DETECTION OF SUBMERGED SEAGRASS BEDS AND CORAL REEF BY GEO-EYE SATELLITE IMGAES

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By

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DECLARATION OF THE SUPERVISORS

We certify that the above statement made by the candidate is true and this thesis is suitable for submission to the University for the purpose of evaluation.

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Detection of submerged seagrass beds and coral reef by Geo-Eye satellite images

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ABSTRACT

Capability of Geo-Eye satellite image with 0.5 meter spatial resolution to detect seagrass and coral reef ecosystem in Palk Bay has been evaluated. Extent and distribution pattern of the seagrass beds and coral reef can yield valuable information to study associated habitats and facilitate to monitoring and management of the marine environment as the dwindling of coastal resources is of great concern presently in globally.

Effects of image pre-processing methods of atmospheric and water column correction were examined in order to increase the accuracy of the analysis. It was revealed that accuracy of the analysis can be increased up to 5% by the atmospheric corrected image while it takes 15% for the water column corrected image. Advantages of two different classification methods were investigated and found that object orient classification method attains high accuracy than pixel based classification method. Accuracy assessment was carried out by creating an error matrix using the ground truthed data. The overall accuracy of the analysis achieved about 80%. The studied area encompasses a number of scattered seagrass patches and densely populated meadows over shallow areas. Fringing coral reefs are located mainly around islands. The analysis shows that area about 508km^2 is covered by seagrass and 27km^2 by coral reefs. As a percentage seagrass cover achieved 23% and 1.2% for coral reef distribution.

Key Words; Geo-Eye image, Image pre-processing, Seagrass and Coral reef ecosystems

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CHAPTER 1

1. Introduction

1.1 Seagrass and Coral reef ecosystem

Lagoons and estuaries, mangroves, intertidal habitats, seagrass and coral reef are the coastal ecosystems, which are interacted each other by providing biological and physical support to stabilize the coastal environment. Lagoons which form between barrier reef and mainland are allowed to grow mangroves and seagrasses. The Mangrove ecosystem traps the sediment and filter nutrition from the inland runoff before reaching the seagrass ecosystem. Seagrass further improve water quality by trapping sediment and nutrients before discharge into coral reef ecosystem. Reefs act as a buffer to dissipate wave energy before reaching seagrass beds and mangrove habitats thereby maintaining the integrity of the coastline.

Seagrass is the only flowering plant which can grow in underwater. It is a rooted plant and seed bearing which form meadows on the sea beds in coastal waters. Coral reefs are community of living organisms which is made up of plants, fish, and many other creatures. Some of the reefs reach the ocean surface, while others are submerged. These ecosystems mainly spread in shallow coastal sea, estuaries, lagoons and bays due to the ability of light penetration for photosynthesis. Seagrass meadows and coral reef ecosystem function as shelters and breeding grounds for other species like microorganisms, algae, invertebrates and vertebrates. Coral reefs are solid as they are formed by the hard part of the animal skeletons. Coral reefs provide hydrodynamic environment serving as barriers to wave action and controlling sedimentation.

Similarly seagrass and coral reef ecosystems are provided significant economic goods and services to the livelihoods and food security of the fisher community living along the coastal areas. In Sri Lanka coastal tourism mostly depend on the coral reef by providing recreational opportunities including Scuba diving, snorkeling and glass bottom boat

viewing, which contributes about Rs20.0 million per year to the national economy of Sri Lanka (Berg, et al., 1998).

Coral reefs are generally can be found within tropical and subtropical waters where the temperature is always above 18°C in winter. The largest and great variety of coral species are occurred in the Indo-Pacific region. Corals can be found from the water surface to depth of 6000m, but reef building corals are generally found at depth less than 46m where sunlight can penetrate (Boulay, et al., 2013). Over 1500 species of reef building corals have been identified all over the world and 1400 species are occurred in Indian and Pacific oceans (Veron, 2000). Sufficient light, nutrients, inorganic carbon, suitable substratum, moderate exposure and temperature are the basic requirements for seagrass grow and distribution. Mostly they grow in shallow waters and growing depth depends on the availability of light for photosynthesis. There are 12 genera of rooted marine angiosperm with 49 species widely distributed in the world. Seven of the genera are more or less confined to tropical waters (Abewickrema and Arulagnanam, 1991).

