# Human Resource Development in Africa

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## ABSTRACT

SMART Africa Manifesto was endorsed by all countries of African Union in 2014. African countries have cooperated to enable innovation, communication and advocacy, capacity building and resource mobilization through ICT. SMART Africa Steering Committee recommended that African space program proposal with Japan was implemented in cooperation with African Union on space developments for achieving Sustainable Development Goals continuously and synergistically in February 2018. The University of Tokyo and Japan Space Systems have cooperated to provide capacity building programs about micro-satellite developments and Earth observation satellite data analysis techniques to African young engineers. 2 optical cameras as a pseudo-multi-spectral were loaded on the planned Japanese 3U-size satellite, RWASAT-1. Those cameras were expected to acquire data for land degradation, deforestation, agriculture and other objects. Japan Space Systems has had training programs about Earth observation satellite data analyses with open and free GIS software and ASTER datasets. Using open and free software and datasets made participants analyze sustainably after the programs. When African young engineers have abilities to develop and operate micro-satellites and to analyze Earth observation satellite data, they also have abilities to expand and share their space technologies to African countries through SMART Africa for African developments in near future.

## INTRODUCTION: CLIMATE CHANGE, SUSTAINABLE DEVELOPMENTS AND EARTH OBSERVATION SATELLITES

Nowadays, environments on the Earth were changed drastically. Climate change, such as rising temperature, season pattern changes, unstable raining cycles, and other abnormal weather events have had serious impacts on human societies. Greenhouse gas emissions from human activities, wastewater from industries, disordered agriculture and urban developments on wetlands and forests were raised as global issues which people have faced and worked on solving for a long time. For responding on those environmental impacts, socio-economic changes and developments, people have cooperated globally. Data and data sources which were able to be acquired objectively were required as evidences for reporting current situation of the Earth and suggesting for the future. Earth observation satellite data (EO data) and satellites form space were recognized as objective data and data sources not affected from any limitations on the Earth.

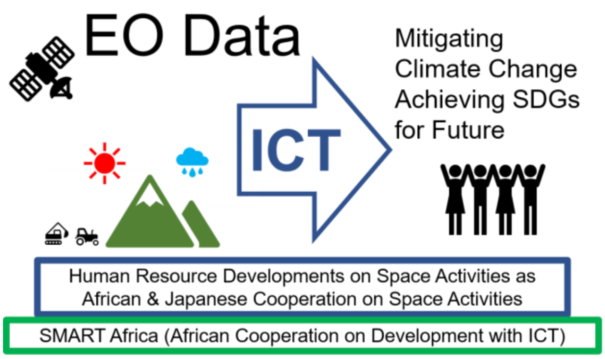


**Figure 1: Image about African & Japanese Cooperation on Space Activities**

### *Approaching for Climate Change*

Climate change has impacts all over the world. Climate change has affected on natural environments, animals, economic costs and communities. Carbon dioxide emission from human activities has driven climate change, such as raising temperature and sea levels (UN, 2015). United Nations (UN) declared international cooperation to contribute solving and mitigating the borderless impacts on the Earth and mankind. UN has also mentioned that climate action was required international cooperation to help developing countries to move toward a low-carbon economy (UN, 2015). The Paris Agreement in December 2015 was the milestone all nations adopted, and all nations have been working on reducing greenhouse gas emissions from human activities and maintaining the raised average temperature within 1.5 degree Celsius. However, failure of climate change mitigation and adaptation was ranked as the highest matter on the report of World Economic Forum in 2019. Climate change caused disasters and food insecurity for about 39 million people in the world in 2017 (World Economic Forum, 2019). Evidences for mitigation and adaptation on climate change were complex, and the implementation would not be enough to prevent damages from the global warming (World Economic Forum, 2019). Climate change was as one of the highest concerns on World Economic Forum Annual Meeting in Davos, and it was the evidence that climate change was serious issue to people on the Earth. New and steady actions have been required for the climate change.

