservation potential is a highly reliable approach.

1 INTRODUCTION

In the southwest Vietnam, Phu Quoc archipelago is relatively rich in marine biodiversity and wetland habitats, especially seagrasses. This marine area is one of the biggest fishery areas in Vietnam and the estimated area of seagrass around 10,000 ha is the biggest site in Vietnam. These areas support not only fish and shellfish species but also populations of sea turtles and dugongs, which are globally threatened species. However, the marine biodiversity and marine fisheries in Phu Quoc are declining due to increased human impacts such as over fishing, unsustainable tourism and the use of destructive fishing methods, such as bottom trawling and dynamite fishing (KGDoFi, 2006). The available data show that although marine fishing increased by 250% during 1990 and 2004 (due to increase of total vessel power) but catch-per-unit-effort (CPUE) decreased sharply in that period.

Protecting marine biodiversity and ensuring sustainable use of ocean resources of this region is therefore of great importance to local people in Phu Quoc. To reverse the degradation, some management measures have been suggested and developed. Marine protected areas (MPAs) are one tool suggested for improving the conservation of natural resources and achieving sustainable development of ocean resources.

In order to protect coral reef and seagrass from negative impact, establishing Phu Quoc Marine Protected Area (PQMPA) is a chance to protect marine resources of coral reefs, mangrove, seagrass and to conserve species of dugong and sea turtle. As a result, Kien Giang province authority issued a decision to establish PQMPA. However, it is under development and it is still lacking a suitable

zoning plan for development and conservation in accordance with scientific researches and social studies. In other words, there is a need for a suitable zoning plan based on physical, biological, and socioeconomic characteristics of the area.

It is now urgent to develop functional zoning and associated regulations for the MPAs. Although declaration of PQMPA, PQMPA management planning is still in early stages. PQMPA boundary should be designed based on GIS and mathematical analysis. So establishing a GIS database, and multi-criteria evaluation are necessary and meaningful for conservation work in Phu Quoc (WAP, 2007).

Objectives

The overall objective of this study is to do conservation planning for PQMPA including boundary identification, zoning, and a draft marine conservation planning. The specific objectives are:

- To establish a GIS database for marine conservation planning and management
- To propose MPA boundary and zoning for PQMPA based on Multi-criteria Evaluation
- To suggest conservation measures useful for drafting conservation plan

2 METHODOLOGY

2.1 Study area

Phu Quoc is famous with high biodiversity of marine resources such as coral reef, seagrass, and beautiful sea beaches. The largest area of seagrass in Vietnam is the habitat for not only important marine species such as grouper, crab, seahorse, but also global endangered or threatened species such as dugong and sea turtle. However, it is under high pressure of negative human activities, for instance over fishing and unsustainanble tourism. MPA is proposed to conserve the marine biodiversity against the decline. To establish the Phu Quoc MPA is in one of the first steps towards protecting the marine resources and developing a zoning plan is urgent.

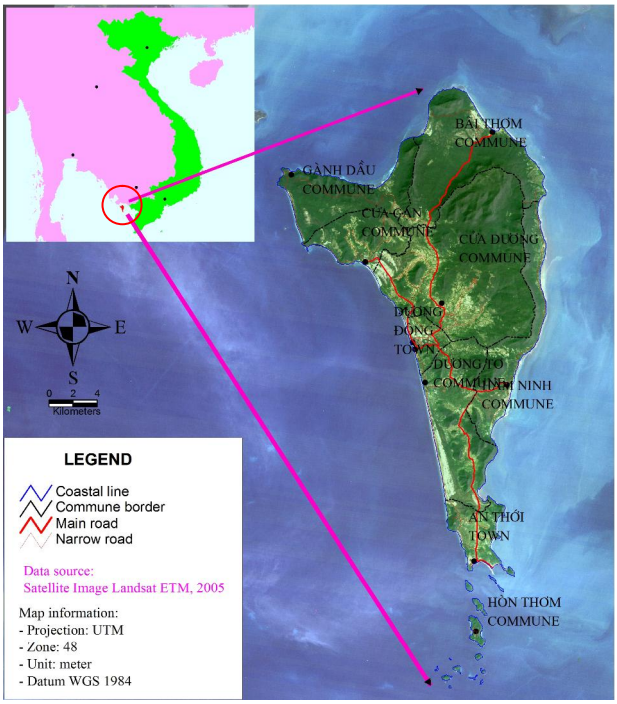

Figure 1 Location of study area - Phu Quoc Island, Kien Giang, Vietnam

Figure 2 Phu Quoc from the South

Figure 3 Phu Quoc from the West

2.2 MPA selecting model

Up to now, there is still no standard model for defining different MPA management zones in Vietnam. Therefore, in this study, in order to develop maps showing potential level of marine conservation for MPA selecting and zoning, a GIS model of different zones is created based on multi-criteria. A questionnaire was designed and interviews carried out to find out a set of criteria for marine conservation potential in Phu Quoc. After reviewing, revising the results of workshop and consultation of marine experts, seven criteria were proposed: bio-geographical criteria, distribution of seagrass, coral reef, global threatened species, fishery resources, land-use planning inland and socio-economic criteria.

- *Scoring by ranking*

Each criteria is reclassified into new classes as high potential, medium potential, and low potential for marine conservation. The model of MPA zoning is created based on a linear combination method of ranking and weighting score. The ranking score presents potential of each factor for marine conservation in each area. The rating assumes consideration of all characteristics at each class and all the costs and impacts of the land if located in this class (Lewis, 1979). In this study, ranking 3 is assigned for high potential, 2 for moderately potential, 1 for low potential, and 0 for no potential for marine conservation.

Table 1 Scoring by ranking and classified potentials for marine conservation

ID	Criteria/ Methods	Layer/ Data source	Unit	High potential (3)	Medium potential (2)	Low potential (1)	No potential (0)
1	Biogeographical criteria • Local participate mapping • Expert consultation (EC)	Bathymetry Depth contour	meter	0 to -5	-5 to -10	-10 to -20	-20 to - 100
		Seabed slope average Depth contour	degree	0 to 0.1	0.1 to 1.0	1.0 to 5.0	> 5.0
		Marine current LPM	Logic	Marine current			No Marine current
		Highproductivity area, LPM	Relative level	High productivity			Low productivity
2	Distribution of seagrass • EC,	Seagrass NIO, RS&surveys	Relative important	High cover, species	Medium cover, species	Low cover, species	No seagrass
3	Distribution of coral reefs • EC	Coral reefs NIO, RS&surveys	Logic	High cover, species	Buffer 200m	Buffer 400m	No coral reefs
4	Global threatened species • EC	Rare Species LPM, KG DoFi	Relative abundance	Very abundance			No abundance
5	Fishery resources • EC	Fisheryresources LPM, KG DoFi	Relative abundance	Very abundance			No abundance
6	Land use planning inland • EC, GIS buffer	Inland planning KQ DARD, sub-FIPI	Relative potential	High potential conservation			No potential conservation
7	Socio-economic • EC		Relative potential	High potential			No potential conservation
		Population density per 1km coastal line	Boats/ 1km	0-200	200-500	500-5000	
		Fishing boat density	Unit	0-15	15-20	20-100	

- *Weighting by rating*

Each factor contributes at different rates, so a different weight was given to each factor. The greater the weight means greater importance in term of marine conservation, then a higher value is assigned. The GIS workshop confirmed that there are seven criteria influencing to potential of marine conservation in PQ archipelago. According to the discussion, the weight of each criterion is decided by rating. The voters were requested to assign weights to each criteria by distributing 100 points among the criteria.

As a suitable approach, the voters were advised to start with the least important criterion and assign it a weight of small number. Then, the next most important criterion was chosen and assigned it a weight in relation to the previously weighted criterion. This process was repeated until all have been assigned weights, sums 100.

