ENVIRONMENT VULNERABILITY DECISION TECHNOLOGY (EVDT)

Mangrove Management

Climate change adversely impacts the coastlines of many countries. Satellite technology and remote sensing modeling can help us understand the climate change phenomena and predict, prepare and defend ourselves against future disasters

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Remotely Earth Observation: EVDT Approach

The transformation in Remote Sensing and Earth in the last decade has undergone rapid development. Remote sensing and Earth Observation are two different fields but have similarities and complement each other.

Remote sensing is a remote observation from a platform that is far from the object being observed with various levels of observations of satellite data, aerial data, and ground-based observations (e.g., geophysical equipment) from altitude [1]. Meanwhile, Earth Observation is a collection of information about physical, biological, and related data about the planet. Earth Observation based on satellite technology is relevant to providing information that is important for the health of the coastal regions, especially for archipelagic nations like Indonesia. The technology included satellite earth observation, satellite positioning and navigation, human space flight and microgravity research, satellite communication, space technology transfer, and research infrastructure.

Various new observation platforms are available to help scientists and researchers to process data, one of which is Environment-Vulnerability-Decision Technology (EVDT). Environment-Vulnerability-Decision Technology (EVDT) is a multi-disciplinary, integrated modeling framework to improve environmental management, policymaking, and observation platform design. The framework guides the creation of an integrated model customized for each application with a specific set of stakeholders and designed using systems architecture.

The Environment-Vulnerability-Decision-Technology (EVDT) Modeling Framework will integrate four models into one tool that can be adapted to specific applications. The four models address the following: Earth Science Models of the Environment; Human Vulnerability and Societal Impact; Human Behavior and Decision-Making; and Technology Design for Earth Observation Systems including satellites, airborne platforms and *in-situ* sensors. The capabilities provided by this framework will improve the management of earth observation and socioeconomic data in a format usable by non-experts while harnessing cloud computing, machine learning, economic analysis, complex systems modeling, and model-based systems engineering [2].

The environment model uses earth science methods to estimate the state of environmental phenomena as follows:

1. The vulnerability model captures the societal impact of environmental changes, including ecosystem services.
2. The decision model captures human behaviors and policy consequences.
3. The technology model provides tools to design earth observation systems or select earth observation technologies such as satellites, airborne sensors, and in-situ sensors.

Adopted EVDT framework can give more benefit to national governments for sustainable development using future space technology. The EVDT framework has been applied to policymaking in Pekalongan, Central Java, Indonesia. The study included measuring the coastal environmental health, planting mangroves to stabilize the coast for coastal resiliency, improving biodiversity in the mangrove areas, and informing the policymakers. The satellite data are used to estimate flooding and then submit a proposal to the policymaker to prevent flooding or protect an area from flooding.

Besides being used in Indonesia, the use of EVDT is also used in Rio de Janeiro, Brazil. Researchers already demonstrated the tools in the viability of the framework case study of the mangrove forests in the Guaratiba area. These mangroves are vulnerable due to urbanization and rising sea levels. They provide a variety of ecosystem services, including serving as a mechanism for carbon sequestration, supporting subsistence fishing, preventing coastal erosion, and attracting an ecotourism industry. The case study of mangrove and community health in Rio de Janeiro demonstrates all four model components [2].

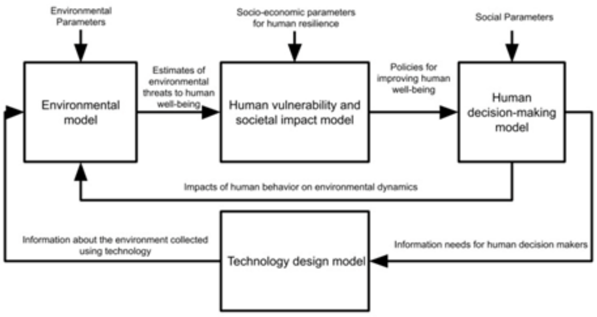

Figure 1. The baseline version of the environment-vulnerability-decision-technology model
(Source: Reid & Wood 2020)

Mangrove Management and Remote Technology

The Environment Model on a study of mangrove and community health in Rio de Janeiro was built upon work by biospheric scientists Fatoyinbo and Lagomasino. They used earth observation data, cloud computing, and machine learning to track mangrove extent, health, and vulnerability overtime for a 600 km^2 area, as well as work by the ESPAÇO research group at the Federal University of Rio de Janeiro on the local mangrove ecosystem [2].