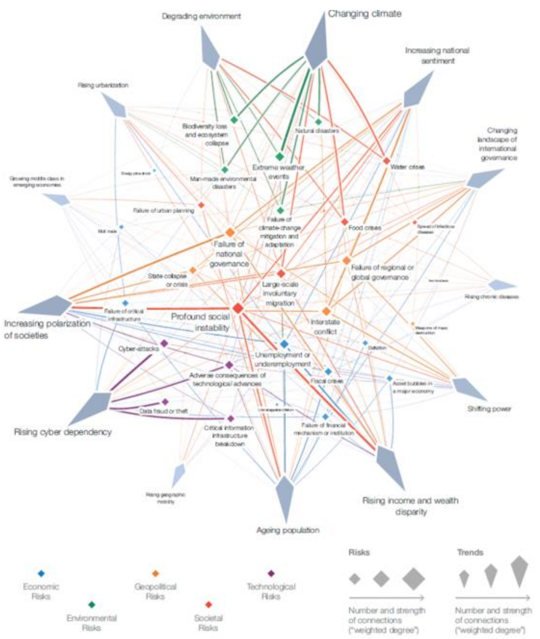


**Figure 2: The Risk-Trends Interconnections Map 2019 (Source: The Global Risks Report 2019 14th Edition, World Economic Forum, 2019)**

### *Sustainable Development Goals*

UN adopted the 2030 Agenda for Sustainable Development in 2015 (UN, 2015). It was a plan for peace and prosperity for people and the planet into the future. The 17 Goals to Sustainable Development (SDGs), which were urgent calls for all countries were applied in the agenda; Goal 1: No Poverty, Goal 2: Zero Hunger, Goal 3 Good Health and Well-being, Goal 4: Quality Education, Goal 5: Gender Equality, Goal 6: Clean Water and Sanitation, Goal 7: Affordable and Clean Energy, Goal 8: Decent Work and Economic Growth, Goal 9: Industry, Innovation and Infrastructure, Goal 10: Reduced Inequalities, Goal 11: Sustainable Cities and Communities, Goal 12: Responsible Consumption and Production, Goal 13: Climate Action, Goal 14: Life below Water, Goal 15 Life on Land, Goal 16: Peace, Justice and Strong Institutions, and Goal 17: Partnerships for the Goals. Because of those goals, all developed- and developing- countries had efforts to realize peace, to solve inequalities and to mitigate climate change without none left behind (UN, 2015).

The 2030 Agenda, SDGs, Targets and Global Indicator Framework were designed to be driven by the recognition that those strategies must be evidence-based and data-driven. High quality, timely and accessible data have been required to provide information for achieving SDGs. Not only big data analysis technologies but also geospatial and EO data and data sources have been also required and provided to all levels of stakeholder from local communities to global to analyze about current situations.

### *Earth Observation Satellite Data for Mitigating Climate Change and Achieving SDGs*

Earth observation satellites were recognized to be data sources for many areas industrially, scientifically and politically. Over 300 different spaceborne Earth observation missions with over 900 different instruments were reported to the Commission on Earth Observation Satellites (CEOS). Those satellites have been acquiring on atmosphere, ocean and lands. Data distributors have provided applications related to environments and human activities. Six characteristics of EO data for SDGs can be listed: (1) open and free, (2) scale and coverage, (3) consistency and comparability, (4) continuity and timescale, (5) complementarity with traditional statistical method and (6) diverse measurements (CEOS, 2018). Not all EO data were free, but United Sates, European countries, Japan and other countries were on the tide to open EO data for science and business advanced. Earth observation satellites on orbits between 400km to 700km acquired data globally. Satellites have been able to acquire data from remote areas where people were hard to be. EO data were not affected by any limitations on the Earth. Those were able to provide data consistency timely and geospatially. Spaceborne Earth observations were started in 1970's. New satellites and instruments have been developed by following technological advanced nowadays. The Earth observations were also planned guaranteed by internationally beyond 2030. Continuity of EO data have been monitoring phenomena on the Earth and achieve SDGs. EO data scientists compiled with data from other sources to measure and visualize the geographical information. Those various data were compiled and analyzed for mitigating climate change overall. About half of 55 Essential Climate Variables benefit from a major contribution from satellite observations or simply would not be feasible without satellites (CEOS, 2018).

## AFRICAN ICT MOVEMENT FOR DEVELOPING AFRICAN CONTINENT

ICT was expected to be one of key methods to connect people and support high economic growth on the African continent. Google was interested in many African companies which developed unique applications, and digitalizing on agriculture has been also in progress in African countries (The Asahi Shimbun, June 11, 2019). African economic growth would become one of the largest markets until 2050 by following drastic African population growth and urbanization.

African have aimed to realize sustainable developments with ICT by themselves. Rapid forest and wetland developments for agriculture fields and urbanization, disordered wastewater managements, air pollution for heavy industry factories and other human activities became serious environmental issues in Africa. African citizens realized those activities to makes their development slow. African countries declared to address climate change, clean energy, urbanization, disaster managements and others by adopting ICT (Transform Africa Summit, 2013). EO data have played roles to monitor their activities on African counties quantitatively. African young engineers were required to achieve skills and techniques about micro-satellite developments, EO data analyses and data managements.