- *Calculation the total score*

The synthesis of marine conservation potentials for each area has been calculated by seven terms, in which each term is the multiplication of weight and score of particular criterion. The method of calculation is expressed in the formula below:

$$\text{Final score} = \sum_{i=1}^{7} (\text{weight of criterion i}) * (\text{score of class})$$

Whole process of GIS analysis for zoning models can be described figure 4 as following:

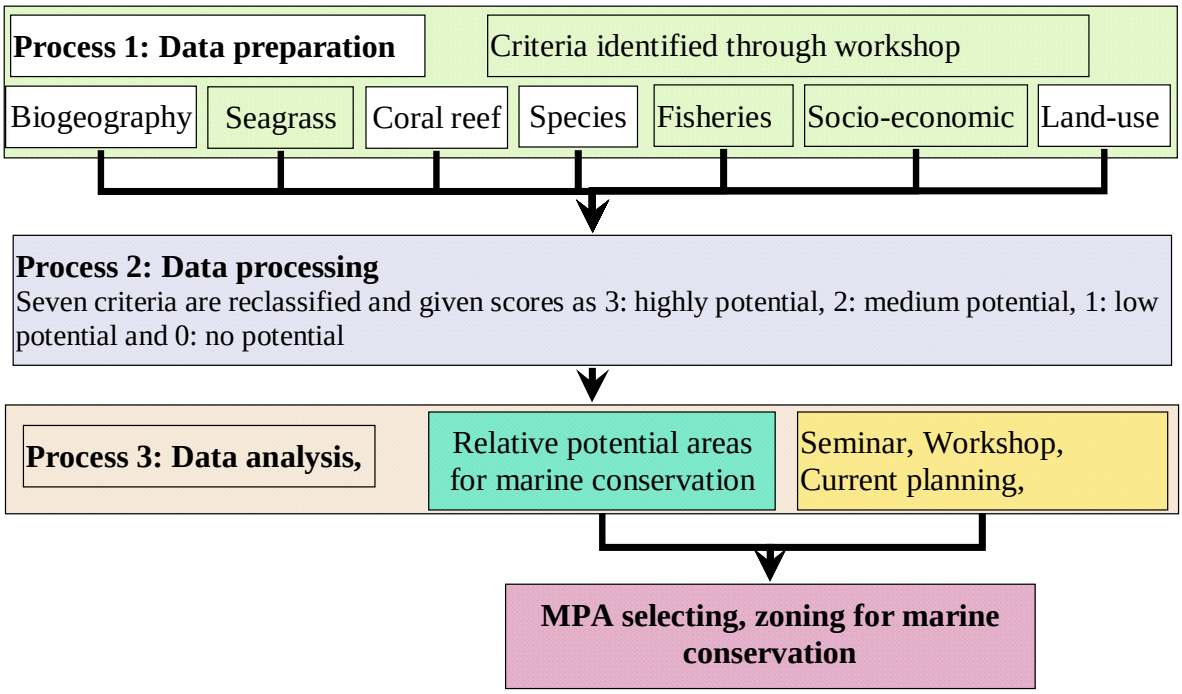

Figure 4. Diagram showing the process of MPA selecting

2.3 Data collection and materials

- Selection of respondents and key informants

Respondents are the fishermen, tourism organizations, merchants and workers, who represent different levels in local community. The key informants are the officers from various governmental organizations such as MARD, former MoFi, Ministry of Natural Resources Environment (MONRE), Vietnam Environmental Protection Agency (VEPA), and National Institutes (FIPI, NIO, HIO, and RIMF). In addition, the officers from provincial and district level with same structure were interviewed. The key informants are the experts from national institutes and NGOs (WWF, Birdlife), who have a lot of experience in PA planning.

- Field visit and observation

Field visit and observation are for crosschecking the information supplied by respondents and key informants. This method is more or less to improve the quality information and data.

Field surveys were implemented from 3rd to 13th November 2007 in order to observe, to measure and collect information about the actual status of local conditions. Global Positioning System (GPS) was used in recording location information of facilities and various incidences. This was also a good opportunity to collect ground control points for doing geometric correction for all spatial data. The main purpose of field-survey is to improve the quality and accuracy of GIS database by crosschecking. The multi-branch datasets were collected since they have been considered essential in formulating a management framework for Phu Quoc MPA.

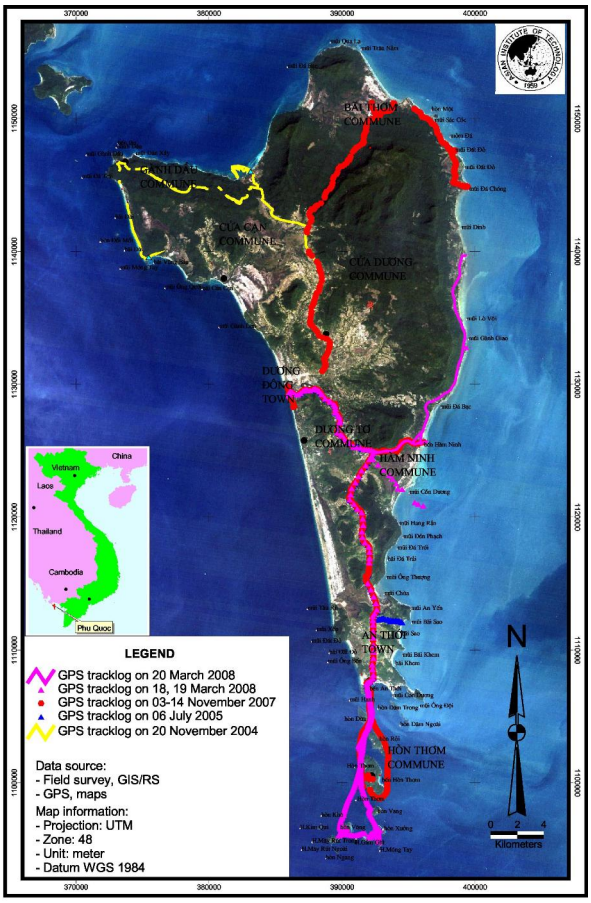

Figure 5. Surveying tracks in connection with GPS

- Local participatory mapping

The local participatory mapping was applied during the field survey in Phu Quoc from 3rd to 13th November 2007 in order to collect mapping information such as distribution of key species or marine production, which scientific-based knowledge, GIS and remote sensing could not get. In this process, the local people and fishermen who have decades of experience of marine travel were invited to supply information and mark onto the hardcopy maps. This information is later scanned, digitized and geo-referenced. Involving local stakeholders with their extensive field experience improved the accuracy and precision of obtaining data. Local participatory mapping is an effective tool for mapping and creating GIS dataset due to it can get valuable information without communication barriers. In addition, local participatory mapping created a common understanding among fishermen and stakeholders on spatial distribution and status of marine resources.

- Mini workshop

The workshop was organized in Kien Giang province in order to introduce the first draft of PQ GIS dataset, to discuss about criteria for selecting MPA and weighting multi-criteria. The participants came from different offices of Kien Giang such as KG DoFi, KG Fishery Inspector, KG DOST, KG DONRE, PQNP, PQFPMB, and PQMPA. Through this workshop, participants representing PQMPA stakeholders got to know about GIS and marine conservation. In addition, brainstorming and discussion about multi-criteria for PQMPA selecting and zoning were carried out.

- *Primary and secondary data collection*

Secondary data has been collected from various sources of information related to the study including books, reports, previous studies and documents at central government and provincial levels, districts and communes

- *Materials*

Software: ENVI 3.5, and ERDAS 8.7 for image processing, ARC VIEW 3.3 – for vector GIS data analysis

Microsoft Excel for database analysis

Equipment for field surveys: GPS Receiver, Compass, Digital camera, Voice recorder (for interview), Video camera, hardcopy of based maps and satellite images

associated with the MPA from various governmental organizations such as MARD, former MoFi, MONRE, Vietnam Environmental Protection Agency (VEPA), and national institutes (FIPI, NIO, HIO, and RIMF). Other secondary data was also collected during visit Rach Gia city in October 2007.

Primary data was collected during field surveys from the local community, stakeholders, provincial departments in Phu Quoc and Kien Giang province, ministries, departments, institutes, universities, organizations, unions, associations involving or relating to MPAs. Following the semi-structured questionnaire, the key informants were interviewed.

2.4 Database Preparation

- *Topographic maps:* topographic maps at scale of 1:50,000 were scanned and saved in JPG format then registered in coordinate system as mapping reference layer.
- *Satellite image data:* High-resolution satellite images acquired in the past were collected.
- *Ancillary data:* The dataset was collected from various sources and compiled in digital form accompanied by attribute data. This dataset can link together with tabular, textual and photographic information.

2.5 Data analysis

- *Land evaluation procedure*

In this study, a model for land evaluation was applied into marine evaluation in general, and into marine conservation planning in particular. This process considered multi-criteria, where each criterion is weighted according to importance/relevance for marine conservation. Each criterion is also classified into classes of potential of marine conservation. This process was applied in one workshop in March 2008 conducted by the author. More detail of this process is presented in the next section.