Figure 2. The mangrove conservation area in Serang City area, Banten Indonesia
(Source: Rosita & Darwati, SEAMEO BIOTROP, taken on 14 November 2021)

In Indonesia, the effects of pollutants and environmental damage in urban areas will impact mangrove management,

Figure 3. Mangroves trap and cycle pollutants, chemical elements and sediments
(Source: https://www.lewisaqui.com/the-importance-of-preservation-and-protection-of-mangroves-in-the-landscape/)

so it is necessary to synchronize the problems in urban areas with mangrove management forests. Mangroves that grow at the end of large rivers act as the last reservoir for waste from industry in urban and upstream villages carried away by river flows. Mangrove forest areas can accumulate heavy metals in the ecosystem where they grow. Mangroves can act as a biofilter for air pollution. The ecological balance of the beach's aquatic environment will be maintained if mangroves are maintained because mangroves can function as a biofilter, binding agent, and pollution trap. Several studies have confirmed that mangroves have a high tolerance for heavy metals [3, 4].

Mangroves tend to accumulate heavy metals found in living plants' ecosystems [5]. The mangrove system cannot stand alone but is related to other ecosystems. Linkages between ecosystems form a more extensive system, namely watershed. The heavy metal accumulation ability is different for each species [6]. Furthermore, mangrove plants accumulate metals [6]. The largest metallic weight is found in the roots. However, other factors such as mobility and metal solubility also affect the accumulation of heavy metals in plants. Based on their mobility and solubility, the ability of plants to accumulate heavy metals according to order is as follows Mn > Cr > Cu > Cd > Pb [7]. Mangroves are good hyperaccumulators. Mangroves do not only grow on soil with a high concentration of toxic elements, but they also collect/accumulate these elements in stems and leaves in large quantities that may even be higher and lethal to other living organisms [8].

Mangrove forests are also among the most rapidly disappearing ecosystems in the world. A significant cause of global mangrove destruction is the development of shrimp ponds, rice, and oil palm plantation. Without the mangroves protecting the coastal areas, more people, more land and more property damages or loss are expected. Mangroves are one of the vital coastal resources capable of delivering exceptional ecosystem services. Among the many mangroves services are sediment accumulation, storm surge protection, carbon sequestration, and climate change mitigation/adaptation in vulnerable coastal areas. Mangroves are ecologically and economically important in enriching coastal biodiversity, supporting fisheries, yielding commercial forest products, and protecting coastlines from the fierce effects of cyclones, floods, waves, and other natural calamities. Mangroves are also known as "oceanic rain forest", "tidal forest", "roots of the sea", "Blue Carbon Forests" and "coastal woodlands" [9, 10].

Future Research Innovation Connectivity

Geospatial information is needed to support policy formulation, decision making, and implementation of activities related to terrestrial space. Geospatial information can be provided through terrestrial survey results and or remote sensing interpretation results. Terrestrial survey results can be pretty detailed and have high accuracy. Indonesian territory has 16,671 islands with a land area of 1,900,000 km^2. Therefore, terrestrial surveys will be expensive and take a long time, and it will be challenging to map dynamic land object changes. The remote sensing interpretation method is expected to overcome the problem of providing geospatial information quickly in Indonesia [11].

Indonesia's challenge regarding remote sensing and earth observation research is that remote sensing satellites in Indonesia are still not optimal and it still depends on satellites belonging to other countries such as Sentinel, Terra, Landsat, Spot, and others. To answer this challenge, a research collaboration between research institutions needs to be improved in addressing problems such as decreasing soil fertility, environmental pollution, wide yield gaps, greenhouse gas emissions, increasingly uncertain weather due to climate change, increasing intensity of pest and disease attacks, and the inefficient use of land. Effective and efficient land management and monitoring can produce recommendations to overcome these problems. We need remote sensing data with human assistance to analyze and validate data in the field.

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