SPACE EDUCATION AND CAPACITY BUILDING FOR SUSTAINABLE DEVELOPMENT

Abstract

By

Harun R. Muturi

National council for Science and technology

P.O BOX 30623 Nairobi, Kenya

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Space science and technology can enhance socio-economic development and has the potential to provide cost effective solutions to many of humanity's pressing needs. This can be exemplified by the fact that space science and technology has been applied globally for the benefit of mankind in the areas such as communication, meteorology, surveys and mapping, exploration and exploitation of natural resources, management and monitoring of the environment. Today, all parts of the world are being united by communication satellites while space based sensor systems are continually monitoring the globe. These technologies are providing the support needed for sustainable development.

Natural disasters have been a common phenomenon in the history of mankind and many times have resulted in destruction of both life and human settlements. Natural disasters include: floods, earthquakes, extreme weather conditions, volcanic eruptions, forest fires, tsunamis, drought and desertification and famine. Application of space science and technology can be essential in the management of national disasters.

To sustain the efficient and informed application of any technology, there must always be a critical mass of trained personnel in this field. This, therefore, calls for enhanced capacity building in space education to support monitoring and management of disasters such as natural hazards in order to provide services related to emergency response, search and rescue efforts among others.

Capacity building for disaster management can be considered to be important for early warning, prevention, mitigation, response, recovery, development and planning in order to manage natural calamities. Capacity building would entail both human resources development and development of infrastructure within institutions.

There are a few institutions in Kenya involved in day-to-day applications of space science and d technology. They include the Department of Resource Surveys and Remote Sensing (DRSRS), the Kenya Meteorological Department, the Regional Center for Mapping of Resources for Development and the San Marco Project-Malindi, the survey of Kenya and national universities among others.

This paper discusses need for capacity building in space education in Kenya with bias towards natural disaster management.

SPACE EDUCATION AND CAPACITY BUILDING FOR SUSTAINABLE DEVELOPMENT

1.0 Introduction

Space science and technology has been applied globally for the benefit of man in areas such as communications, meteorology, surveys, mapping as well as exploitation and management of natural resources and natural disasters. These technologies are providing support necessary for development activities.

The objectives of capacity building in space education in Kenya would include among others the following: contribution to capacity building in space sciences and technology in Kenya; promotion of the utilization of satellite data and technology towards environmental applications; preparation of scientists and professionals in Kenya to take more active role in developing equipment, software and application techniques specifically adapted to the needs of the country; promotion the utilization of meteorological and other satellite data for natural disaster mitigation; education of specialists from Kenya in satellite applications in support of socio-economic development, natural disaster management and well-being.

2.0 Natural Disaster Management

A natural disaster is a serious disruption of the functioning of a society causing widespread human, material and or environmental losses which exceed the ability of the affected society to cope using its own resources. Natural disasters have been a common phenomenon in the history of mankind and many times have resulted in destruction of both life and human settlements. Natural disasters include: floods, earthquakes, extreme weather conditions, volcanic eruptions, forest fires, tsunamis, drought and desertification and famine. Application of space science and technology can be essential in the management of national disasters.

The components of coping and managing natural disasters include the following: early warning, prevention, mitigation, response and recovery (relief, rehabilitation and reconstruction, development and planning).

Capacity building in space in education is necessary since it can equip the professionals in the area of space science with knowledge, skills and equipment necessary to manage and mitigate the impacts of natural disasters.

In Kenya, there is insufficient number of both well-trained experts and professionals and the necessary infrastructure including specialized equipment in the field of space science and technology, well equipped laboratories and equipment and institutions which can be used to teach and demonstrate several aspects of space science.

There is, therefore, need for human and institutional capacity building in space science and technology through education, training and provision of facilities and equipment.

3.0 Applications of Remote Sensing Technology

Space science and technology can enhance socio-economic development and has the potential to provide cost effective solutions to many of humanity's pressing needs. This can be exemplified by the fact that space science and technology has been applied globally for the benefit of mankind in the areas such as communication, meteorology, surveys and mapping, exploration and exploitation of natural resources, management and monitoring of the environment. Today, all parts of the world are being united by communication satellites while space based sensor systems are continually monitoring the globe. These technologies are providing the support needed for sustainable development.

3.1 Natural Disaster reduction and economic Planning

Remote sensing can be used to prepare hazard maps, determine locations and spatial distribution of disaster affected areas; identify population at risk from disasters, design and implement natural disaster planning.

Remote sensing technologies are continuing in ways that will increase their value to resource managers. This is because these systems will enable users to discriminate a greater number of features more quickly and will also enhance decision-making process. Simultaneously, research continues into new ways in which remote sensing technologies can be used to facilitate strategic planning for environment and development issues. GIS technologies also continue to evolve as more powerful computer hardware and software systems are developed.