### *Transform Africa for Leading African Digital Evolution*

Transform Africa Summit was the African top-level meeting for discussing and leading African developments by ICT. The first Transform Africa Summit was organized in Kigali, Rwanda in 2013. Heads of Master States (Rwanda, Kenya, Uganda, South Sudan, Mali, Gabon and Burkina Faso) committed to provide leadership for accelerating African socio-economic developments through ICT. Those heads culminated to aim five topics: (1) to put ICT at the center of national socio-economic development agenda of Master States, (2) to improve access to ICT especially broadband, (3) to improve accountability, efficiency and openness through ICT promoting the introduction of advanced technologies in telecommunication, (4) to put private sector first, and (5) to leverage ICT to promote sustainable (Transform Africa Summit, 2019). Transform Africa Summit has aimed to promote global competitiveness and job creation through connecting continents to knowledge economy, innovation and transformation (Transform Africa Summit, 2019).

### *SMART Africa as a Framework of African Development with ICT*

SMART Africa Manifesto was adopted at the first Transform African Summit 2013. SMART Africa Manifesto was endorsed by all countries of African Union in 2014. 24 of 54 African countries (Angola, Benin, Burkina Faso, Cameroon Chad, DRC, Côte d’Ivoire, Djibouti, Egypt, Gabon, Ghana, Guinea, Kenya, Mali, Niger, Rwanda, Sao Tome & Principe, Senegal, South Africa, South Sudan, Togo, Tunisia, Uganda and Zambia) became as Member Sates of this alliance. Five pillars (Policy, Access, e-Government, Private Sector/Entrepreneurship and Sustainable Development) and four enablers (Innovation, Communication and Advocacy, Capacity Building and Resource Mobilization) of SMART Africa were written. Those contributed to economic growth and job creation with ICT (SMART Africa, 2019). Through this alliance with ICT, African countries planned digital government and cooperation for achieving policy and framework, more demands, market condition and outlook, investment, new industries and new jobs. African countries have prepared for big data analyses, government API, unified communication, cloud-based infrastructures and optimized data centers as digital government platform. To realize digitalized government for African countries, SMART Africa raised private investment as USD 300 billion into various sectors.

### *African and Japanese Cooperation on Space Program*

Satellites were a part of the African target fields of SMART Africa. SAMRT Africa Steering Committee recommended that African space program proposal with Japan was implemented with African Union on space developments for achieving SDGs continuously and synergistically in February 2018. SMART African made agreements with the University of Tokyo to develop satellite technologies and capacity building programs to the African continent in May 2018. Cooperation between SMART African and the University of Tokyo focused on African capacity building for not only satellite developments but also data center for EO data analyses applying to agriculture, energy management, urban planning and other fields. Satellite technologies have important roles for ICT development and capacity building in African countries.

Purposes of the African and Japanese cooperation on space activities were capacity buildings on space craft engineering and EO data utilization developments for achieving SDGs and improving activities within agriculture, wetlands as parts of environmental conservations and in smart urban planning on the African continent. As the African and Japanese space activities, the University of Tokyo and Japan Space Systems have cooperated to provide capacity building programs about micro-satellite development and EO data analysis techniques to African young engineers respectively.

## JAPANESE SPACE TECHNOLOGIES AND EO DATA UTILIZATIONS AS INTERNAITONAL COOPERATION FOR SDGS

Japanese enterprises, academia and government have developed satellites and instruments, operated observations, used EO data for achieving SDGs. One of venture companies planned a small-satellite consternation to realize real-time Earth observation. Another venture company from a university developed a synthetic aperture radar as small satellites' missions. Japan Aerospace Exploration Agency (JAXA) operated Earth observation satellites and opened EO data and applications. Many Japanese space activities for SDGs were not operated by a single company or organization. They brought each own specific technology and cooperated each other to approach for their goals. The cooperation on the space programs were not only with Japanese but also international.

### *ASTER, the Japanese Spaceborne Sensor*

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) datasets became open and free in 2015. To open all ASTER datasets, the National Institute of Advanced Industrial Science and Technology (AIST) and United States Geological Survey (USGS) have websites MADAS (https://gbank.gsj.jp/madas/) and Earth Explorer (https://earthexplorer.usgs.gov/) respectively.

ASTER was developed by the Ministry of Economy, Trade and Industry of Japan (METI) for natural resource developments. It was loaded on Terra, a satellite of National Aeronautics and Space Administration (NASA). ASTER was launched in 1999. ASTER has four high performance functions: (1) wide spectrum of wavelengths (3-band Visible Near Infrared (VNIR), 6-band Short Wave Infrared (SWIR) and 5-band Thermal Infrared (TIR)), (2) stereoscopic data in a single orbit using near-infrared bands, (3) high geometric and radiometric accuracy, and (4) worldwide coverage and about 20-year-long observation history. Japan Space Systems charged of ASTER sensor development. Japan Space Systems has also been conducting observation scheduling, data processing, archiving and distributing ASTER datasets.

