MARINE AND COASTAL MONITORING: NANOSATELLITES TECHNOLOGY

Research on nanosatellite technology needs to be developed on a large scale toward space technology research. The system utilizing satellite-based space technology is suitable to tackle the constraints on the geographical range and structure of the Indonesian Archipelago in facing global climate-change

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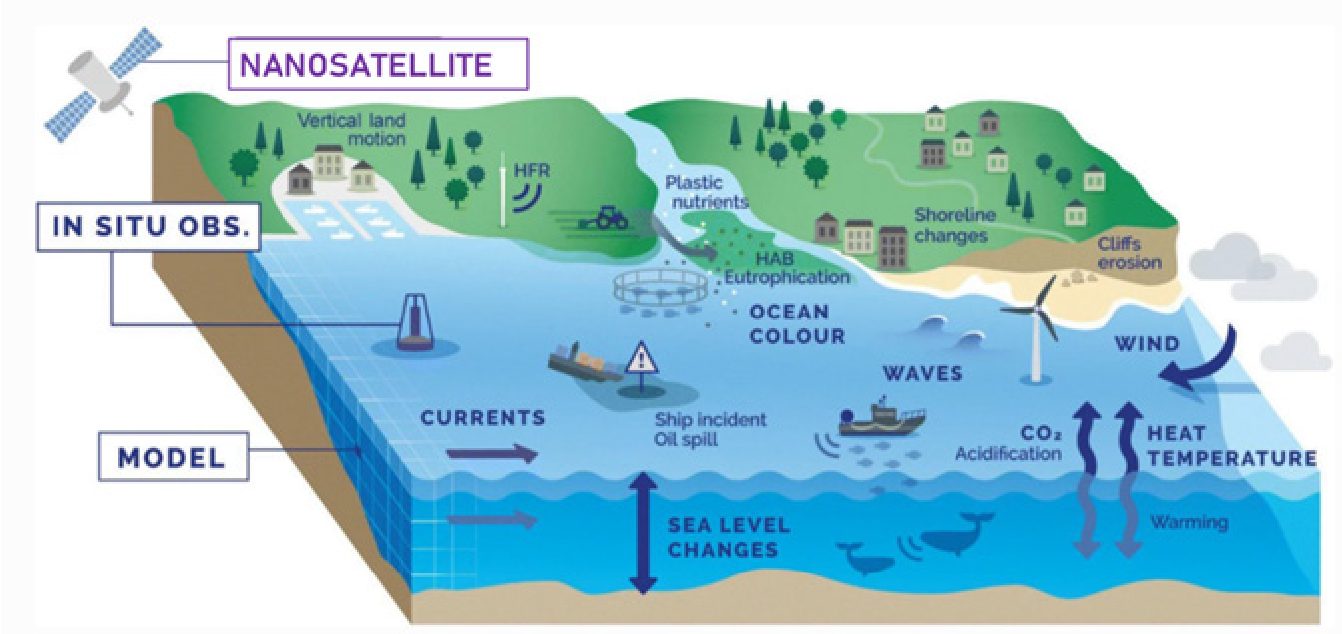

Figure 1. Nanosatellite technology as an instrument for global climate change monitoring (Source: Mellet *et al*. 2020)

NANO SATELLITE TECHNOLOGY:
A Monitoring Tool for Marine and Coastal

Marine and coastal areas have large social, economic and environmental values. Those areas are densely populated, have critical infrastructures as economic assets, and center of human activities for tourism, fisheries and navigation. Coastal areas are also very productive ecosystems in terms of marine resources. Currently, coastal zones are exposed to various natural and anthropogenic hazards. Earth observations using remote sensing satellites, provide invaluable information to reduce the risks associated with marine hazards, sustain coastal zone monitoring programs and support forecasting and early warning systems [1].

Remote sensing technology is widely used as an effective tool in disaster risk management. Disaster risk managers or experts need to monitor the environmental situation, simulate complicated disaster occurrences as accurately as possible to develop better prediction models, suggest appropriate contingency plans and prepare spatial databases using remote sensing data. The remote sensing data can be used very effectively to immediately assess the severity of impact damage due to earthquakes, landslides, flooding, forest fires, cyclones, and other disasters. Nanosatellites for marine coastal monitoring are used for earth observation/remote sensing; disaster mitigation and climate change; ocean weather, aerosol and air quality; marine debris and pollution; surveillance; and for ocean mapping, trophic state and habitat.