- *Remote Sensing and GIS analysis:*

• Spatial data analysis: Overlay mapping is an effective technique for the presentation and analysis of diversified spatial information. As result, new layers are generated containing attribute information of original layers. GIS is a particularly flexible approach to the manipulation of spatial data, and the integration with socio-economic information.

• Buffering is one technique to create a new polygon features around existing features. This technique is useful in spatial analysis since it can buffer areas with a particular distance from the original object.

3 CREATION OF GIS DATABASE, RANKING AND SCORING FOR EACH CRITERION

A GIS database including mapping layers has been designed and established with the aim to integrate multi-criteria for conservation and development, based on bio-geological, socio-economic and management aspects. In order to integrate this local GIS database with other GIS data, the projection UTM, datum WGS1984, zone 48 had been setup for all layers. Each thematic mapping layer contains both spatial and tabular information. This GIS database has been prepared by various inputs, processing and combining with the results from biological and social economic surveys as mentioned in methodology.

3.1 Bio-geographical criteria

The layer of bio-geographical criteria in term of relative potential for marine conservation is created based on expert consultation mapping and the combination of bathymetry, slope of seabed, distribution of currents and high productivity areas (figure 6).

The marine water surrounding Phu Quoc archipelago is typical representing for shallow marine water in the southwest of Vietnam. The depth contour of the sea around Phu Quoc archipelago ranges from (-60) to 0 meter (in comparison with Mean Sea Level). The depth contour of (-20 m) runs along the western coast of the main island. The digital elevation model showed that it is very deep in the south of Phu Quoc archipelago at group of South An Thoi islands. This characteristic is influenced

by tectonic activities long time ago. The deepest bathymetry is found in the channel (no.1) between An Thoi port and Hon Dua island (-60 meters). In the shallow water from (minus 10m) to 0 m in the surrounding islands, coral and seagrass habitats is found on the bottom where they can get the sunlight for photosynthesis process.

According to the result of the local participation mapping, there are three currents there between An Thoi, Hon Dua, Hon Roi and Hon Thom. In addition, there are also marine currents around Thailand Gulf and Phu Quoc archipelago following clockwise direction. The currents are moving nutrients between areas, bringing feedstuff, larvae, and many species thrive in such areas (figure 7).

3.2 Seagrasss

Sea grass beds that are most diverse in terms of species composition are located in Bai Thom and Ham Ninh (9 species). However, the critical sea grass beds that are large in terms of area are found in the Northern part of the archipelago, amounting to 700ha sea grass bed stretching from Ganh Dau to Rach Tram; 1,000ha from Bai Thom to Ap Da Chong; 6,000ha in Bai Bon; 4,300 ha from North Bai Vong to Cay Sao cape; 250ha in An Thoi. Sea grass beds that distribute from the shore to the depth of 2 meters often have high coverage and biomass. The coverage level and biomass reduce following the depth of the marine water. (figure 8)

Based on the number of species and distribution of seagrass species, (which feeds the dugong), density and biomass, the scientist and marine experts classified the seagrass beds in Phu Quoc into relative potential for marine conservation. In order to protect seagrass, it is also necessary to protect the surrounding environment. Thus, Reef Guardian International recommended protecting buffer region of 600 feet or 183 meters. In this study, depending on the potential of conserving the seagrass bed (e.g. high-medium) different buffers were used. For high conservation potential a double buffer of 400m was used and for medium potential a single buffer of 200 m was used. (figure 9)

3.3 Coral reefs

The map of coral reefs was digitized based on the results of field survey and satellite image interpretation by NIO in 2006. The distribution of coral reefs has been established in figure 10 by GIS technique. In order to protect coral reefs, the surrounding environment needs to be protected. Therefore, Reef Guardian International recommended protecting its buffer area. In this study, buffering was done in the same way as for seagrass. (figure 11).

3.4 Marine biological resources and distribution of rare species

The secondary reports showed that many rare species in the red book such as sea cow (dugong), dolphin, sea turtle and grouper are found in study area of Phu Quoc (KGDoFi, 2006). The local participatory mapping and key informant interview showed the distribution of rare species as in figure 12. The local people including fishermen, sea product merchants, local authorities, officers contributed the information. Then the map was cross-checked and digitized

Based on the distribution of rare species, relative important and relative abundance, expert consultation mapping was implemented in order to produce the relative potential for marine conservation in terms of globally threatened species distribution (figure 13).

3.5 The relative importance for marine conservation of fisheries resources

The marine waters around Phu Quoc are counted as very important fishing grounds where fishing boats from main land provinces and even foreign boats from Thailand concentrate. Thus marine conservation plays an important role in fishery management and migratory species conservation.

Based on the information supplied by local participatory mapping and mapping consultation PQMPA, KGDoFi, the distribution of fishery resources was mapped and showed in figure 14. After that, the relative marine conservation potential in criterion of fishery resources has been discussed. The experts from KGDoFi, WWF and NIO classified the marine study water into some small regions.

Firstly, the marine regions from Mui Trau Nam to Mui Da Bac and the group of islands in the south of Hon Thom are considered as high potential for marine conservation in terms of fishery resources criterion since they have high diversity of fish species, breeds and spawning areas. Next, the marine areas from Mui Trau Nam to Cua Can and surrounding Hon Thom Island are regarded as medium potential for marine conservation. Lastly, the rest regions in the western coast and eastern of An Thoi town are believed to have low potential since they are low productivity areas as figure 15.

3.6 Inland planning

Terrestrial land-use status and planning has close relation with marine conservation potential since inland and coastal planning have a direct impact to the marine conservation. The terrestrial land-use status and planning of Phu Quoc archipelago is displayed in figure 16.

Based on the terrestrial land-use status and planning, expert consultation mapping and scientific analysis was applied in mapping the relative marine conservation potential in term of terrestrial planning. This map is presented in figure 17.

3.7 Socio-economic criteria

Socio-economic is an important criterion to consider in nature conservation. Areas having less population will be more suitable for conservation than the high density population areas in terms of management and finding out the alternative livelihood. In Phu Quoc, we can evaluate the suitability for marine conservation based on comparison between communes in term of population density, or boat fishing density in one kilometer of coastal length. The map showing the distribution of settlement area and the population density by commune coastal length of Phu Quoc is displayed in figure 18. Then this data were classified into classes in consideration of marine and coastal conservation potential. As the result, the map showing the relative potential for marine conservation by socio-economic criteria has been established. It is showed in figure 19.

In summary, this section presented the process to establish the GIS dataset including seven criteria concerning marine conservation potential. It will then be applied for overlaying mapping layers and mapping calculation in next chapter. In addition, a number of auxiliary layers were also established such as rivers, streams, land-use, etc. All layers are in same projection of WGS-84 for mapping overlay later on.

The establishment of a GIS dataset applying GIS/RS/GPS, local participatory mapping, expert consultation and secondary data including many layers in same projection is necessary and useful for marine conservation work, especially in MPA selecting and zoning. It also showed that GIS, RS and GPS is good tools for overlaying map layers, buffering areas, doing statistical calculation, updating the information and modeling the marine conservation option. Furthermore, the combination of GIS, RS and GPS brought high accuracy result, so quality of data is improved considerably in comparison with manual work.