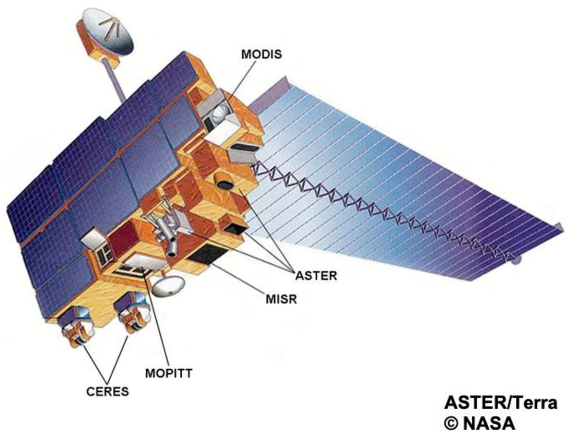


**Figure 3: ASTER, Terra**

METI and NASA have also developed and released digital elevation model named ASTER Global Digital Elevation Model (ASTER GDEM) since 2009. ASTER GDEM was generated ASTER VNIR (Band 3 Nadir and Band 3 Backward) data. ASTER GDEM has 4 unique features: (1) wide coverage (ASTER GDEM covers between 83 degrees North and 83 degrees South and between 180 degrees East and 180 degrees West with 22,600 tiles), (2) 30m spatial resolution, (3) 7 to 14m DEM accuracy (standard deviation) and (4) ongoing data acquisition for improving data quality. ASTER GDEM was also released as open and free, applications such as oil resource exploration, volcanic hazard and flood hazard maps and other applications have been developed with ASTER GDEM.

### *RWASAT-1, the First Micro-satellite in Rwanda*

The University of Tokyo developed a 3U-size micro-satellite named RWASAT-1 for a part of space activities between Africa and Japan. Two optical cameras as a pseudo-multi-spectral camera was loaded on RWASAT-1. Those cameras had abilities to cover VNIR as similar as ASTER VNIR. To make mission cameras small, Raspberry Pi Zero was used as the processing unit. Those mission cameras would have 10m to 20m of ground sample distance (nominal: 17.6m at 400km altitude). The swath was as 45km (field of view was designed as 6.5 degrees). Focal distance was as 50mm and focal number as 2.0 of the cameras' lenses. The mission cameras were consisted of 2 cameras which had 3 bands each (Table 1). The mission cameras were expected to acquired green, read and near-infrared bands through the multi-band-pass-filer.

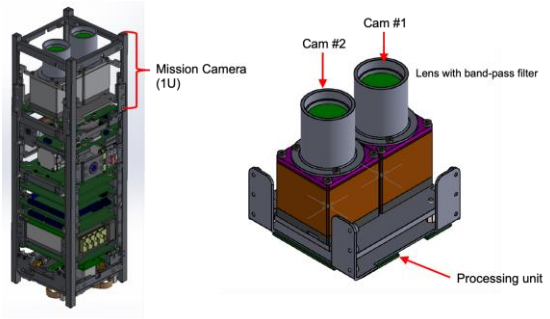


**Figure 4: Mission of RWASAT-1**

**Table 1: Band Specification of RWASAT-1 Mission**

| # | Wavelength | Camera |
|---|---|---|
| **1** | B: 457nm | #1 |
| **2** | G1: 530nm | #1 |
| **3** | G2: 560nm | #2 |
| **4** | R1: 628nm | #1 |
| **5** | R2: 670nm | #2 |
| **6** | IR: 910nm | #2 |

### *FIELDNAUT, Android App for Field Survey*

EO data were not used on researchers' PCs on desks only. Researchers were out to their target fields and collected and compared with survey results and EO data as well. Researchers on sites usually carried many instruments. They had Global Navigation Satellite System (GNSS) receivers for positioning their locations, laptop PCs for calculating and comparing their thematic maps and actual sites, maps for checking locations and cameras and notebooks for records, and other instruments for measuring target objects.