The development of satellite technology is currently increasingly advanced. The trend shows that in the last decade the production of satellites has led to the technology of small-sized satellites (micro and nanosatellites). A nanosatellite is a satellite having a mass of 1 to 10 kg, with a standard cubesat that lasts for 10 years. The most popular nanosatellite size is 3U dimension which is 30 cm high, 10 cm wide and 10 cm long. The nanosatellite is becoming popular due to its shorter development time, more affordable price, highly available COTS components, low latency because of low orbit, and less battery power for communication. Nanosatellites were developed for space research and for the development of satellite technology at a lower cost compared to conventional satellites. The cost of launching a nanosatellite is cheaper because a nanosatellite is launched by using a piggyback method or riding a rocket or satellite launched using the Poly-Pico Satellite Orbital Deployer (P-POD). One rocket can carry 1-3 nanosatellites to be launched into LEO orbit [2].

Since 1766, nanosatellites had already been launched in 76 countries, worldwide. Some 541 companies participated. In Southeast Asia, some countries also develop and launch similar programs. Singapore launched 7 programs, Thailand 5, Malaysia 2, Philippines 2 and Vietnam 2. And as forecasted, over 2,500 nanosats will be launched within the next 6 years (www.nanosat.eu).

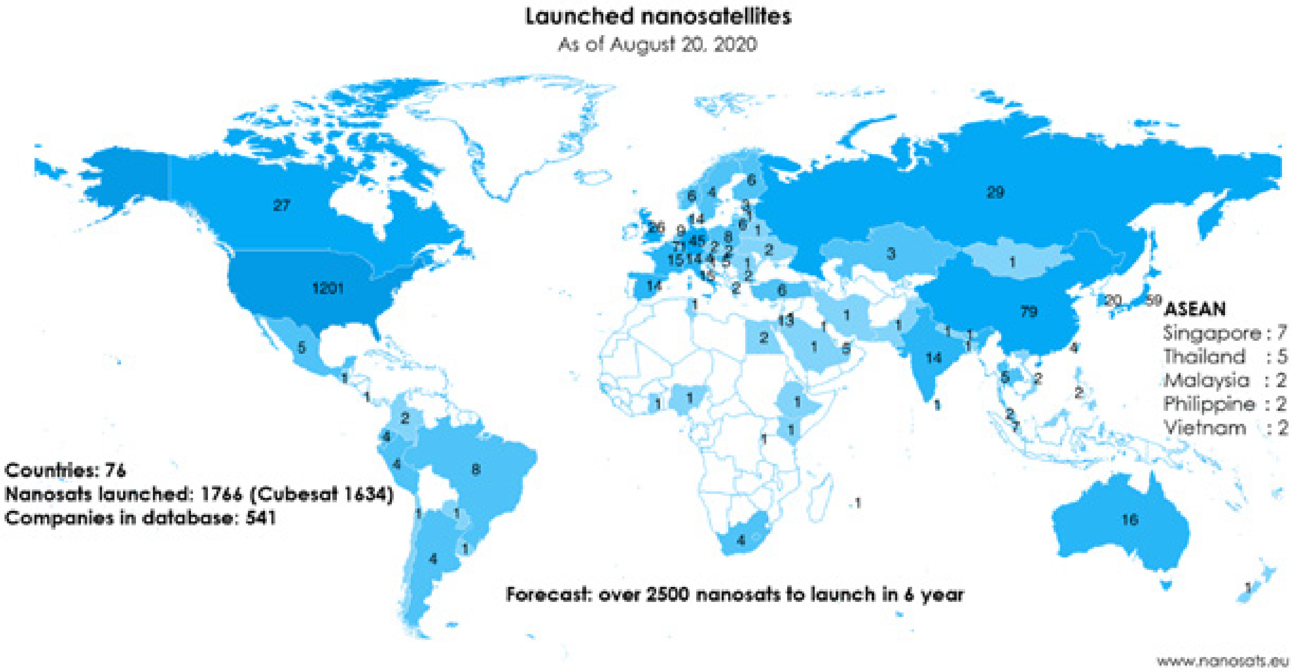

Figure 2. Launched nanosatellites as of 20 August 2020
(Source: www.nanosats.eu)

Almost all nanosatellites use passive satellite sensors. Now, some nanosatellites equipped with Radar and Lidar technology are developed by NASA and Georgia Institute in the USA.

Nanosatellite technology is already approved and implemented as an instrument for global climate change monitoring. In 2018, SEAHAWK was launched for ocean color monitoring. PLANETSCOPE, from France, is used to identify bathymetry, benthic habitat and seagrass species mapping in shallow water. In 2019, HARP, launched by the University of Maryland, is a hyper-angular rainbow polarimeter for aerosol and cloud particles study. In June 2021, BeaverCube was launched by MIT-STAR Lab, using coastal imaging with IR dan VIS sensor for tracking excess soils, sediments, decaying leaves, pollution and other debris.