Powerful computers can make it easier to integrate remote sensing data into a GIS, perform modeling and statistical analysis and convert larger volumes of data into customized information. Hence, in economic planning, it should be possible to identify optimal sites prone to environmental vulnerability.

3.2 Water and Coastal Zone Management

Remote sensing and GIS can be used to estimate water supplies and upgrade knowledge of hydrographic systems, map flood plains, inventory lakes and wetlands, measure soil moisture, estimate snow-melt run-off, assess regional water demands and supplies; develop plans fro more efficient use of surface and ground water resources; and investigate sources of water contamination and develop appropriate prevention mechanisms.

3.2.1 Constraints

The commitment of the Kenya Government towards the establishment of facilities related to space science and technology has underlined the Government's determination in the exploitation of space science and technology for provision of impetus towards rapid national development. While this is a major step in the right direction, a number of issues have hindered full exploitation and optimization of the benefits that can be accrued from this effort. These issues are:

(a) Lack of a space policy aimed at guiding and giving direction towards development of all space science and technology related matters.
(b) Lack of a comprehensive science and technology training curriculum, equipment and facilities in many tertiary institutions.
(c) Inadequate facilities for reception, processing and interpretation of space data
(d) Lack of co-ordination in space related matters between different government departments and agencies dealing with space science and technology.

4.0 Institutional Framework

There are a few institutions in Kenya involved in day-to day applications of space science and technology. They include the Department of Resource Surveys and Remote Sensing, the Kenya Meteorological Department, the Regional Centre for Mapping of Resources for Development, the San Marco Project- Malindi, the Survey of Kenya and national universities among others.

4.1 Department of Resource Surveys and Remote Sensing

The Department of Resource Surveys and Remote Sensing (DRSRS) was established in 1976 with funding from the Government of Kenya and Canadian International Development Agency (CIDA). Its main function was to monitor the condition and trend of rangelands through livestock, wildlife and vegetation surveys using remote sensing, aerial surveys and background sampling techniques. This was a response to the 1972 Stockholm Conference, which created the United Nations Environment Programme (UNEP).

The DRSRS is mandated with the collection, storage analysis and dissemination of geospatial information on natural resources to facilitate informed decision making for sustainable management and development with the major aim of alleviating poverty and environmental degradation. The data collected by the department forms the basis for preparation of polices and development plans for decision-making.

The department programmes and activities are executed in six major themes namely: aerial surveys, ground surveys, remote sensing, data management, publications and training and air services programme.

4.2 Kenya Meteorological Department

Kenya's Meteorological department is the pillar in the worldwide efforts to monitor, understand and predict weather and climate for the implementation of reliable and suitable development initiative.

In addition to meteorological and hydrological services, the Kenya Meteorological Department also provides oceanographic and other environmental data including vegetation-monitoring services. Public services include the daily weather forecasts for public welfare, aviation and marine users and weather related hazards. Short range, medium and long-range weather forecasts are integrated into the national economic planning and management programmes.

The Department uses data from meteorological satellites to assist in weather prediction and monitoring.

4.3 Regional Center for Mapping of Resources for Development (RCMRD)

The Regional Center for Mapping of Resources for Development (RCMRD) previously called Regional Center for services in Surveying, Mapping and Remote Sensing (RCSSMRS) was established in Nairobi, Kenya in 1975 under the auspices of the United Nations Economic Commission for Africa. It is an intergovernmental organization and is managed by Member states. Currently the Center has 15 contracting member States.

4.3.1 Objectives

The RCMRD has the following objectives: to develop and constantly update harmonized and standardized land resources and urban development digital data and information infrastructure for the region based on demand; to develop a regional early warning system for food security, environmental monitoring and disaster management using mainly satellite data; to undertake projects for creation of spatial information system suitable for development planning at regional and community levels; to strengthen and harmonize the fragmented regional and African data using accurate geodetic GPS techniques and research into the field and data processing methodologies; to develop capacity and capability in the maintenance of surveying and mapping equipment and offer advisory and maintenance services to the member States; to undertake research and training in the application of geo-information in land resources and urban development mapping and assessment for sustainable development;

4.3.2 Achievements

Since the Center was established, it has been very instrumental in capacity building in resource surveys, mapping, remote sensing, GIS and natural resources assessment and management in Africa. To date, the Center has trained about 3000 technical officers

from its member States and other African countries in these fields. The Center has also implemented numerous projects on behalf of its Member States and development partners.