FIELDNAUT was a solution to reduce number of instruments which researchers had on research sites. FIELDNAUT was an Android application for field survey and developed by Japan Space Systems. FILEDNAUT was a one-stop solution for collecting local data of field survey. FIELDNAUT had 3 functions; (1) positioning, (2) taking notes and photos, and (3) showing thematic maps and EO data (the latest Sentinel-2 data) images as background maps. Surveyors with FIELDNAUT were able to share their result datasets among group members through Social Network Service (SNS) if researchers had SNS accounts. FIELDNAUT also provided 4 types of output files: (1) GPX (GPS eXchange Format) and (2) KML (Keyhole Markup Language) files for recording positioning data, (3) CSV (Comma-separated Values) files for recording waypoints and notes, and (4) JPG (Joint Photographic Experts Group) files as photos. Those files were common file formats and useful for data analyses on open and free Geographic Information System (GIS) software.

Author also developed FIELDNAUT Software Development Kit (SDK) for customizing and educating. Autor were able to re-build and arrange FIELDNAUT program by following every project. Authors also were able to provide FIELDNAUT SDK as a training material for capacity building on GIS data management programming.

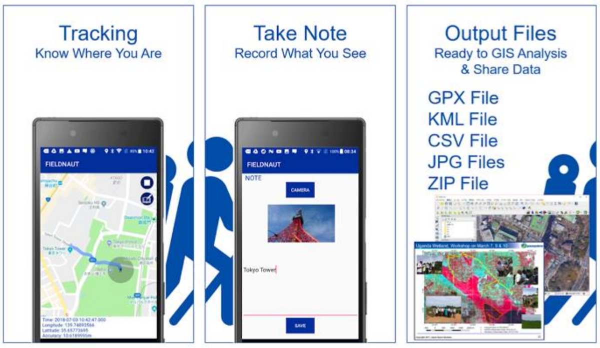


**Figure 5: FIELDNAUT Functions**

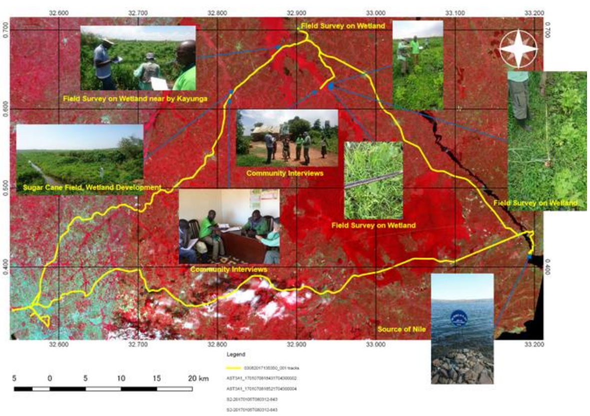

**Figure 6: Results of Field Survey on Wetland Monitoring by FIELDNAUT in Uganda on March 9, 2017**

### *Case Study: EO Data for Wetland and Peatland Managements in Uganda*

Wetlands have fostered various bio-species, purified and supplied water sustainably. Wetlands have also provided food and minerals. Peatlands, as parts of wetlands, contain organic materials and water. The peat soil has been consisted of carbon stock layers which was formed by decomposed plants and animals for thousand years. Peatlands has been calculated to contain at least 550 giga tons of carbon, which is almost double volumes of all forests in the world (The Ramsar Convention, 2015). Peatlands and Wetlands have isolated carbon and buffered water managements for climate change. Rapid and disordered wetland developments have affected on environments and human activities.

Developments on wetlands and wetland degradation were drastically in Uganda. Wetlands covered 15.6% of Ugandan territories in 1994, but its coverage was decreased as 10.4% in 2008. Over 2,000,000 tons of carbon dioxide was emitted annually by agricultural developments on peatlands in Uganda. Those emitted carbon dioxide became a cause of global climate change as greenhouse gas. Raised temperature, changed rain-fall cycles, declined glaciers and flood and drought by abnormal weathers would be occurred because carbon emissions from peatlands (UNFCCC, 1992; IPCC, 1996). Those impacts by climate change induced poverty and food insecurity, and they obstruct agricultural development in the world including Africa (Abler et al. 2000).

EO data were necessary to evaluate historical land coverage comparisons before and after wetland and peatland developments continuously. Agricultural activities on wetlands were monitored by ASTER for over 16 years between February 2001 and January 2017. Wetlands were shown as light and dark red areas in ASTER data observed in 2001. Artifacts (roads) became recognized on ASTER data observed after 2007. Authors were to the target area and observed there changed as sugarcane fields in 2017 (Figure 7).