Nanosatellite Development in Indonesia

Indonesia has been a satellite user since 1976 by launching the PALAPA satellite and became the first ASIAN country to use satellite technology for telecommunications. Since 2003, Indonesia has been trying to develop microsatellites independently and cooperate with developed countries. The National Institute of Aeronautics and Space (LAPAN) as a satellite technology development agency in Indonesia has launched Indonesia's first microsatellite named LAPAN-TUBSAT in 2007. This micro-sized experimental satellite opens a new chapter for Indonesia in mastering satellite technology [3]. Indonesia has also successfully launched the LAPAN-A1/LAPAN-TUBSAT satellite, the LAPAN A2/LAPAN Orari satellite, and the LAPAN A3/LAPAN-IPB satellite [3].

Figure 3. The design of Surya Satelit 1 (SS-1)
(Source: http://fkmtfindonesia.or.id/blog/mengintip-club-riset-nanosatellite-mahasiswa-tf-universitas-surya/)

Currently, Indonesia is developing the LAPAN-A4 satellite. Like its two predecessors, this fourth-generation satellite is entirely made in Indonesia. The main mission of this fourth-generation satellite is to observe the earth, in regards to the environment and natural resources, using an optical imager. Another mission of LAPAN-A4 is the monitoring of maritime traffic using the Automatic Identification System (AIS) which is capable of recording millions of ship data per day globally. This satellite also

Sources: Satellite - Satelit LAPAN A3. pusteksat.lapan.go.id; Globe - https://www.pexels.com/id-id/foto/planet-bumi-220201/

targets the scientific side by carrying a magnetometer payload. The LAPAN-A4 satellite will be launched using India's rocket launcher (ISRO) in 2022.

In 2016, LAPAN collaborated with Surya University to develop a nanosatellite called Surya Satellite-1 (SS-1). Surya Satellite-1 (SS-1) is the first nanosatellite in Indonesia with an Automatic Packet Reporting System (APRS) mission. Indonesia plans to launch this satellite in April 2022 in Japan. The condition of the nanosatellite is now entering the final stage of development. The disadvantage of this satellite lies in its incapability of taking pictures with a high resolution because of its small capacity.

However, the Government of Indonesia has built a Multifunction Satellite Project Earth Station for the Republic of Indonesia Satellite (Satria-I) in Cikarang, Bekasi Regency. These earth stations or gateways are part of the terrestrial segment that will connect the satellite with the earth observation office. Apart from Cikarang, ten other gateways will be built in Batam, Banjarmasin, Tarakan, Pontianak, Kupang, Ambon, Manado, Manokwari, Timika, and Jayapura.

The development of satellite infrastructure in Indonesia is expected to mitigate the risk of climate change. The development of nanosatellite technology can be of great support, in mitigating natural disasters, for the BNPB, BMKG and all other Indonesian institutions. The realization of the nanosatellite technology development program can be an emerging technology for marine coastal monitoring. Implementation and development of nanosatellites can be a national pride for space technology development in Asia.

Future Research of Nanosatellite

The need for the use of satellite technology is overgrowing every year around the world. This triggers technology competition. The Asia and Pacific region is no exception, where satellite technology has been widely used for telecommunications, remote sensing and science missions. The specific condition of Indonesia's territory makes the need for satellite technology becomes increasingly higher compared to several other countries. With the development of the digital era, the need for satellite technology is not only for a communication tool but also for various applications such as remote sensing for observation and monitoring of agricultural, plantation, urban, forest, coastal and ocean areas for various needs, atmospheric observations, space and climate weather predictions (weather satellites), navigation satellites, scientific and communication satellites.

Research on the development of nanosatellite technology needs to be established toward large-scale space technology research. The system for utilizing satellite-based space technology is able to overcome the constraints that emerged from the geographical range and structure of the Indonesian archipelago in facing global climate change. Geospatial Information then becomes crucial for supporting Disaster Risk Reduction Management activities.

The development of nanosatellites are continuously carried out by satellite data provider companies. Research on nanosatellite technology involves universities in collaboration with the country's space agency. Several universities conduct research and development on nanosatellites including Technische Universität Berlin, Santa Clara University, Tokyo Institute of Technology, Stanford University, University of Tokyo, Hokkaido Institute of Technology, Nitte Meenakshi Institute of Technology, University of Applied Sciences of Southern Switzerland (SUPSI), Zhejiang University, Nanyang Technological University, Kyung Hee University, and many other universities [4]. Various countries participate in the race to develop nanosatellites. The players in this technology are still dominated by the American and European countries. For the Asian region, nanosatellite research is dominated by India, Japan and China.

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Sources: Satellite - Satelit LAPAN A3. pusteksat.lapan.go.id; Globe - https://www.pexels.com/id-id/foto/wallpaper-bumi-41953/