Wide distribution of seagrass and coral reef habitats can be found around Sri Lanka as she is endowed with many shallow coastal water bodies including lagoons, estuaries, bays. It is reported that 15 species Out of 49 species of seagrasses belonging to nine genera can be found from Sri Lankan waters (DeSilva, 2007). Seagrass ecosystem can be found extensively from the lagoons and estuaries such as Puttalam, Negombo, Mawella, Koggala, Kokilai, Jaffna and Batticaloa (CRMP, 2002). Very extensive seagrass beds are reported from the Dutch Bay in Kalpitiya to the western end of the Jaffna Peninsula, and from Mannar to the northwest across the Palk Bay to Rameswaram Island on the Indian coast (Samarakoon and Pinto, 1988). The seagrass beds in the Palk Bay and Gulf of Mannr area are the main habitat of the endangered dugong (*Dugong dugong*) (BOBLME, National Report Sri Lanka).

Reefs in Sri Lanka are categorized as coral reefs, sandstone reefs and rocky reefs. The most extensive coral reefs in Sri Lanka are the patchy coral reefs in the northwestern coastal and offshore waters, occurring within the Gulf of Mannar and west of the Kalpitiya Peninsula

(Rajasuriya and White, 1995). Northern coast contains fringing coral reefs adjacent to the shore, growing from the sea floor usually on a nucleus of rock mainly around the small coastal islets (Rajasuriya and Premaratne, 2000). It has been estimated that about 2% of the coastline contains fringing coral reefs (Swan, 1983). Total 183 coral species belongs to 68 genera are recorded from Sri Lanka (Rajasuriya, 2000).

However Seagrass and coral reef ecosystems are in a threat in worldwide presently, due to the unplanned coastal developments, high population density in the coastal area, overfishing, pollution, destructive fishing methods and discharge of seawage. Large scale commercial trawling, beach seining, push nets and drift netting over the seagrass beds can be found from Puttalam, Negombo, Chilaw estuaries and Jaffna areas. Anchor damage to coral reefs is also common during fishing operations and when boats are anchored within reef lagoons. Natural phenomenon such as, global warming, sand accumulation are affected for the seagrass and coral reefs growth as well. Erosion of south and west coasts directly impact to the coral damage. It has been estimated that average of the erosion of above coasts is about 40cm per year (Berg, et al., 1998). The tsunami wave in 2004 also was significantly impacted on coastal habitats. Coastal seagrass communities and coral reefs ecosystem affected due to large volumes of sand and marine sludge being transported and deposited by the tsunami waters (Bambaradeniya, 2005 ; Jayawardane, 2005).

Seagrass meadows and coral reef ecosystems in shallow waters therefore are essential to protect and manage in sustainable manner. Number of international laws is functioning to protect coral reefs and seagrass ecosystems, such as Earth Summit in 1992 under the chapter 17 of Agenda 21, International Coral Reef Initiative (ICRI), created in 1994, The World Natural Heritage Convention, discussed in chapter 15, UNESCO Biosphere program in 1993. Likewise, there are several legislations to protect coral reef in Sri Lanka and number of initiatives had taken to protect these ecosystems, such as, Ambalangoda and Hikkaduwa Rocky Islets declared as sanctuaries by Gazette No. 8675 of 25th October 1940, Naval Head works in Trincomalee and the Great and Little Sober Islands within the Trincomalee harbor were declared in 1963, In 1973 the Paraitivu Island west of the Jaffna Peninsula, In 1974 the Pigeon Islands north of Trincomalee declared as a sanctuaries,

Hikkaduwa and Bar Reef marine sanctuaries were declared in 1979 and 1992 respectively under the section 2(2) of the Fauna and Flora Protection Ordinance.

However an inter-ministerial committee on marine parks and sanctuaries formed under the National Aquatic Resources Agency (NARA) in 1982 had identified 20 locations around the coast to be declared as marine parks and sanctuaries, but only declared Bar Reef and Hikkaduwa marine sanctuary among them. Polhena reef, Great and Little Basses reef, Passekudha and Kalkuda Bay, Unawatuna Coral reef and adjacent area, Reefs within the Galle Bay, Weligama bay, Thennadi bay, Vandaloos bay and Elephant point are some of recommended locations by NARA to be declared as marine parks.