Authors were invited by the Ministry of Water and Environment of Uganda to have field survey as monitoring wetlands and a seminar for EO data analysis to officers in March 2017. Authors observed wetlands and discussed plans to make balances between environmental managements and agricultural and urban developments with ministry officers during the 1-week trip in Uganda. Lacking human resources on EO data analyses was a problem in Uganda and other African countries. Authors also had 3-day EO data analysis training to 16 participants. The practice was fundamental, but those techniques would be the first and important step to expand EO data analyzers for wetland managements in Uganda. Those EO data were also evidences for political suggestions on balances between wetland managements for mitigating climate change and agricultural and urban developments for supporting human activities and following population growth as SDGs Goal: 2 Zero Hunger, Goal 6: Clean Water and Sanitation, Goal 11: Sustainable Cities and Communities, Goal 13: Climate Action, Goal 14: Life below Water and Goal 15: Life on Land.

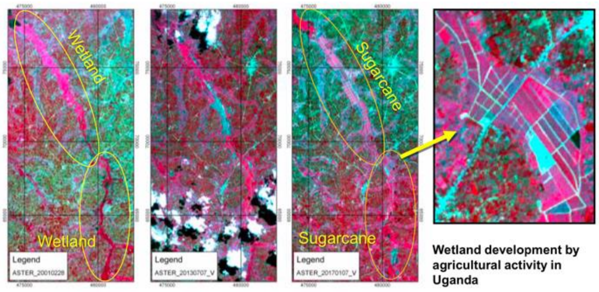


**Figure 7: 16- year Historical Land Coverage Changes by ASTER in Kampala, Uganda between February 2001 and January 2017**

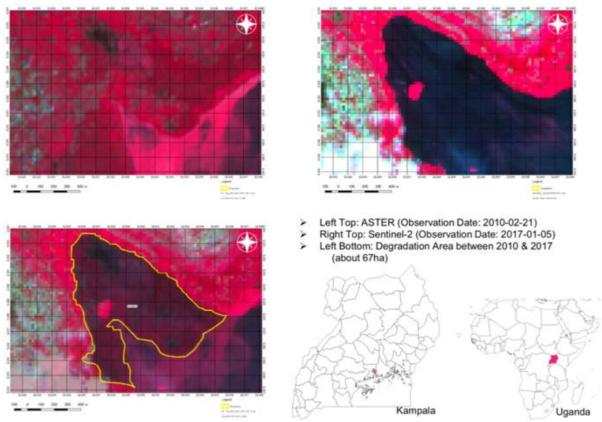


**Figure 8: Wetland Degradation on Lake Victoria, Kampala, Uganda. About 67ha of Wetland Degradation Recognized between 2010 and 2017**

**Figure 9: EO Data Analysis Seminar at Ministry of Water and Environment of Uganda in March 2017**

## CAPACITY DEVELOPMENTS ON SPACE ACTIVITIES FOR AFRICAN YOUNG ENGINEERS

Japan Space Systems is an organization to contribute developments of space technologies and space industry in Japan. As its one of activities, Japan Space Systems was established to promote popularization and education, and personnel training regarding "space systems" (Japan Space Systems, 2012). Japan Space Systems has had training programs about EO data analyses for achieving SDGs and mitigating climate change since 2012. About 400 participants from over 90 countries took the programs as of 2018. The program was consisted of three sessions: (1) in-class lecture and practice for EO data analyses, (2) practical field survey trainings and (3) business networking.

All participants had in-class lectures about data utilizations with open and free satellite datasets such as ASTER, Landsat, Sentinel, ASTER GDEM, SRTM (Shuttle Radar Topography Mission) and geological feature data on the internet. Using open and free GIS software and EO data made participants use and analyze sustainably after the programs.

Participants had field survey trainings with GNSS. They also learned image verifications of EO data analyses. Moreover, participants learned skills about data integration with field survey results and analyzed EO data. Participants started to work on their faced issues and topics, such as land slash managements, fair economic transportation systems, medical hazard maps water well managements with achieved skills after the programs.

Japan Space Systems also invited Japanese companies and provided business networking sessions to participants. Many Japanese private companies have had high technologies and rich experiences and projects on global issues: environmental assessments for mineral resource developments, water purification for industrial waste, recycling systems for reducing waste and bio-fuel development for clean energy. Developments in African countries requested private sectors for transferring technologies, ideas and budgets sustainably. As African continent was called as the last frontier, Japanese companies have been interested in businesses and activities in Africa although the physical distance between African continent and Japan far. The business networking sessions became opportunities for African participants to know and achieve Japanese companies' technologies and activities. The sessions were also opportunities for Japanese companies to have marketing on African markets directly. The business networking sessions were the first steps both African and Japanese to know each other and collaborate in near future.