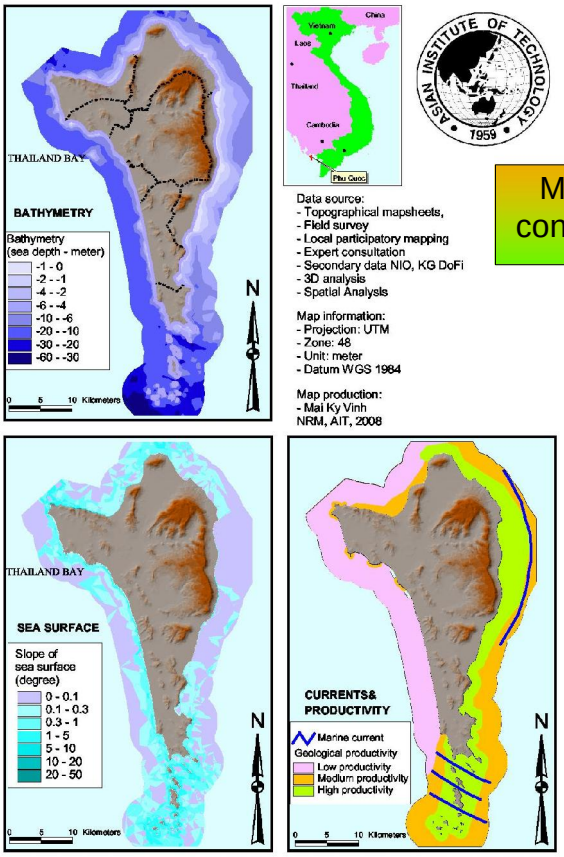

Figure 6. Biogeographical features

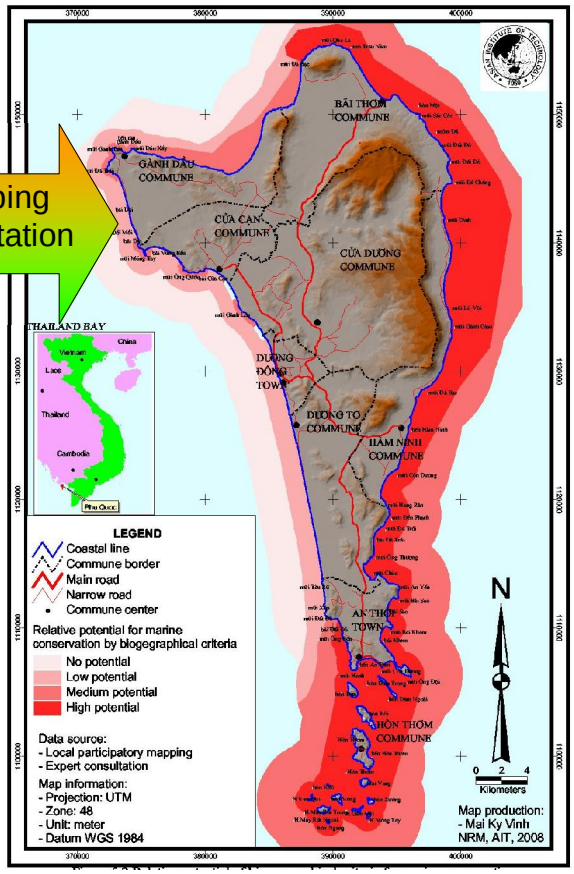

Figure 7. Potentials for marine conservation (criteria 1)

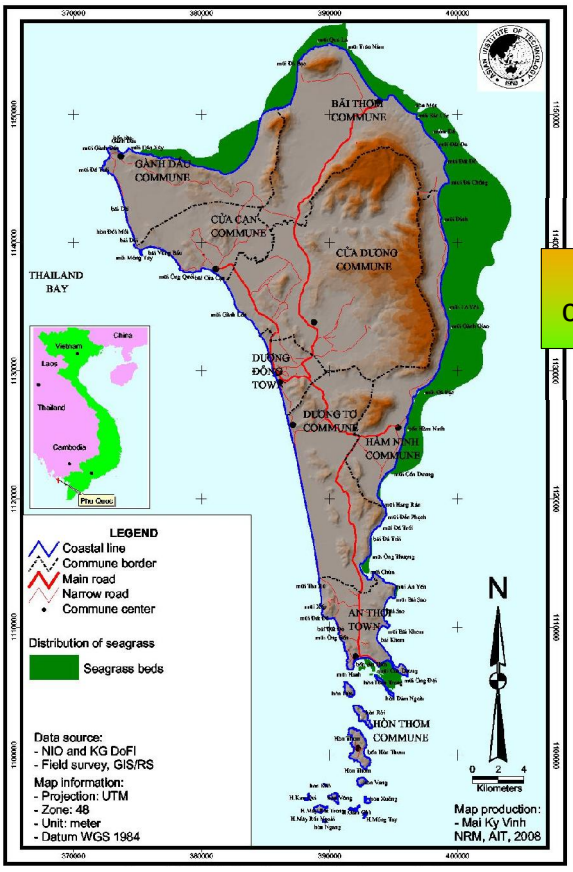

Figure 8. Distribution of seagrass

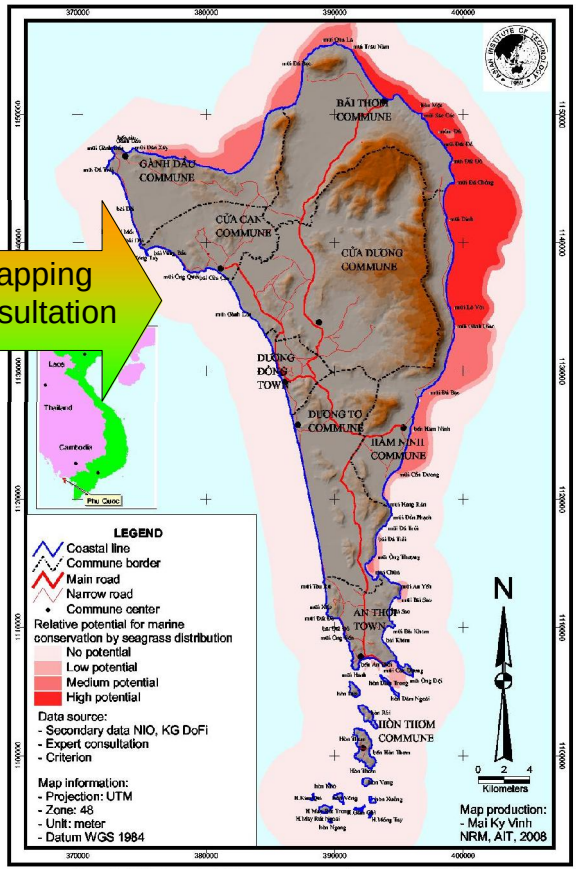

Figure 9. Potentials for marine conservation (criteria 2)

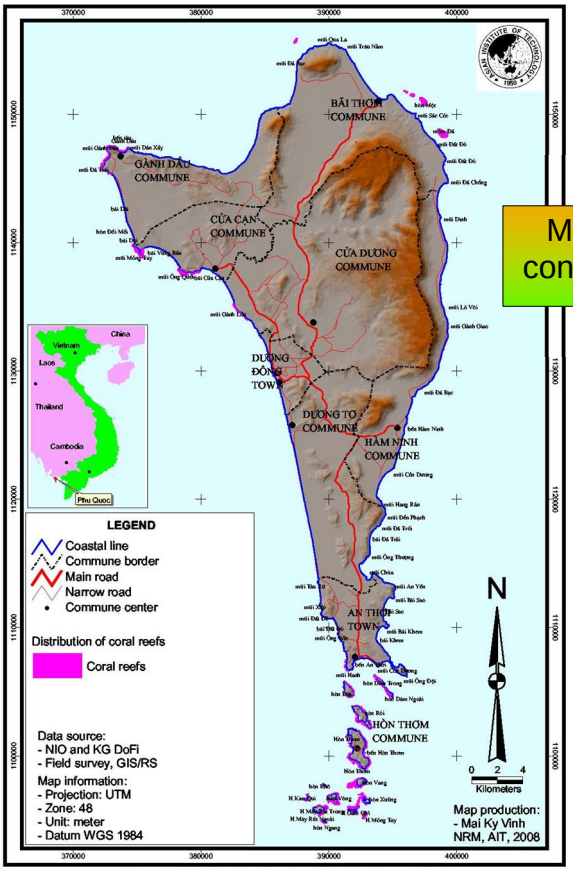

Figure 10. Distribution of coral reefs

Mapping consultation

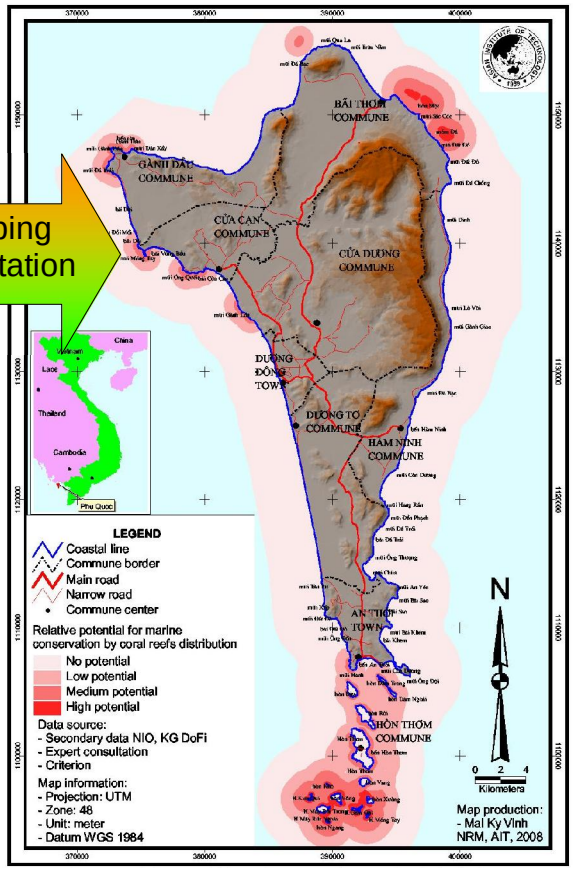

Figure 11. Potentials for marine conservation (criteria3)

