Progress of GIS and Remote Sensing Applications in Agricultural and Environmental sectors in Myanmar

Zaw Naing
Managing Director, Myanmar Credent Technology
Central Committee Member, Myanmar Engineering Society
Myanmar Info-Tech, Hlaing Township, Yangon, Myanmar, 11051
zawnaing72@gmail.com, zawnaing@credent-myanmar.com

Abstract: Being an agriculture-based economy, a resourceful country and being hit by the Cyclone Nargis, in 2008, which has been the deadliest natural disaster in the history of Myanmar, agriculture, climate change and environmental affairs are important areas for the country of Myanmar. GIS and Remote Sensing technologies have been applied in various sectors of Myanmar since 1980s, but have been progressive quite slowly. This paper traces back the progress of the utilization of satellite- and geo-information in those areas in Myanmar and illustrates the progress by means of case studies which will present which organizations in Myanmar have been utilizing those technologies and information for what purposes, and the challenges ahead. The case studies will showcase what have been done so far by the geo-information users from government ministries like Ministry of Agriculture and Irrigation, Ministry of Forestry, Water Resources Management and Utilization Departments, National Commission for Environmental Affairs, Ministry of Mining, Ministry of Education, Ministry of Science and Technology, etc., together with the other stake-holders like United Nations (UN) agencies, Food and Agriculture Organization (FAO), Japan International Cooperation Agency (JICA), Myanmar Engineering Society (MES), Myanmar Computer Federation (MCF) and private sector, etc. It will also highlight the capacity building efforts, and the interest of the government ministries and the stake-holders in utilizing the satellite- and geo-information in respective areas such as agricultural planning, disaster management and disaster risk reduction, forestry management, cadastral mapping, urban planning, municipal management, environmental impact assessment for development projects, etc.
Keywords: Myanmar, GIS, remote sensing, agricultural planning, forestry management, disaster risk reduction, disaster risk management, environmental affairs, capacity building

1. Introduction

The use of remotely sensed data is not a new concept in Myanmar. In 1924 an area of 14,000 square miles of dense tropical mangrove forest was surveyed by means of vertical photography. In 1925 aerial reconnaissance was tried for the purpose of demarcating forest type boundaries on existing topographic maps. Using satellite data was started in 1980. A quick appraisal of the forest cover of the whole country was carried out using Landsat imagery of the 1972-1979 period. Comparing to the progress and pace of utilization of GIS and remote sensing (RS) technologies and data worldwide, the Myanmar's progress and pace is quite an infant stage for a few reasons like dependency of the technical and financial support on foreign donors-funded projects, slow process of technical transfer and capacity building, and lack of institutions in that geospatial technological areas. But, there has been a wide range of projects, applications and utilization of such data and technologies with such limited capacities and this paper will review those efforts and works especially in agricultural and environmental sectors.

2. Agriculture and Environmental sectors in Myanmar

The economy of Myanmar is largely based on the agriculture sector with 37 % of its GDP and 13.3% of its total export earnings, employing 61.2% of the total labor force. With 18 million ha of total arable land and 57.5 millions of people with 1.75 % population growth, the agriculture sector plays a very significant role in Myanmar.

Myanmar is a resource rich country with rivers, forests, wild life, gem stones, jades, minerals like tin, copper, zinc, gold, and oil and gas, etc. Rich resources used to become the curse. Exploitation of resources is creating the environmental challenges. Myanmar has been facing environmental pollution, degradation and deterioration, climate change, and natural disasters. Nargis cyclone in May 2008 was a strong tropical cyclone that caused the deadliest natural disaster in the recorded history of Myanmar.

Myanmar government has established the National Commission for Environmental Affairs (NCEA) in February 1990 with the objectives to safeguard the environment and prevent its degradation, to set environmental standards, rules and regulations to control pollution including water pollution, air pollution, noise pollution, disposal of hazardous wastes and toxic chemicals, to lay down short, medium and long term environmental plans, policies and strategies that take into account both environmental needs and developmental requirements, and to promote environmental awareness through information and education so as to foster public participation in environmental protection endeavours.