### *Capacity Building Programs for Rwandan Young Engineers*

The University of Tokyo and Japan Space Systems have invited Rwandan young engineers for educations about space technologies and ICT developments through the African and Japanese cooperation on space activities by following SMART Africa since 2017. The University of Tokyo has had programs to develop a micro satellite and spaceborne tools and data platform for achieving SDGs with Rwandan young engineers. Japan Space Systems has also had programs to utilize EO data and develop EO data management tools for achieving SDGs.

Japan Space Systems invited Rwandan young engineers training programs about EO data analyses with open and free GIS software and ASTER datasets. Rwandan young engineers had their first time to learn how to analyze their interesting fields with ASTER datasets as substitutes of RWASAT-1. EO data analysis training programs were held in Tokyo, Japan and Kigali, Rwanda in December 2017 and March 2019 respectively. Rwandan young engineers learned downloading ASTER, Landsat and Sentinel datasets, mapping, having field survey with GNSS and compiling data on the maps. Authors showed participants their study cases: monitoring deforestation and forest degradation in Peruvian Amazon, monitoring lead contamination and environmental assessment in Kabwe, Zambia, field survey and evaluating potential fields for rice production in Zambia and detecting mining potentials in Rwanda. Those activities inspired Rwandan young engineers' minds and led unique ideas about EO data utilizations into their interests, such as urban planning and detecting potential fields for solar power plants.

Rwanda is one of ICT advanced countries in Africa: Many Rwandan young engineers are interested in developing IT solutions. Rwandan young engineers focused on learning GIS data integration system during the training program in Tokyo, Japan. The participants worked on Android application development for collecting location and mapping based on FIELDNAUT SDK.

Rwandan young engineers found possibilities to develop mapping applications as working record keepers, corn and sugar cane field maintenances and data sharing for trip memories. They tried added reporting systems and data sharing systems among group members as FIELDNAUT new functions. Participants became able to develop, customize and arrange the Android applications. They also enjoyed the programing.

**Figure 10: System Integration in Tokyo, Japan**

***ABE Initiative and Internship Program***

ABE Initiative stands for Master's Degree and Internship Program of African Business Education Initiative for Youth. The initiative was started by the announcement of the Prime Minister Abe at the 5$^{th}$ Tokyo International Conference on African Development (TICAD V). ABE Initiative was as a strategic five-year plan to prove over 1,000 youths in Africa with opportunities to study at Japanese graduate schools as well as to take internship programs at Japanese enterprises and organizations (JICA, 2013). ABE Initiative developed effective techniques in various fields for improvements of African industries. 1,218 ABE Initiative students have come from all African countries between 2014 and 2018 (JICA, 2018). ABE Initiative was not only a scholarship program for African young students, but also business opportunities for Japanese companies to Africa. Although African countries where population and economic growths drastically have been attractive for Japanese companies, Japanese companies were hard to find triggers and contact persons to expand to African markets. Japanese companies were able to have chances to build relationships with their own target countries and markets through inviting ABE Initiative students during the program. ABE Initiative students have become keys to import Japanese high-quality technologies to their home countries, and they would become bridges to connect Japanese companies and African companies to launch new private cooperation.

Japan Space Systems has had internship programs for ABE Initiative students since 2016. This activity has been expanded year by year: 10, 16 and 28 students participated in 2016, 2017 and 2018 respectively. Japan Space Systems also prepared for internship program September 2019. Not all internship students at Japan Space Systems had special backgrounds for EO data analyses, even geology, agriculture, forestry, maritime or natural science. They all had unique backgrounds and interests such as public health, economics, accounting, civil engineering, security and world relationships. Students who had unique backgrounds came at one place and learned same techniques about EO data analyses. They inspired themselves, and they were affected to acquire new fields, skills and technologies. The internship program for ABE Initiative was designed a two-week training course at Japan Space Systems: (1) EO data analysis, (2) ideathon as a group work, (3) field survey training in Hakone and (4) business networking and special lectures with Japanese leading companies and professors from Japanese universities in various fields. Students were also able to select Advanced EO Data Analysis and System Development Courses in the second week.

EO data analysis training was provided on the first two- or three-day of the internship program. Students learned several EO datasets such as ASTER, ASTER GDEM, Landsat, SRTM and Sentinel. They also learned to use open and free GIS software. Students had experiences about making maps, imaging EO data, overlaying GIS data on EO data, normalized difference vegetation index (NDVI) analysis and classifications. Using open and free GIS software was a key tool for achieving SDGs because students would be able to use without budgets after they back to their own countries. They would be able to start their EO consulting business with their own ideas, small laptop PCs, internet environment but no huge budgets. EO data analysis trainings were designed as a trigger for students to be interested in the Earth observation and how they to take EO data into their study themes and activities at the graduate schools.