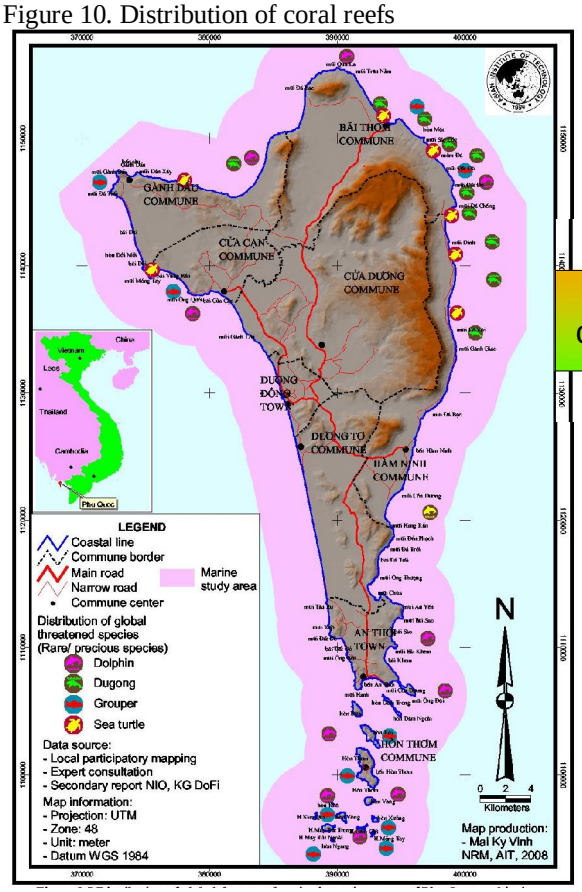

Figure 12. Distribution of rare species

Mapping consultation

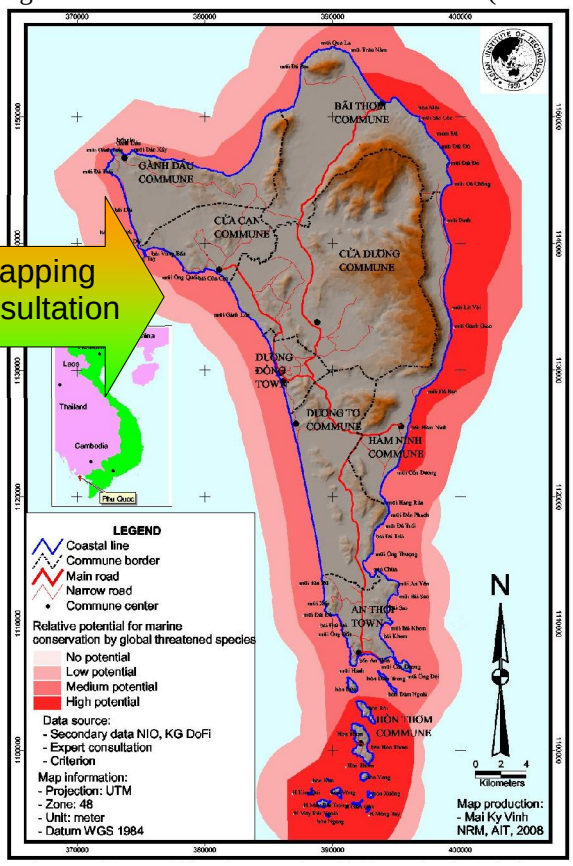

Figure 13. Potentials for marine conservation (criteria 4)

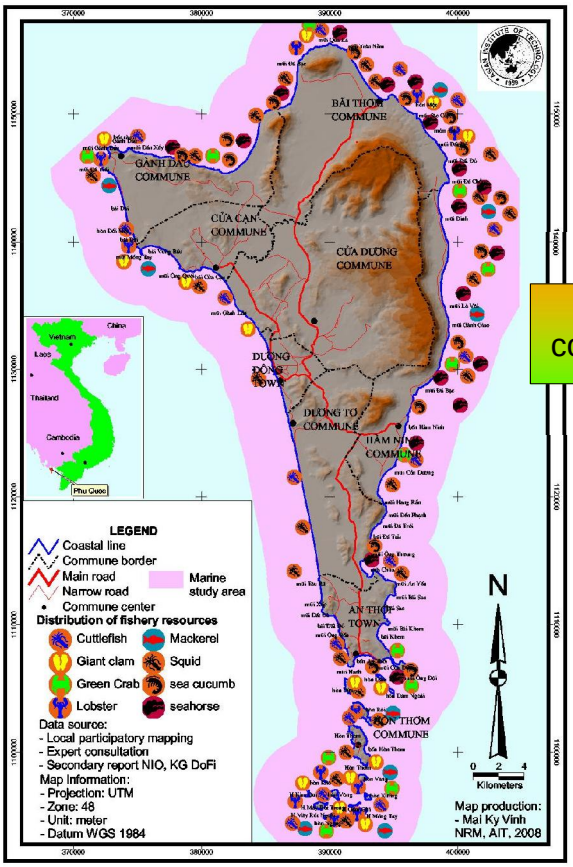

Figure 14. Distribution of main fisheries resources

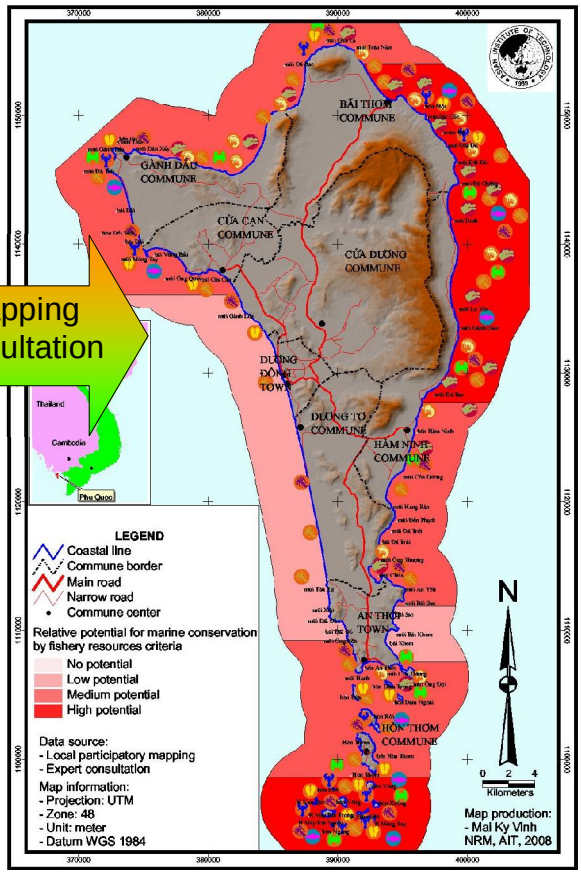

Figure 15. Potentials for marine conservation (criteria5)