3. Geo Information Utilization in Agriculture Sector

Cadastral mapping, crop yield estimation, agricultural census, agricultural atlas, agricultural planning, rural agricultural and economic study, pumping site selection, arsenic mitigation mapping, land use and land cover mapping, 3D GIS and Digital Elevation Models (DEMs) for irrigation and watershed management are examples of utilization of geo and satellite information in Myanmar agricultural industry.

3.1 Cadastral Mapping, Crop Yield Estimation and Agricultural Census

Settlement and Land Records Department (SLRD) of Ministry of Agriculture and Irrigation (MOAI), being responsible for land administration, has to maintain different types of records for each Kwin (farm land parcel) map. SLRD started using the GIS mapping system in 1998 by scanning the paper maps and digitizing them to be digital maps. Then, SLRD digitizes orthophotos producing digital Kwin maps, with the attribute data in Microsoft Excel and Access and linking them with digital map in GIS platform.

The SLRD intends to use satellite images to investigate the crop areas and crop yield estimations. It started a pilot project of crop yield estimation in Ayeyarwaddy delta region in 2005 with the help of Department of Agriculture of Australia and Myanmar Credent Technology. The main crop of interest is rice.

MOAI is also cooperating with Geo-Informatics and Space Technology Development Agency (GISTDA) of Thailand using Thailand Earth Observation System (THEOS) satellite imagery for rubber plantation inventory assessment and rubber yield prediction in Mon State, Southern Myanmar.

3.2 Agricultural Planning, Rural Agricultural and Economic Study, then Agricultural Atlas

In 2001-02, a pilot project, GIS-MARES (GIS- Myanmar Agriculture and Rural Economic Study) was launched with the assistance of Japan-Myanmar Economic Structural Adjustment Programme. The project area covers 7 districts of different agro-ecological conditions including Bago, Kyaukse, Magway, Myaungmya, Myeik, Taunggyi and Thaton districts. Data collection was made for 41 project townships in 7 districts for last ten years. Village-tracts level data was also collected from a selected township of each district. Collected data covers several areas such as general information, population, household, land use, land holding size, crop production, cropping pattern, agricultural inputs, credit, livestock and fisheries, procurement and government offices and facilities. This publication primarily concentrates on land and crop production. This was the very first publication of GIS application particularly in Myanmar agriculture

In 2005, a remarkable work with GIS was done for Myanmar agricultural industry. Ministry of Agriculture and Irrigation (MOAI) mainly funded by the United Nations Development Programme (UNDP) with additional support provided by the Asian Development Bank (ADB), produced and distributed the digital agricultural atlas of the Union of Myanmar (Fig. 1) - a collection of GIS-derived maps, tabular data and related documents depicting political, physical and agricultural resources in Myanmar. Data are integrated in a "warehouse" framework to be displayed in Dynamic Maps, the GIS free software developed by the Food and Agriculture Organization of the United Nations (FAO), Environment and Natural Resources Service (SDRN). The atlas contains general layers from international data providers and agricultural-related layers generated from 2001-2002 statistics collected at state/division, district and township level.

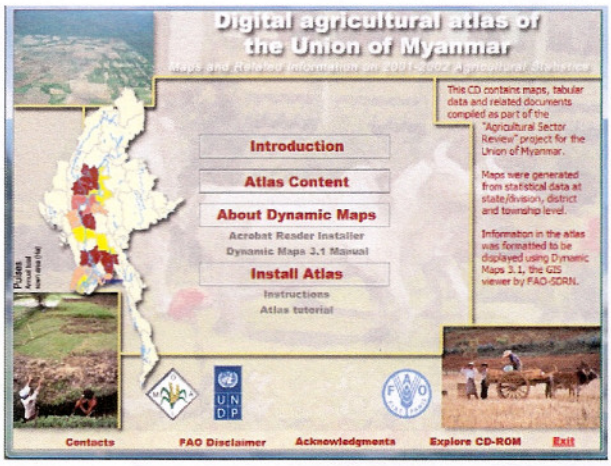


Fig. 1 Digital agricultural atlas of the Union of Myanmar (2005)