Ideathon is a unique method to have a brainstorming with group members. Ideathon is a coined word, idea and marathon. Participants from various backgrounds each other came together and concreated an idea about a shown topic through discussion. During the ideathon session, students were separated into four or five groups, and discussed about how they would be able to solve their interesting topics, such as making malaria hazard maps, managing water resources, watching child services and developing fertile agriculture fields in African countries with their own theses and EO data analysis techniques. For instance, a group showed a solution about fair value chain for agricultural products. Their issue was local farmers did not have any ideas about how far to the market and how much cost for product transportations. Thus, dealers priced products from the local farmers lower and sold high at the markets. The group tried to analyze traffic conditions among markets and local farmers with EO data, DEM data and infrastructure maps. They calculated fair prices of the products and transportation fees. Their fair value chain system idea contributed Goal 1: No Poverty, Goal 2: Zero Hunger and Goal 8: Decent Work and

Economic Growth of SDGs. Ideathon provided students opportunities to consider about problems in their own countries through the discussions and make friendships among students.

Field survey training in Hakone was one of highlights during the internship program. Hakone is located in Kanto Region, Japan. It is an active volcano with about 11km (North to South) by 8km (East to West) large caldera. Hakone volcano is a complex of volcanic edifices. Multiple and scattered eruption centers are recognized in Hakone area (Mannen, 2008). Unique volcanic features in Hakone have been acquired by Earth observation satellites. Comparisons between EO data and results of field survey in Hakone were suitable samples for EO data analysis trainings. Students were able to understand how to operate field survey and how to analyze EO data with samples at the local. During field survey training, they calculated carbon stock amount of cedar trees by measuring breast high diameters and tree heights. Students also checked their location with GNSS devices and plotted on EO data maps for comparisons between EO data and local situations. EO data maps had been prepared by students before the field survey.

Japan Space Systems provided business networking sessions during the second week of the internship programs. Japan Space Systems invited Japanese leading companies to show their technologies and activities in the all over the world. Students already had EO data analysis skills, and they were interested in how to apply those skills into businesses. During the business networking sessions, students faced Japanese edge-cut technologies and tried to concrete their new business ideas. The sessions also provided opportunities Japanese companies to collect information and situations in African countries. The sessions became the first bridge to get to know and to collaborate each other Japanese companies and internship students.

Internship students learned EO data analysis skills and worked on their own themes and activities at graduate schools with. They realized potential of EO data analysis techniques for not only mining, agriculture, forestry, climate change but also economy, health care, computer science and anything which they were interested in. They showed their own future plans with achievements during the internship programs as final presentations on the very last days of internship programs.

**Figure 11: Satellite and GIS data Analysis Training**


**Figure 12: Group Photo at Owakudani, an Eruption Center, Field Survey Training in Hakone**

**Figure 13: Ideathon, Group Discussion**

## CONCLUSION

Nowadays, People on the Earth have worked on mitigating climate change and achieving SDGs together globally. Those activities were not able to be concluded by one nation because they relate with every phenomenon and effects on human activities and environment on the Earth. International cooperation became more important roles, and science and technologies were key methods to achieve SDGs. African countries have changed their minds to develop their continent by themselves through ICT. The concept of SMART Africa was transforming Africa into one single digital market from 54 countries and 5 regions. African countries have had abilities to share their visions and carried out to their sustainable developments through ICT. Satellite developments and EO data analyses became the ways to observe the Earth objectively for providing political advices and piloting the future visions. Satellites also have provided communication networks. Those network systems have accelerated economic growth, agricultural trade, energy management, resource development, environmental management on African continent through SMART Africa Initiative.

Japanese engineers have cooperated to develop African capacities for satellite technologies and EO data analyses because they faced African potentials to grow up their markets and vigor. Mitigating climate change and achieving SDGs will be realized with capacity building programs and citizen participations. Japanese government recognized the importance of capacity buildings for mitigating climate change and sustainable developments. ABE Initiative was one Japanese embodied activity as the international cooperation with African countries for SGDs and African autonomy. Japan leads enterprises, academia and governments to seek out the ways to cooperate with African countries into mitigating climate change and achieving sustainable developments by technologically, socio-economically and educationally.

African countries were transformed drastically because of their SMART Africa as African cooperation by ICT and their awareness on sustainable developments on African continent. ICT, space technologies and EO data analyses were some of methods, but they were powerful tools to develop the society and mitigate climate change. When African young engineers have abilities to develop and operate micro-satellites and to analyze EO data for solving faced issues in Africa, they also have abilities to expand, share and use their space technologies for sustainable developments through SMART Africa.

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