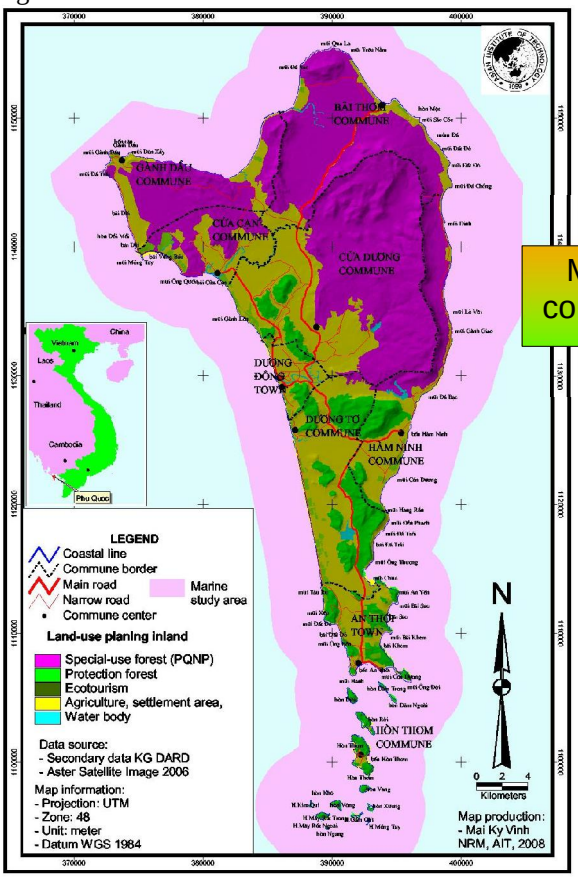

Figure 16. Terrestrial plan for Phu Quoc Island

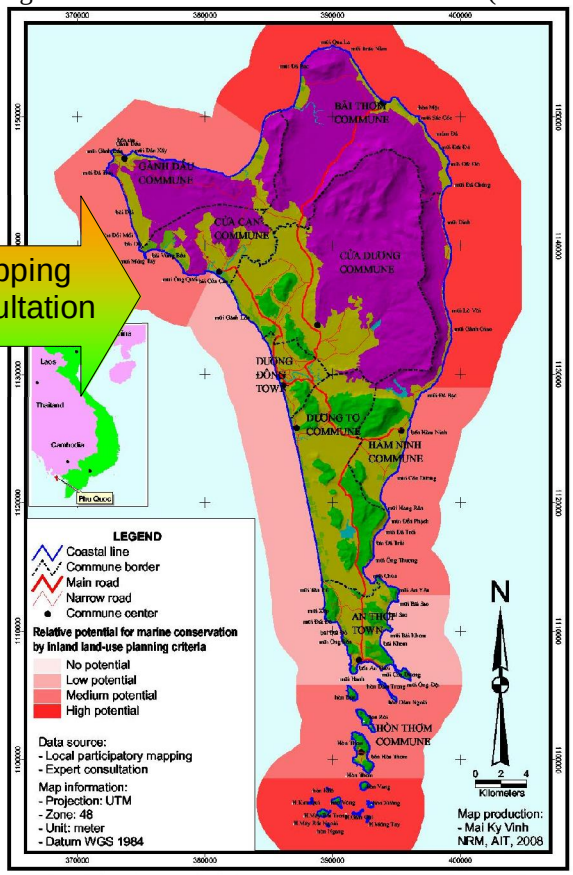

Figure 17. Potentials for marine conservation (criteria 6)

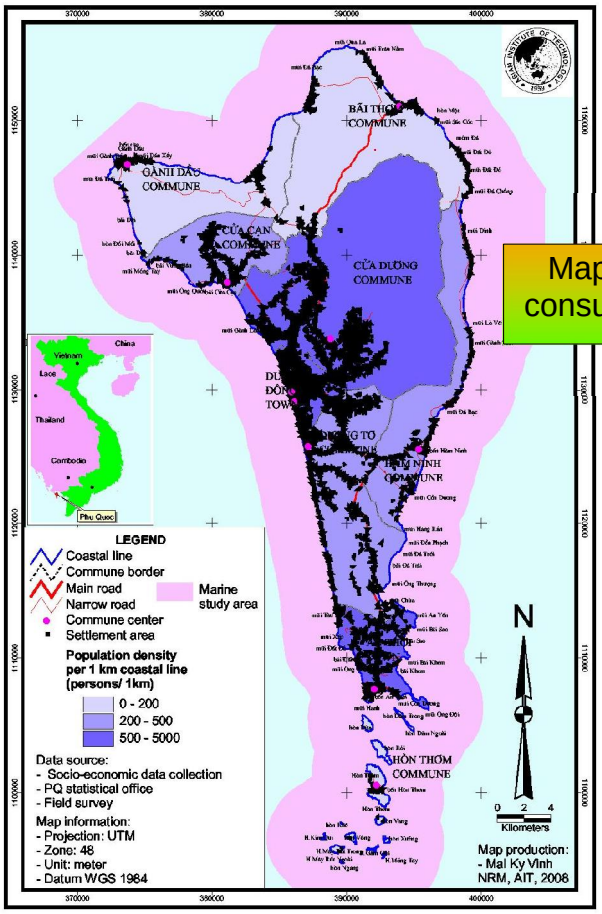

Figure 18. Socio-economic criteria

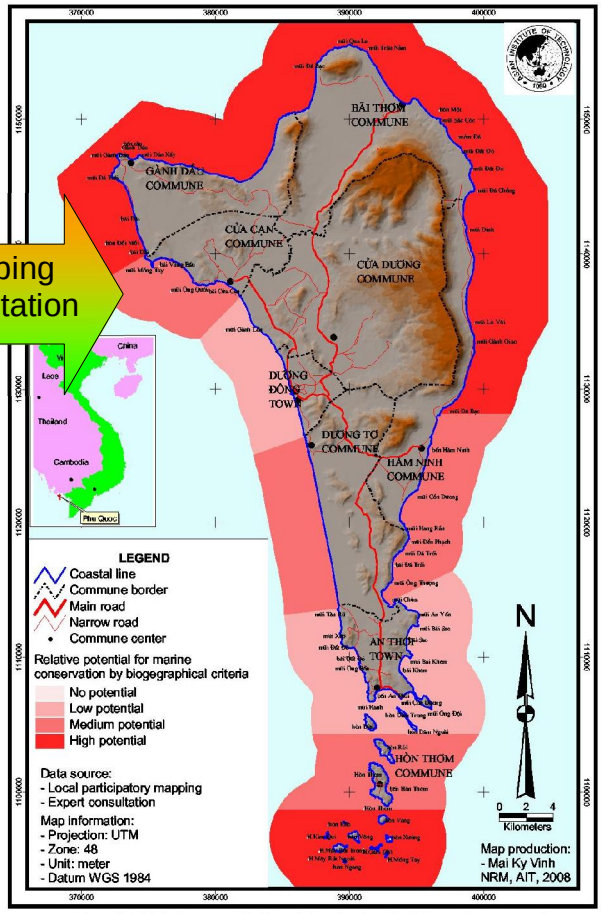

Figure19. Potentials for marine conservation (criteria7)

4 SELECTING AND ZONING FOR PHU QUOC MARINE PROTECTED AREA

4.1 MPA selecting and zoning

The region for GIS modeling was based on our objectives, scope of study area, discussions with PQ MPA, and KG DoFi. These areas include the whole Phu Quoc Island, group islands in southern An Thoi, and surrounding marine area. It includes only Vietnam terrestrial and marine territorial. The region, which has total area of 710.7 km^2, was used in the GIS overlaying and modeling to select the location of suitable management zones.

The criteria of design aspects include size and shape, location, position of boundaries, zoning, ecological representation, and links to other available MPAs. Added to these, it also considered in term of ease of management, for example, MPA is next to sources of threats as major fishing grounds or urban areas. Zoning is an important management tools for MPAs. First, zoning allows regions to be set aside for specific activities such as protection of main habitats or nursery areas, research, anchoring, fishing, tourism, and education. It also helps to mitigate or exclude the conflict between MPA users, to facilitate the compliance and to better the quality of activities, for example tourism. In general, a zoning scheme includes regions under severe protection and regions with less severe restrictions. They may include sub-zones, which can be modified on a seasonal or temporal basic, for example for boat access due to breeding cycle of organisms. The zoning category aims to provide the balance between conservation and development or use. In addition, this zoning category also is very simple because if it were not simple, it would be difficult to enforce due to distinguish the different zones by stakeholders.

The management plan includes zoning plan, and the plan should specify the borders of different zones and explain how each area can be used. The zoning plan may be part of the management plan or a separate document, and in some cases, the zone types are laid out in the MPA legislation. The

plan should identify the boundaries of the different zones and explain how each area can be used. The external boundary of the MPA is vital that zones are obviously marked once agreed and approved.

4.2 Weighting the criteria by rating and scoring

In order to identify the weights for each criterion, the rating method was applied. There were 20 persons (12 from KG province and 8 from different central offices) have been questioned about their idea about rating for seven criterions influencing to marine conservation potentials. The weight of each criterion is decided by rating or scoring criteria weights by allocating 100 points among criteria. The result of rating for criteria and statistical parameter is listed in table 2 as following.

Table 2. Statistical parameters of seven criteria

ID	Items	C1	C2	C3	C4	C5	C6	C7
	Standard Error	*0.88*	*1.08*	*0.93*	*0.94*	*0.63*	*0.97*	*1.20*
	Median	*10*	*20*	*20*	*15*	*10*	*10*	*12.5*
	Standard Deviation	*3.94*	*4.84*	*4.15*	*4.21*	*2.82*	*4.36*	*5.35*
	Confidence Level (95.0%)	*1.8*	*2.3*	*1.9*	*2.0*	*1.3*	*2.0*	*2.5*
Average weight (mean)		*9.5*	*20.0*	*20.1*	*15.0*	*10.8*	*11.4*	*13.4*

In other words, the equation showing the relationship between integrated marine conservation potentials (IMCP) and seven criteria as following:

IMCP = 10* C1 + 20* C2 + 20* C3 + 15* C4 + 11* C5 + 11* C6 +13* C7

Using the above equation to calculate the total score and the area by group. The map showing the total score is displayed in figure 20. Then this data were classified into classes and showed in figure 21.