Previously, there was an enormous amount of agricultural sector data existed but not available nationally. Much of these data derived from biannual surveys of production and yields conducted throughout most regions of the country, while other data were collected in relation to activities of the Settlement and Land Records Department (SLRD) of MOAI and government enterprises operating within the sector. Although an annual statistical compendium is published for the economy as a whole, in which agricultural data are included, most data are available only in a form that is aggregated to national or, at best, provincial/regional level. Equally, the national statistical data often provide only a single annual figure for production, while for many crops there are two or even three harvests per year. Many areas of data were simply not covered, given the need to present information on all aspects of the economy.

Ministry of Agriculture and Irrigation and UNDP reviewed and agreed that detailed data on such a crucial sector should be more widely available and it was decided to prepare the present geographical digital dataset to be distributed on CD-ROM that would not only provide the detailed breakdown of many aspects of the sector lacking elsewhere, but would also use Geographical Information System (GIS) tools to allow the information to be represented, browsed and queried in a geospatial way. Because much of the underlying information was not available in Yangon and very little was in electronic format, the data was collected from each provincial/ regional capital and geo-reference it for use in the GIS system.

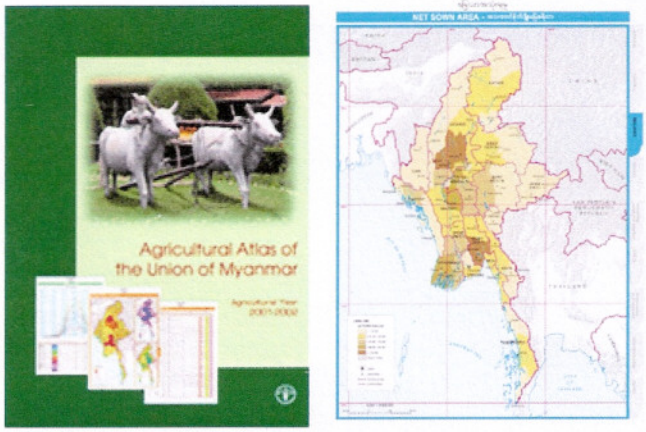


Fig. 2 Agricultural Atlas of the Union of Myanmar (2005)

The Myanmar digital agricultural atlas contains 23 general data layers and 187 layers derived from agricultural statistics and climate data. Maps in the following topic groups: General, Physical and Climate, contain information derived from general data providers and depict regional and country-wide characteristics. The other topic groups contain maps derived from agricultural-based statistics from 2001-2002 survey. Statistics are aggregated at division/state, district or township level.

An A3-sized printed atlas (120 pages) (Fig. 2) was published collecting the most important maps, associated tables and derived charts extracted from the Digital Agricultural Atlas.

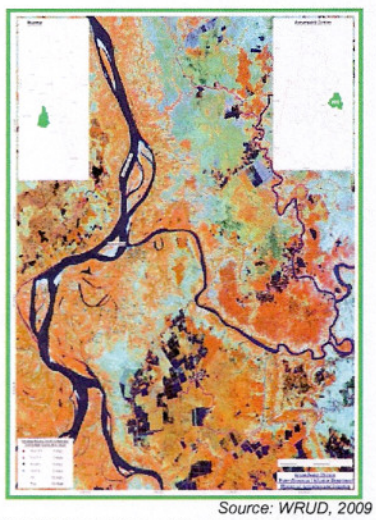
3.3 Pumping Site Selection for Agriculture

Since 2000, utilization of geo information systems in agricultural sector has been increased. The Water Resources Utilization Department (WRUD) of Ministry of Agriculture and Irrigation (MOAI) started to establish GIS, Remote Sensing and Photogrammetric sections in between 2000 and 2004. The WRUD used landsat satellite images of 1980, 1990 and 2000 to detect the scale of changes of the Ayerwaddy river for its water pumping projects from the river. The WRUD selected the pumping sites at the places of minimal changes of river channel. Later, the WRUD utilized photogrammetry and aerial photographs for pumping irrigation projects.