4.3.3 The Center's Core Programmes

The RCMRD has the following core programmers: resource mapping; remote sensing and environmental management; engineering services; human resources development and training;

(i) Resource Mapping Programme

The Center's objective is to generate resource data and information that are demand-driven and are of immediate use for development; be in a position to advise the users on the options and optimum applications of such information; and participate in advising planners in member states on the implications of the use of this information in the national development process. The programme will also focus on generation of land information through GPS and other survey and mapping techniques.

(ii) Remote Sensing and Environmental Management Programme

This programme seeks to increase the awareness of the environmental concerns and the new development in environmental information technology. The programme will, through such activities as environmental data archiving; maintenance of early warning systems for food security; monitoring of the environment; collection, compilation and utilization of remote sensing data from environmental assessment; provision of support to remote sensing and GIS sections in member states; and research in environmental assessment and management address the urgent environmental problems in the member states.

(iii) Engineering Services Programme

In line with the current trend of equipment design which is based on the application of digital and microprocessor technologies, this programme aims at expanding the Center's capacity and capability to service and maintain automated equipment and hardware utilized in resource mapping and environmental management. This programme is expected to become fully fledged and technically dynamic providing service and maintenance solutions on all types of equipment, both old and modern, used for mapping and remote sensing. It is expected to constantly update its capability and keep abreast with the changes in technology.

(iv) Human Resources Development Programme

This programmed at capacity building of professionals from member states in the field of remote sensing, surveying and mapping techniques.

4.4 **The San-Marco Project, Malindi**

The san-Marco Project has the following components:

i) **The sea segment with five platforms**

The sea segment is equipped with launch facilities able to accomplish orbital and sub-orbital (sounding rockets) launches for scientific payloads. It is made up of five platforms (three floatable and two fixed).

ii) **The Land segment**

The land segment has three ground stations for satellite data acquisition, receiving and recording and real-time relay transmission. One of the three stations is dedicated to remote sensing data acquisition and processing.

The San-Marco project also has a ground station dedicated to the acquisition of the scientific satellite SAX for X-ray astronomy.

4.4 IGAD Climate Prediction and Application Center (ICPAC)

The major goal of the ICPAC includes improved and enhanced sub-regional and national capacities for the use of climate knowledge towards providing c*limate information. prediction products and services, early warning, and related applications, as a contribution to sustainable development in the IGAD Sub-region.*

The three parallel objectives of ICPAC are as follows:

i) To improve the **technical capacity** of producers and users of climatic information, in order to enhance the input to and use of climate monitoring, production and early warning products;

ii) To develop an improved, proactive, timely, broad-based system of information and product **dissemination and feedback**, at both sub-regional and national scales through national partners.

iii) To expand the knowledge base within the sub-region in order to facilitate informed decision making, through a clear understanding of climatic and climate-related processes, enhanced research and development, and a well managed reference archive of data and information products.

4.4.1 ICPAC products

4.4.1.1 Monitoring of past climate:

The recent past climate over the Horn of Africa is monitored on a deckadal (ten day), monthly and seasonal time scales in order to detect the evolution of any significant

anomalies that could impact negatively on the socio-economic activities of the region as follows:

- Dekadal, monthly and seasonal summaries of rainfall and drought severity.
- Monthly temperature anomalies.

4.4.2. Current State of Climate

The current state of climate is monitored and assessed using climate diagnostics and modeling techniques. These are derived from information on the state of the Sea Surface Temperature anomalies over all the major oceans basins, surface and upper air anomalies of pressure, winds and other climate parameters.

4.4.3. Prediction Products

These are derived from statistical models run at the Center and dynamical model outputs from advanced centers on a decadal, monthly and seasonal time scales. The Center has recently acquired a super computer to enhance its dynamical modeling capability and is in the process of calibrating a regional spectral climate model for the Horn of Africa that will be implemented in the near future. The prediction products are provided through outlooks for a decadal, month and season. Consensus pre-season climate outlook are also organized in conjunction with the major climate centers worldwide in order to derive a single consensus forecast for the region.

4.4.4. Impacts

An assessment of the vulnerability together with the current and potential socio-economic conditions and inputs (both negative and positive) associated with the observed and projected climate anomalies is also made on a decadal, monthly and seasonal time scales.

These products are disseminated to all national meteorological and hydrological services of the participating countries to serve as an early warning information and products for policy makers, planners and health, energy, agricultural and water resource sectors, farmers as well as research institutions among others.

4.5. The National Disaster Operations Center

The National Disaster Operations Center was founded in January 1998 under the Office of the President. The Center is involved in planning and response coordination in the event of occurrence of a disaster.

Before establishment of the Center, disasters in Kenya were dealt with as they occurred and mostly as a response.