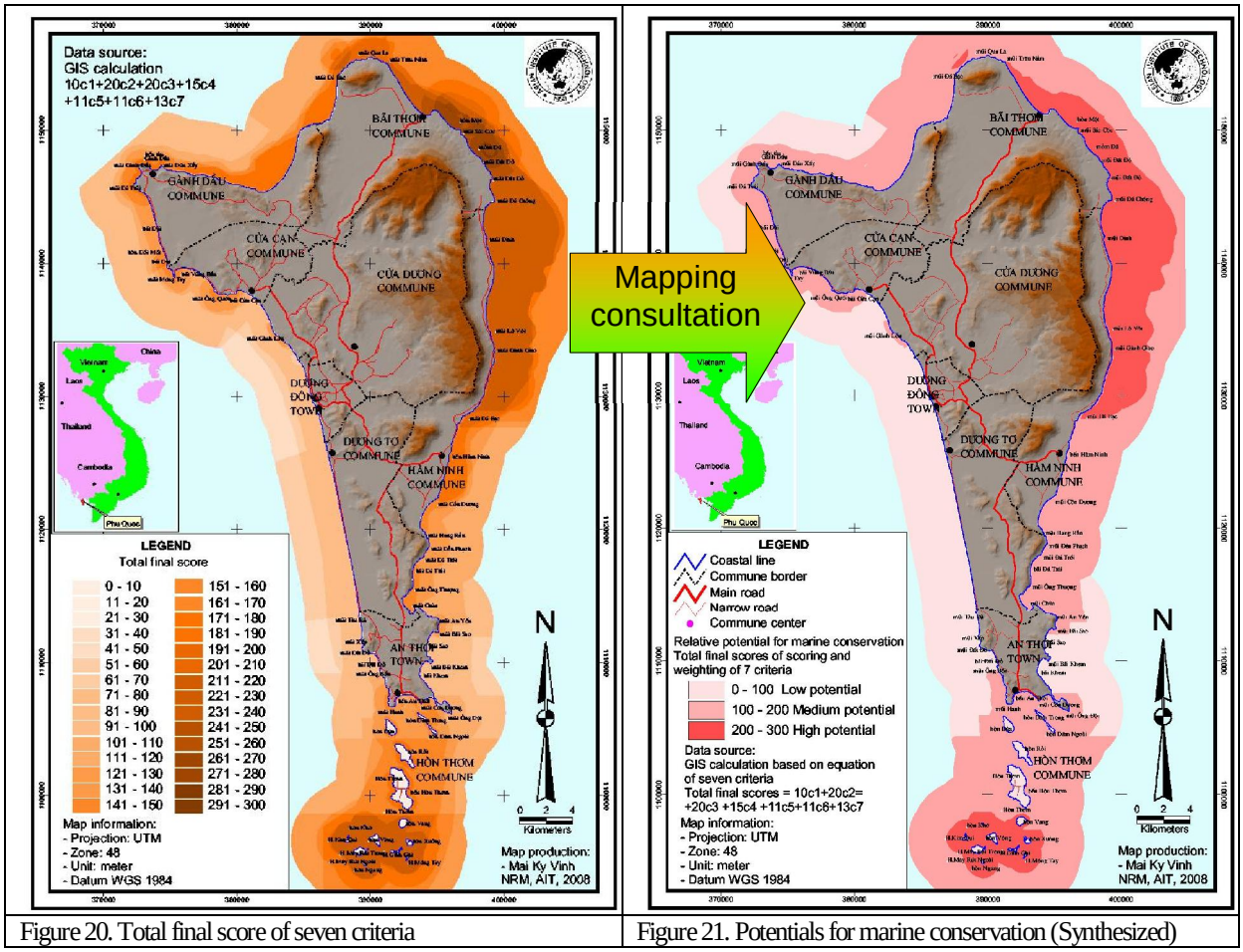

Figure 20. Total final score of seven criteria

Figure 21. Potentials for marine conservation (Synthesized)

4.3 PQMPA selecting and zoning

A training- seminar-workshop was organized in Kien Giang province in order to introduce the GIS database, especially the map showing total score of potential for marine conservation. The participants from KGDoFi, WWF, NIO and stakeholders discussed about PQMPA boundary proposal. All experts and participants also reviewed and revised the proposed PQMPA boundaries in the past by NIO, IMAR, RIMF. The PQMPA boundary proposed by KGDoFi is realizable. Firstly, the marine areas from Mui Trau Nam to Mui Da Bac was suitable for seagrass protection and was proposed as seagrass MPA. Then, the participants also highly supported the group of four islands in the south of Hon Thom as coral MPA. The selecting and zoning for terrestrial protected areas were delineated based on the biodiversity in combination with the administrative boundaries, river, stream, road or watershed boundaries. Because of difficulties in identification of location in marine water, the boundary of MPA is identified and delineated based on estimation of distance and place where can arrange the buoys.

In brief, based on the total score representing for relative marine conservation potential areas in combination with local consultation, expert consultation and available planning, PQMPA was proposed including two sites seagrass MPA in the northeast and coral MPA covering four islands in southern Hon Thom as in table 3

Table 3. Area of zoning area for PQMPA

MPA planning	Location	Area (ha)	Percent
Core zone – seagrass protection	Coastal Bai Thom, Bai Bon	2776.0	16.1
Rehabilitation zone – seagrass protection	Bai Thom to Mui Cay Sao	5416.5	31.5
Core zone – coral protection	Hon Gam Ghi, Hon Xuong, Hon Vong and Hon Mong Tay	760.7	4.4
Rehabilitation zone – coral protection	Hon Thom commune	8240.1	47.9
Total		17193.2	100.0

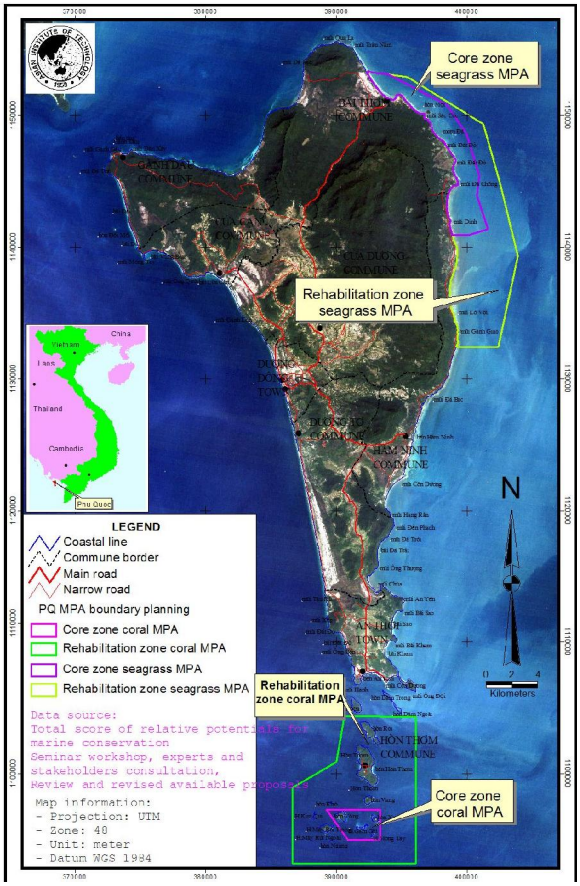

Figure 22. Potentials for marine conservation (Synthesized)

The PQMPA is located in marine water of four communes: Bai Thom, Ham Ninh, Hon Thom and An Thoi town. The map showing the PQMPA is presented in in the figure 22.

5 CONSERVATION PLANNING AND MANAGEMENT FOR PQMPA

5.1 Stakeholders analysis

In order to understand PQ MPA management and identify who the actors or stakeholders involve in MPA, Stakeholder analysis was conducted. It is important to identify these actors in

cooperation in marine conservation. Failure to identify these actors might cause non-cooperation, even strong opposition. Thus, it is excellent to get the involvement of local people especially local fishermen as an essential part of any project design and implementation. Stakeholder analysis is suitable in early stages of conservation planning.