3.4 Arsenic Mitigation Mapping by GIS

The WRUD did another significant job for arsenic mitigation project (2005-09) in collaboration with UNICEF by means of its GIS and satellite image processing capabilities. It produced the following arsenic contamination maps;

(1) Existing Drinking Water Sources Map.
(2) Arsenic Content of Groundwater Sources Map.
(3) Arsenic Content of Surface water Sources Map
(4) Location Map of Villages Vs Satellite Scene with Percentage Range of Drinking Water Sources containing Arsenic >50 µg/l. (Fig. 3)
(5) Geology and Geographic Distribution of Villages with Percentage Range of Drinking Water Sources containing Arsenic >50 µg/l.
(6) Geographic Distribution of Villages with Percentage Range of Drinking Water Sources containing Arsenic >50 µg/l.
(7) Arsenic Contaminated in School Water Sources Map.



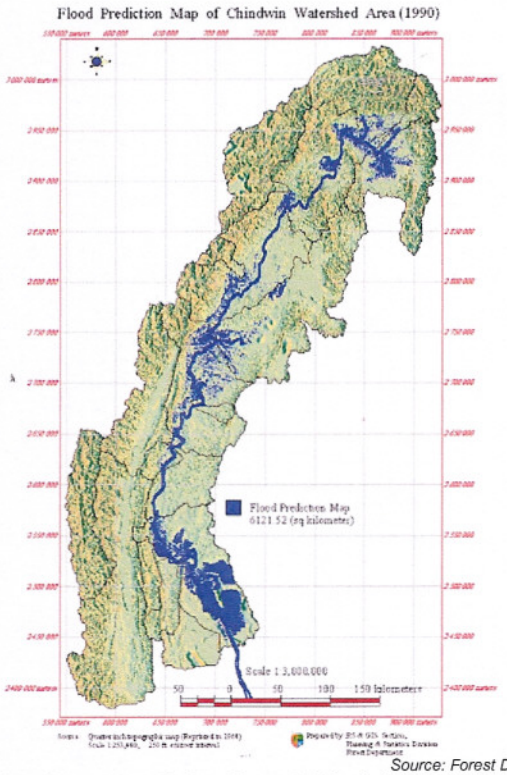
Source: WRUD, 2009

Fig. 3 Arsenic contamination map

3.5 Land Use, Land Cover Mapping, 3D GIS and DEMs for Irrigation and Watershed Management

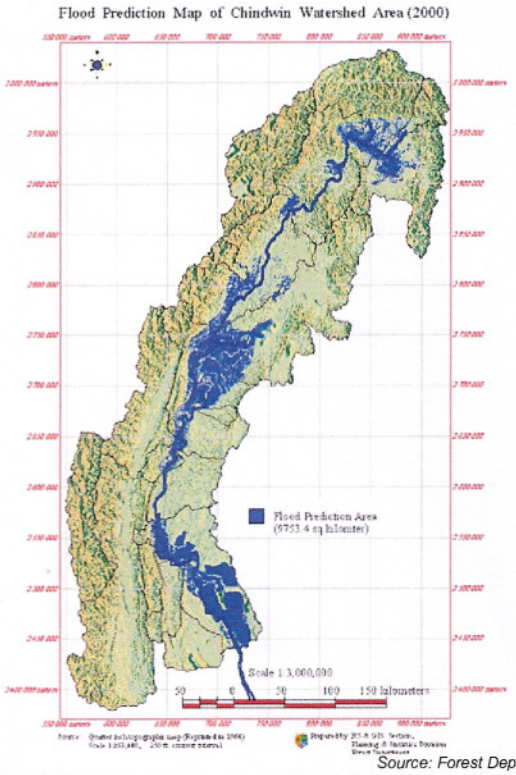
To boost the agricultural production, new reservoirs and dams have been constructed throughout the country especially since 1990. The existing reservoirs and dams also have been renovated. The life spans of these reservoirs and dams depend on such factors like forests growing in the watershed areas, land use and land cover changes, population and urban growth, etc.,. At the same time, the flood prediction and forecasting is also a challenge.