Several government organizations in Sri Lanka are responsible for manage and conserve coral reef and seagrass ecosystems, which are National Aquatic Resources Research and Development Agency (NARA), Coast Conservation Department, Central Environment Authority, Department of Wildlife, Department of Fisheries and Marine Pollution Prevention authority. They have given authority to enforce low by the acts of Fauna and Flora Protection Act, the Coastal Conservation Act, the Marine Pollution Prevention Act and the Fisheries and Aquatic Resources Act.

1.2 Remote Sensing for underwater habitat mapping

Remote sensing is the most important tool among the enhanced technology presently available for underwater habitats mapping. Satellite based sensors are capable to provide wide spectrum of information available through the electromagnetic spectrum. Shallow coastal ecosystems with clear water can be monitored due to the good light penetration. Marine applications via remote sensing have therefore been increased in recent years due to their synoptic perspective. Aerial photography, airborne digital scanning systems, satellite-based remote sensing are potential and effective in seagrass and coral reef mapping as well as long term monitoring. Seagrass and coral reef distribution can be quantified through remote sensing and monitor changes over time period. Further it provides spatially comprehensive and inclusive representation of spatial distribution than point or transects based surveys. Therefore different methods in remote sensing can be applied for seagrass

and coral reef identification in difference ways and methods depend on the output requirements and site conditions.

2. Rationale

As Sri Lanka is surrounded by precious ocean resources including bays and lagoons, more attention should be provided to tap the ocean resources which are valuable segments to a country's development. On the other hand a large portion of the population in Sri Lanka depends on the marine resources. Population density along the coastal area is much higher than national average ranging between 487 and 2600 per square kilometer, it takes 230 person in the inland (SIDA, 1993). Land resources are also limited due to the rapid increasement of population further to inland. Therefore it is promised by the government Sri Lanka to take necessary measures to tap the vast potential of the ocean resources under the "Mahinda Chinthnaya". In this context the first step should be the preparation of integrated ocean development strategy and cross-cutting marine affairs management structure. Resource survey is one of the main requirements at this milieu. Identification and estimation of marine resources like seagrass beds and coral reef will be vital step under this process.

Therefore, mapping of seagrass beds and coral reef yields valuable information to study associated habitats and facilitate to formulate environmental monitoring and management of the marine environment. Thus, accurate information on seagrass distribution is vital to managing seagrass resources. Decision makers including coastal managers need maps containing information on the characteristics of seagrass resources and coral reef such as where these species occur and in what proportions and quantities. Therefore seagrass and coral reef distribution, abundance, and diversity can aid in decisions and guidelines for coastal zone management. Further spatial distribution and estimation can be created as information for planning, monitoring, protecting and decision making on the public policy regarding the development and preservation of the marine environment.

Several studies have been undertaken in the world to identify the spatial and species distribution of sea grass by remote sensing technology. But only few such studies could be found in national level. Thus, this study is attempted to fill this deficiency for the long term planning of the marine resources. Moreover seagrass and coral reef mapping via transect based survey required more times and human resources. But mapping with satellite imageries takes less time and it can easily identify the change detection over period. Subsequently the study area is relatively shallow hence remote sensing application can be applied easily due to the good light penetration to the sea bottom.

Shallow coastal area of the Palk Strait has been selected as the study area, which lays between Tamil Nadu state of India and Northern Province of Sri Lanka.

3. Objectives

Main objective of the study is to assess the ability of high resolution multispectral satellite images combine with field data for the extraction of underwater habitats.

Other specific objectives to achieve the main objectives are,

- Mapping the spatial distribution of seagrass meadows and coral reef with the view of identifying the long term management of the marine environment.
- Estimate the quantity of seagrass and coral reef ecosystems in the Palk Bay.
- Compare different classification methods for sea grass and coral reef mapping

4. Research Questions

Mainly there are two questions are going to be evaluated by this study, which are,

- What proportion seagrass beds and coral reef are occurring in the Palk Bay?
- Can image pre-processing methods, such as atmospheric and water column correction increase the accuracy of the analysis?
- What is the most accurate classification method for underwater habitat mapping?