The primary stakeholders are organizations or people affected by PQMPA. This includes beneficiaries (from tourists) or those negative impact people (for example, those accidental resettled). In general, the primary stakeholders are classified according to social analysis as they should be divided by gender, social or income classes, and occupational or service user groups. In PQ MPA, primary stakeholders are categorized into classes as following: farmer associations, youth unions, women's associations, village leaders, tour guides, teachers, fishermen.

The secondary stakeholders play the middle role in the process of supporting aid to primary stakeholders. They can be divided into funding, implementing, monitoring and advocacy organizations, or simply governmental, non-governmental organizations (NGOs) and private sector organizations. In many cases, it would also be necessary to consider key individuals as specific stakeholders (for example the heads of departments or other agencies, who have personal interests at stake as well as formal institutional objectives). It should also be noted that there may be some informal groups of people who act as intermediaries. In the PQ MPA, secondary stakeholders are categorized into the following classes: Ministry of Agriculture and Rural Development (MARD), Forest Protection Department (FPD), Kien Giang Provincial People's Committee, Phu Quoc District People Committee, PQ MPA Management Board, Commune People Committees, Tourism agencies and companies, Red Cross Association, Schools, Commune Clinics, and NGOs (DANIDA, World-wide Fund for Nature…)

In summary, the key stakeholders and their interest and likely impacts to PQMPA were identified. It was found that there are the positive impacts outweigh the negative impacts. The information was found would be useful in formulating a management framework for PQMPA.

5.2 Institutional assessment

- ***Institutional framework and management for protected areas in Vietnam***

The key informant interview showed that the management of protected area in Vietnam is complicated. Almost terrestrial protected areas are managed by MARD and FPD. The MONRE manages the wetland sites. Meanwhile, MPAs are managed by MoFI.

- ***Organization and mechanism of the PQ MPA Management Board***

The PQMPA Management Board was established in 2007. Currently, a total of 06 persons working at the MPA, including three members of the Director's Committee (one director and two vice directors), 1 administrative and finance staff, 2 researchers. PQMPA will recruit some staffs for tourism section. The figure 6.2 presents the organizational chart of PQMPA M

The PQMPA Management Board has the following functions and tasks

- Management and Protection of natural marine resources: Effective protection of the pristine characters of biodiversity and natural resources in the marine waters.
- Management and protection of natural landscape, natural ecosystems in marine as grass, corals and mangroves, and the rare and endangered species such as dugong, dolphin, sea turtle.

- ***Framework for management of zones***

In Vietnam, the rule and regulation for management zones for MPA have not been formally promulgated yet. In order to achieve the objectives of the zones in the marine component, activities would either be strictly prohibited or permitted according to the purposes of each zone. At the moment, the PQ MPA is divided into 2 zones basing on their functions. The activities proposed to be ban in core zones including: any fishing, aquaculture, establishment settlement areas, causing pollution, and bring alien species. It needs to have a itinerary to ban a number of fishing type and fishing season in rehabilitation zone.

5.3 Framework for the management of PQMPA

In order to develop a management framework for the PQ MPA, the management objectives were reviewed and the new one was added and then identifies the programmes or activities necessary to achieve these objectives. The new management objectives of PQMPA include:

- Management and protection of the wild characters of biodiversity and natural landscape, natural ecosystems in PQMPA both terrestrial and aquatic, fauna and flora mainly the rare and endangered species such as corals and seagrass.
- Organization and implementation of scientific research projects,
- Organization of tours and social marine and environmental education, and
- Improvement in the local participation in the development and implementation of management and protection activities in the PQ MPA.

At the first step, the existing management objectives of PQMPA were reviewed and one more objective was added. Based on the above discussed, and the problems/constraints in the management of PQMPA were identified. Thus, four programmes were designed for solving these problems (in short-term) and conservation and development of the biodiversity in the PQ MPA (in long-term), namely:

- Conservation and protection programme
- Scientific research programme
- Education and awareness programme
- Local community participation programme

5.4 Discussion

The objectives of this study were achieved and a model for MPA selecting and zoning based on potential conservation has been developed and implemented. The development of the model using a GIS framework proved successful and allowed the creation of a transparent and repeatable spatial modeling approach for zoning potential marine conservation value combining multi-criteria data.

As mentioned before, the modeling approach presented here includes opportunities to prioritize or demote certain factors depending on the desires and interests of decision-making groups. A further use to this methodology is that it allows decision makers to develop and compare scenarios for selecting and zoning MPA. The models decrease the difficulty of problem

In the future, PQMPA should implement the activities concerning buoys in order to identify the MPA border. In addition, it needs to have a regulation and enforcement for MPA.

In August 2007, Vietnamese government decided to integrate Ministry of Fisheries into the Ministry of Agriculture and Rural Development. Thus, KGDoFi will be integrated into KGDARD in the near future. This is an opportunity for integrated management between terrestrial and marine conservation by the cooperation between PQNP and PQMPA. It is ideally there would be one entity of PQNP including both terrestrial and marine components. Therefore, the seagrass protected areas could be managed much better by existing ranger stations in Bai Thom and Ham Ninh commune.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The research gained the objectives through the application of knowledge and lessons learned marine resource management, together with the use of advanced techniques such as RS/GIS/GPS analysis, field surveys, multi-criteria analysis, stakeholder analysis, and institutional assessment. In general, the study established a GIS dataset including basic layers and seven criteria relating marine conservation, selected PQMPA based on identification the high potential of marine conservation in combination with local consultation, expert consultation, and revision the available planning, and suggested conservation measures.

Firstly, this research has established a comprehensive GIS dataset for PQ MPA by applying GIS/RS/GPS, local participatory mapping, expert consultation and secondary data including many layers in same projection. This GIS dataset includes natural condition layers such as rivers, roads, administrative boundaries, seabed slope, topographical features, marine currents, biological production. In addition, the distribution of natural resources was also created, for example coral reefs, seagrass, rare species, fishery resources, forest and current land-use. Furthermore, socio-economic data as population, number of fishermen, number of fishing boats, and their density also integrated into administrative layers to generate the socio-economic layer. This research showed that GIS, RS and GPS are good tools for overlaying map layers, buffering areas, doing statistical calculation, updating the information and modeling the marine conservation option. Furthermore, it provides and supports an effective visualization, then can be easily understood and modified later on. Besides, it is useful in combination with local knowledge and common sense during planning process. In fact, this database has been practical and useful for PQMPA

Secondly, the study designed the PQMPA boundary and its zoning based on finding out the high potential areas for marine conservation. Based on the discovery of high potential areas for marine conservation in combination with local consultation, expert consultation and available planning, two sites were proposed for marine conservation. The research discovered seven criteria involving marine conservation potential as c1: biogeographical criteria; c2: seagrass; c3: coral reefs; c4: rare species; c5: fishery resources; c6: terrestrial planning and c7: socio-economic criteria. Multi-criteria analysis and land suitability evaluation were applied to find out high potential areas for marine conservation. Finally, an equation has been established showing the relationship between integrated marine conservation potentials. The study also found that the weighs for seagrass and coral reefs criteria is higher than the rest criteria.

Lastly, this research also proposed the conservation measures by the socio-economic analysis, institutional analysis, and stakeholder analysis. It identified the key actors who play important roles in MPA management in order to increase the involvement of local people in MPA management.

6.2 Recommendations

The study showed that GIS/RS/GPS aided marine conservation meaningful. However, in order to apply MPA work, it needs to improve the capacity of local staffs on using GIS by implementing short training course. Hence, Ministry of Agriculture and Rural Development and KG DARD should have a priority on GIS/RS education and training for local staffs, particular for MPA technical staffs. In addition, the technical assistance should be supplied annually. That would be the opportunity for local staffs sharing and exchanging the experiences.

The list of criteria involving in marine conservation potential could be reviewed and revised carefully with the input from national and international participants in different branches. Then, these criteria would be established in GIS and classified into classes of relative potential for marine conservation. Next, the equation corresponding between integrating marine conservation potential and criteria would be created based on rating or scoring criteria weights by allocating 100 points among criteria. Each equation could be applied only for a particular MPA, not for whole country due to the different criteria and different weights of criteria. Furthermore, the model is flexible in case we can add some more criteria and identify again the weights by ranking and rating.

Local participatory mapping is powerful tool in combination of local knowledge with GIS/GPS/RS. The satellite data brings the overview of study area. Meanwhile, local people could supply precious information of location of rare species and the distribution of marine habitat. Through local participatory mapping activities, the awareness of local people in marine conservation has improved to a new level.

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