Therefore, the effective watershed management is very essential to the country. Accordingly, from 2005, watersheds of all important dams and reservoirs are now saved in GIS format using the latest satellite data such as Landsat 7 and Aster images. Critical watersheds are being mapped in 3D GIS. The Digital Elevation Models (DEM), hydrologic flood control models, aspect maps and slope maps for those critical basins were generated. Simulation of land cover changes and flood predictions are made, e.g., flood prediction map of Chindwin Watershed Area (1990) and (2000) (Fig. 4 and Fig. 5). Then, watershed management plans including construction of embankment, land use planning, sustainable forest management, etc., are accordingly developed.



Source: Forest Department

Fig. 4 Flood Prediction Map of Chindwin Watershed Area (1990)



Source: Forest Department

Fig. 5 Flood Prediction Map of Chindwin Watershed Area (2000)

4. Geo Information Utilization in Environmental Sector

Current environmental issues and activities in Myanmar include but not limited to sustainable forestry, biodiversity and wild life conservation, combating desertification and drought, climate change, mangroves, urban air quality management, forest fire, and disaster risk reduction, disaster risk management and rehabilitation. Geo and satellite information are essential to view, review, analyze the situation, plan, monitor such environmental challenges and issues, and Myanmar has been starting to get a momentum in that area.

4.1 Forestry

Forest Department (FD) of Ministry of Forestry (MOF) used aerial photographs for assessing the vegetative cover of the Ayeyarwady Delta Mangroves in the 1920s. Since then Forest Department occasionally uses remote sensing data in compiling data for her periodical forest management plans (10 year cycle).

In 1980, by FAO / UNEP project - Tropical Resources Assessment Project, a quick appraisal of the forest cover of the whole country was carried out using 1: 1,000,000 scale Landsat imagery of the 1972-1979 period. In 1981-86, United Nations Development Programme (UNDP) funded a project - "National Forest Survey and Inventory" which included taking the aerial photography covering the whole of Myanmar; and as such, two sets of Landsat MSS imageries for the period 1974-1980 at 1:1,000,000 and 1:250,000. Next project - "National Forest Management and Inventory" provided a set of Landsat TM imagery for the period 1989-90 at 1:500,000 scale and a countrywide land use map was produced by visual interpretation.

The Digital Image Processing system was installed in the Forest Department in early 1996 with financial assistance of another UNDP project "Watershed Management for Three Critical Areas Project" for its land use mapping component. Landsat5 TM scenes were acquired along with the digital image processing system.

The FD together with the Japan Forest Technical Association (JAFTA) mapped a large part of the country starting from 1996 up to 1999, under the Information System Development Project for the Management of Tropical Forest funded by JICA. 68% of the country was covered during 4 successive years.