The Center has initiated the following activities:

(i) Redrafted a policy and bill for disaster management
(ii) Commenced hazard and vulnerability mapping
(iii) Formed provincial and district disasters management committees all linked to the National Disaster Operations Center
(iv) Carried out a thorough inventory for planning and targeting for mobilization on nationwide awareness campaigns
(v) Remolded individual ministerial and departmental responsibility refocusing on when they may be required to act collectively.
(vi) Some government departments such as Department of Defense, police, airport and ports authorities have formed specific sub departments with a responsibility for planning and disaster response.
(vii) Intensified networking.

In order to harmonize the above-mentioned activities, a Minister of State in the Office of the President handles disaster management in Kenya.

At present, the Center is inadequately funded and understaffed and lacks capacity to handle remotely sensed data.

5.0 Capacity Building in Space Science and Technology in Kenya

In order to sustain the efficient and informed application of any technology, there must always be a critical mass of trained personnel in the particular discipline. Likewise, to sustain the space industry, there is need for experts in the applied as well as in the pure science aspects of space technology. Specifically, there are to be found in space industry specialists in astronomy, astrophysics, astronautics, remote sensing, engineering, computer science, aeronautic engineering, as well as experts in the fields of natural sciences, earths' science's, and appeal sciences among others.

5.1 Space Science Education

Remote Sensing and GIS are important components of space science education. This is because remotely sensed data is important for providing an ideal view of the earth for various studies needing synoptic or period observations such as geology, forests, water resources, agriculture, range management, floods fires, and volcanic eruptions among others.

Lack of qualified teachers in primary, secondary schools and tertiary institutions such as universities, polytechnics and institutes of technology poses a serious problem to the country as far as the development of space science and technology is concerned.

In order to cope and manage natural disasters, there is need to develop adequate capacity in space science and technology through education, training and provision of equipment in the field of space science and technology.

In order to provide opportunities for students in space science and technology to gain necessary knowledge, experience and application skills in space science and technology, curricula should be developed for teaching space science based subjects. Additional curricula should also be prepared for training experts and professionals in space science and technology.

Capacity building in space education should be able to provide the country with professional scientists, engineers and technicians in the country who are capable of handling and interpreting space based data and information.

Equipment required for space based activities include the following among others: disaster monitoring satellite; micro-computers with modems and CD ROM players; internet capability data analysis workstations; image processing workstations; GIS terminals; laser and colour printers; graphic analysis and display; radiometers; 35 mm cameras; GPS receivers; topographic maps; mirror stereoscopes; HRPT ground system; and automated AVHRR among others.

5.2 Institutional Capacity Building

There are several institutions the public, regional and private in Kenya involved in either training or provision of services in the area of space science and especially remote sensing and Geographical Information Sciences. These institutions include the following: DRSRS; the Survey of Kenya Institute of Surveying and Development, (CETRAD); the Survey of Kenya (Kenya Institute of Surveying and Mapping), the KMD, ICPAC; the RCMRD; the San-Marco Project, Malindi, national universities, and polytechnics.

In many cases, these institutions lack capacity in terms of qualified personnel and the necessary infrastructure to facilitate acquisition, storage, processing and interpretation of remotely sensed data. It is therefore necessary to strengthen and encourage these institutions to diversify their training programmes in the space science and technology.

5.3 Constraints

The limited application of space technology in the country has to a great extent been contributed by lack of a sufficient base of qualified personnel and lack of the necessary infrastructure. There are presently a reasonable number of Kenyans with expertise in certain aspects of space technology, such as in remote sensing, telecommunications, meteorology, and mapping and positioning. However, there are practically no dedicated experts in space science as such. Further, there are limited facilities for studies in the applied space sciences, but even these are often very limited in scope and continuously do suffer from lack of adequate facilities.

There is, therefore, a clear need for coordinated programme for the training of experts in the area of space sciences and technology in Kenya. This will call for the expansion of already existing facilities for training in space-related sciences in the country.

6.0 Recommendations

6.1 Training Programme

The following training programme has been suggested in order to enhance capacity in space science and technology for the natural disaster management in Kenya.

6.1.1 Technicians

The objective is to produce technicians with adequate theoretical background and practical skills in remote sensing technology.

No institution in Kenya presently provides training that meets all the requirements of training for technicians.

6.1.2 Basic and Applied Sciences

The objective is to produce high-level manpower that can interpret, analyze and apply data and information provided by satellites and to conduct advanced scientific research in their respective areas of expertise.

6.1.3 Resources Surveys and Remote Sensing

The objective is to provide for education and research in the application of aerial photography and other remote sensing techniques to forestry, soil survey, ecology, resource management, rural survey, urban planning, environmental management, and water resources and natural disaster management.

6.1.4 Meteorology and Atmospheric Sciences

The objective to provide for education and research in the physical processes and dynamics of the atmosphere and their interaction with the earth's surface ecosystems and climate change process.