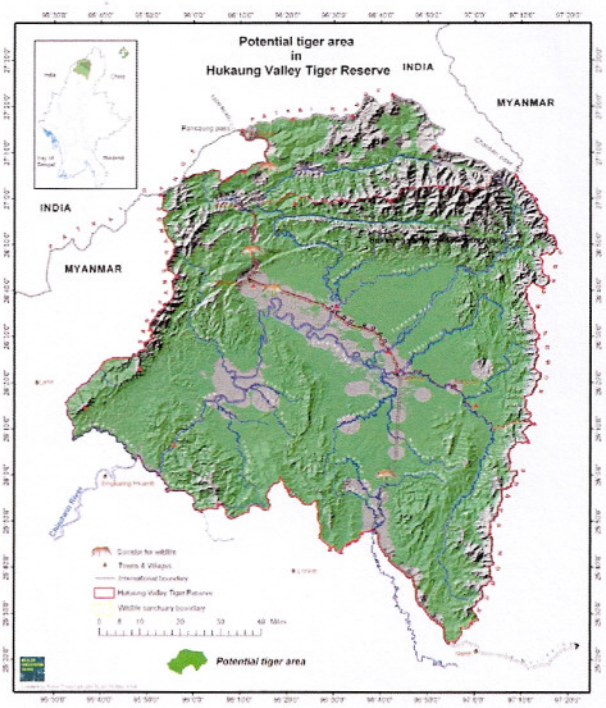
Remote Sensing and GIS Section of the FD have performed various projects in land use mapping, erosion susceptibility mapping, forest inventory mapping and regeneration plan mapping for various regions of the country. The FD also involved in poppy survey and mapping using satellite imagery and GIS starting from 2000-2001 growing season of poppy cultivation together with United Nation Drug Control Program (UNDCP) and Central Committee for Drug Abuse Control (CCDAC) of Ministry of Home Affairs (MOHA) of Myanmar. IKONOS data has been used.

National Commission for Environmental Affairs (NCEA) which has been established since 14 February 1990 is headed and chaired by Minister for Forestry, and the Director General of Department of Planning and Statistics of Ministry of Forestry acts as secretary. Being the foremost and most capable organization of utilizing geo and remote sensing information and technologies in the country, Ministry of Forestry has made a great deal of contribution of GIS and Remote Sensing technological support to the environmental conservation and management activities as and when needed by NCEA and other stakeholders.

4.2 Biodiversity and Wild Life Conservation

Myanmar possesses a flora and fauna of rich diversity. Various forest types are inhabited by a vast array of plants and wildlife species. Rivers systems and tidal forests serve as breeding place for a wide range of aquatic species. Conservation of these biological resources has been incorporated in the broader scope of nature and wildlife conservation which is regarded as one of the national priorities in Myanmar. Protection of soil, water, wildlife, biodiversity and the entire environment is identified as important imperative in the 1994 National Environmental Policy of Myanmar, 1995 Myanmar Forest Policy, and Myanmar Agenda 21 - a programme for environmentally sound and sustainable development in Myanmar which was approved by the Government in 1997.

Wildlife Conservation Society (WCS) a non-government organization in Myanmar used GIS and remote sensing to identify potential tiger habitat in the Hukaung Valley Tiger Reserve. The Tiger population is declining due to a combination of habitat loss, human persecution and loss of prey base. In order to understand their status and distribution in Myanmar, Wildlife Conservation Society (WCS) and Nature and Wildlife Conservation Division (NWCD), Forest Department conducted country-wide tiger surveys across the country from 1999 to 2002 and developed a National Tiger Action Plan (NTAP). Socio economic survey was also conducted in villages, which locate inside and around the study sites. Tiger database was developed in Access format for future analysis. The country-wide tiger surveys confirmed the presence of tigers at four of 17 sites. One of the priority sites for tigers in Myanmar is the Hukaung Valley, which was gazetted as Wildlife Sanctuary in 2001.



Source: Wildlife Conservation Society (WCS), 2004

Fig. 6 Potential Tiger Habitat Map in Hukaung Velley Tiger Reserve

As part of the strategy for implementation of the NTAP, tiger inventory and distribution survey have been conducted in Hukaung Valley Wildlife Sanctuary since 2001. These surveys determined that a potentially viable population of tigers exited and that the site should be the focus of applied conservation efforts in the future. Base on these results, the Hukaung Valley Wildlife Sanctuary area was extended to incorporate the 8418 sq miles Hukaung Valley Tiger Reserve in March 2004.

In order to effectively manage the Tiger Reserve, basic information on the number and spatial distribution of tigers is needed. Information from surveys combined with remote sensing and GIS technology were used to identify areas where tigers are potentially present. Camera-trap records and a mark-recapture approach are used to obtain sample tiger density estimates. Then a spatial model of tiger distribution for the Hukaung Valley Tiger Reserve was developed. Potential tiger habitat map was produced (Fig. 6). That GIS project supported potential tiger habitats, estimation of tiger population, and administration and effective management of the Tiger Reserve.

WCS has continued utilization of satellite information to assess the land use changes and to measure the current increase in rates of forest conversion in the project area. WCS is currently working on classification and comparison of SPOT images from 2006, 2009 and 2010 with its existing Landsat images from 2000.

4.3 Combating Desertification

Although the Central Dry zone of Myanmar is a semi-arid region, the situation is approaching to the desertification level. In 1997, the Remote Sensing and GIS Section of the FD did 1:50,000 scale maps of land use, slope information, erosion susceptibility and regeneration planning data for 20.12 million acres of the Central Dry Zone using Landsat TM imagery. With the help of the information obtained from the Land Cover Map and above mentioned related information of the Central Dry Zone of Myanmar, Dry Zone Greening Department has its Thirty Years Master Plan by which it has been planned which area should be naturally regenerated or artificially regenerated or which area should be totally protected. In 2006, Landsat 7 ETM data was acquired and a re-assessment of the dry zone greening project activities was performed.

4.4 Detecting Urban Land Surface Temperature

Remote Sensing Department of Mandalay Technological University (MTU) did a research project to develop a method for detecting urban land surface temperature in Mandalay City using Multi-temporal Landsat image data for the period 2000 to 2005. Land surface temperatures are important in studying of global warming in estimating radiation budgets in heat balance studies and as a control for climate model. The ability of the surface for emit radiation (surface emissivity) is a main parameter for detecting land surface temperature (LST). Therefore, knowledge of the surface emissivity is crucial for estimating the radiation balance at the earth surface. The LST was determined based on association surface emissivity value with land cover information. This project indicated that LST data can aid in modeling urban planning and monitor environment.

4.5 Disaster Risk Management (DRM), Disaster Risk Reduction (DRR) and Rehabilitation

The Cyclone Nargis hit the Ayerwaddy delta area of Myanmar in May 2008. It has been the deadliest natural disaster in the history of Myanmar. About 150,000 people died, and many towns and villages were flooded and destroyed. Cows and buffalos which were the workforce of Myanmar agricultural industry were also lost. The communication networks and electrical distribution networks were down for about a week even in Yangon, the commercial city of Myanmar. The roads not only in towns in the delta area but also in Yangon were flooded and blocked with the fallen trees.

Not later than the international and local humanitarian works, the international geospatial community responded immediately. The United Nations Institute for Training and Research (UNITAR) Operational Satellite Applications Program (UNOSAT) provided satellite imagery and related geographic information to UN humanitarian and development agencies and their implementing partners. Digital Globe's WorldView1 imagery with 50cm resolution and QuickBird imagery were used for initial damage assessment. Because of prior establishment before the Nargis cyclone, Myanmar Information Management Unit (MIMU) of United Nations Development Program (UNDP) could provide the administrative GIS data layers for production of required maps for the rescue and rehabilitation works of not only the UN agencies and its implementing partners but also the Myanmar government's ministries and non government organizations (NGOs).

Yangon-based MIMU has then expanded its operations, and continued providing the necessary GIS data and print-out hardcopy maps to those who require them for their rebuilding and rehabilitation works in the cyclone affected areas.

After that hugely-impacted cyclone disaster, many stakeholders have participated, involved and engaged in disaster risk reduction, disaster risk management and rehabilitation works. Geo and satellite information are also utilized as useful tools for such works.

Ministry of Science and Technology (MOST), having a Remote Sensing Center under its Mandalay Institute of Technology (MIT), has coordinated and cooperated with Sub-committee on Space Technology and Applications (SCOSA) of ASEAN, Kobe-based Asian Disaster Reduction Center (ADRC) and Asian Institute of Technology (AIT) for capacity building and human resources development programs for utilization of GIS and remotely sensed data for disaster risk reduction purposes.

Myanmar Engineering Society (MES), Myanmar Geosciences Society (MGS) and related government bodies formed Myanmar Earthquake Committee (MEC) and produced seismic zonation maps (Year 2006) of Myanmar and major cities. MEC also has worked together with Bangkok-based Asian Disaster Preparedness Center (ADPC) to conduct the training workshop on Seismic loss estimation using simplified and GIS-based approaches.

MES also started training courses on application of GIS and Remote Sensing technologies for Disaster Risk Reduction (DRR) and Disaster Risk Management (DRM) in cooperation with Myanmar Credent Technology- a private geospatial IT company.

After the Nargis cyclone, Myanmar has developed Myanmar Action Plan on Disaster Risk Reduction (MAPDRR) (2009-2015). By MAPDRR, it is aimed to prepare hazard risk maps and hazard and vulnerability atlas of Myanmar. Sub committees were formed, sub-components were divided, and the actions are taking placed. MIMU has been providing the GIS data and technical support.

4.5 Environmental Impact Assessment (EIA) for Resources Extraction and Exploration Projects

As Myanmar is resourceful, there are extraction and exploration of minerals, oil and gas, gems stones, etc. While extracting the natural resources, the nature should not be destroyed. For that reason environmental examination and Environmental Impact Assessments (EIA) are made for such resource exploration projects. For example, when Ministry of Mines gives mining permission, initial environmental examination (IEE) is done. If necessary, EIA is also demanded. Department of Geological Exploration and Mineral Exploration (DGSE) is responsible for IEE. Usually, DGSE does IEE by means of field survey and the remotely sensed information, i.e., aerial photography or satellite imagery. The land-cover types and structure of the mine project area were studied using the aerial photography, Landsat TM, and Aster images.

5. Conclusions

Utilizing geo and satellite information in Myanmar in agriculture and environmental sectors has been getting momentum. Myanmar stakeholders are willing to learn and develop the skills and capacity in GIS and remote sensing technologies to utilize them in the respective application areas. With the current development in Myanmar political situation, it is expected that economic activities are going to be faster, more open, and consequently agriculture sector will also experience advancement and progressive developments, and utilization of geo and satellite information will be increased and will be contributing to the country's economic development. It is also believed that utilization of geo and satellite information in environmental conservation and disaster risk reduction endeavors also will be significantly improved and giving the intelligence to protect the nature, the people and the society.

6. Acknowledgement

It is a pleasure to thank those who made this paper possible _ U Soe Win Maung, Department of Agricultural Planning (DAP); Dr. Kyaw Zaya Htun, Mandalay Institute of Technology; U Toe Aung Kyaw and Dr. Myint Soe, Department of Geological Survey and Mineral Exploration (DGSE); U Mg Mg Than, Forest Department; Daw Htwe Nyo Nyo and U Sai Than Maung, National Commission for Environmental Affairs (NCEA); U Maung Maung Win, Myanmar Credent Technology; Dr. Than Myint and Ko Kyaw Thin Latt, Wildlife Conservation Society (WCS); U Saw Hlaing, Settlement and Land Records Department (SLRD), and U Sein Tun, Department of Water Resources and Improvement of River Systems (DWRIRS). I also would like to take this opportunity to express my deepest gratitude and appreciation to the organizers of the workshop "Advanced Use of Satellite- and Geo-Information for Agricultural and Environmental Intelligence" _ Dr. Yoshio Inoue, National Institute for Agro-Environmental Sciences (NIAES), Tsukuba, Japan; and my mentor, Dr. Jiaguo Qi, Center for Global Change and Earth Observation (CGCEO), Michigan State University; for making this workshop happened and for their kind invitation to participate in this international workshop which provides me a great chance to study and understand more in depth about utilization of geo and satellite information in agricultural and environmental sectors.

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