Mainstreaming the use of geographic information in a developing country context: examples from Rwanda

by Felicia Akinyemi, Kigali Institute of Science and Technology

Abstract

Advances in information and communication technology coupled with the digital revolution have fundamentally impacted on geographic data production and information use. Geographic information science (GISci.) refers to a body of integrated disciplines such as photogrammetry, remote sensing, geographic information system/land information system and other aspects of surveying and mapping sciences such as geodesy, surveying and cartography, with information and communication technology. Geographic information (GI) is becoming more important everyday at all levels of society. It has a central role in supporting economies, improving business effectiveness in the private sector, enabling more efficient decision-making and increasing citizens' involvement in governance. This paper traces the development of GISci. as well as the development and use of Geographic Information Technologies with special reference to Rwanda. Awareness of the importance of GI is currently high in Rwanda especially since 2006 when the first SDI conference was organized. As a consequence of this increasing awareness, the range of GI applications is increasing by the day. There is a huge demand for GI specialists in organizations which in turn is necessitating the design and development of different educational and training programs for developing human capacity in the field of GISci. In its examination of available educational and training programmes, it is found that courses are either completely focused on GISci or GISci courses are being offered as part of undergraduate or post-graduate programmes in various fields. This paper contributes to the better understanding of the situation as regards the development and adoption of GISci. in a developing country context.

Keywords

geographic information, geographic information science, education, training, technology, Rwanda

Introduction

It is increasingly recognized that geographic information (GI) and spatial analysis lie at the heart of nearly all major international peace, global health and economic development problems [1]. This is because GI is vital to making sound decisions at the local, regional, and global levels. Crime management, business development, flood mitigation, environmental restoration, community land use assessments and disaster recovery are just a few examples of areas in which decision-makers are benefiting from GI use, together with the associated infrastructures such as spatial data infrastructure (SDI) that support information discovery, access and use of information in the decision-making process [2]. GI has a central role in supporting economies, improving business effectiveness in the private sector, enabling more efficient decision-making and increasing citizens' involvement in governance that improves quality of life [3, 4]. Apart from the use of Geographic Information Technologies (GIT) in the academia, public and private sector institutions as well as community based grassroots groups such as local level nonprofit agencies, voluntary associations and non-governmental organizations (NGOs) are harnessing the power of location to leverage their varied operations. It is important to note that a growing number of grassroots organizations are beginning to use geospatial data and technologies in local planning, problem solving and service delivery [3]. There is need to transform GISs into community information systems to help empower communities in their activities [5].

Geographic data and information are recognized by the Government of Rwanda (GoR) as essential for socio-economic planning and development. It is seen as a part of the nation's information infrastructure and it should be accorded the same level of support as the other elements of the infrastructure [6]. Over the years, GI applications in Rwanda are increasing and these applications are as varied as the types of data that are spatial in nature. This increase is due in part to the current drive by the government to promote evidence-based decision-making within the context of an information rich, knowledge-based economy. Evidence based decision-making requires the use of accurate data in the scientific analysis of a given situation in order to derive results that could feed into government policies. Already, the spatial dimension to problem solving in health, poverty reduction and addressing complex national development issues is known. Consequently, most institutions in Rwanda are aspiring to use geographic information and communications technologies (Geo-ICTs) such as GIS, remote sensing, cartography, database management technologies, in their day-to-day activities, producing geographic data of different themes and presenting results as maps in reports [7].

This paper seeks to describe the development of GI and use as well as educational and training opportunities available locally in Rwanda. The setting of GI development is described within the context of different arrangements. The paper outline is as follows: a brief background is given about how GI developed in Rwanda, different initiatives and types of existing GI applications are described. Also, the available training and educational courses at both undergraduate and post-graduate levels are presented. The study contributes to ongoing efforts in advancing GISci. by improving the understanding of the driving factors and the institutional structures supporting its adoption in a developing world context.

Background to the development of GI in Rwanda

To manage a country well, governments as well as other stakeholders require information such as about the people, the land where people live and work, location of administrative boundaries and of objects such as buildings and roads, ownership (land tenure), value and (possible future) use of the land. These types of core data/information can help governments to determine how they deal with land in policies designed to combat poverty, to achieve sustainable settlement goals and to manage natural resources. To support the Rwandan quest to use Geo-ICT in research, decision making and development, development of human capacity through education and teaching is essential. Due to the wide range of fields in which Geo-ICT was starting to be used, the Geographic Information Systems and Remote Sensing Research and Training Center was created in 2001 at the National University of Rwanda (CGIS-NUR). Its establishment is part of the university's strategy to build ICT capacity and infrastructure to support teaching, learning, research, management and community development to meet developmental challenges at different levels in society [8]). The centre has supported key national institutions in producing various spatial datasets. In recognition of the centre's role of promoting the use of GIT and transforming Rwanda into a spatially IT literate one, it won a Special Achievement in GIS award at the ESRI User Conference in 2006.

In 2005, a Geo-Information Science based Education and Research project was embarked upon by the CGIS-NUR in cooperation with International Institute for Geo-Information Science and Earth Observation (ITC), University of Twente, The Netherlands. This development project was funded by the Netherlands Program for the Institutional Strengthening of Post-secondary Education and Training Capacity (NUFFIC) for 4 years. It facilitated the development of some GISci. modules incorporated in various undergraduate and postgraduate programmes. New GISci. based programmes were also developed as well as short-term, tailor- made trainings. To run these new programmes, it was crucial to develop the necessary manpower. The project improved the GISci. capacity by providing MSc and PhD fellowships and training faculties in short courses. Overall, 1 PhD candidate, 14 Masters and 22 short courses students were trained under this project in The Netherlands and South Africa in the GISci. Science fields of Geo-informatics, Geographic Information Management, Environmental Management, Urban Planning and Land Administration. Among others, the project helped to develop infrastructure and facilities at the National University, identified and engaged stakeholders which increased awareness of Geo-ICT and built a network of users in Rwanda. Furthermore, long-term south-south partnerships between the centre and regional partners were established [9].

Awareness of the importance of GI is currently high in Rwanda especially since 2006 when the first spatial data infrastructure (SDI) conference was organized. This conference raised the awareness of GI use outside the academia. It was aimed at kick-starting the establishment and maintenance of a national spatial data clearinghouse and defining a spatial data policy for the country. Elaborating further on this initial initiative [10], the specific objectives were to:

- Develop a common understanding of the concept of SDI and its implication for implementation in Rwanda
- Assess national institutions hosting geographic data and attributes, their actual roles and constraints (collection, processing/analysis, archiving, integration/standard, sharing and accessibility)
- Encourage the collection, processing, archiving, integration, and sharing of geospatial data and information using common standards and interoperable systems and techniques and accessible via the web by:
    - Discussing SDI implementation policies and institutional aspects (legal framework, information policy, education, financial aspect)
    - Discussing SDI implementation technological aspects (clearinghouse, metadata, standard, Geo-ICT infrastructure, internet and network connectivity)
- Path the way on how a SDI framework, metadata system and clearinghouse could be implemented in Rwanda with emphasis on the following:
    - Identify how the GoR can support the process
    - Identify how education and research can support the process

In the absence of a traditional national mapping agency (NMA) in Rwanda to produce maps of various kinds, the National Land Centre (NLC) was created in 2007, now a component of the Rwanda Natural Resources Authority (RNRA) under the Ministry of Natural Resources. It is the government institution in charge of Geo-ICT and has in its mandate the production of all geodetic, topographic, hydrographic and cadastral surveys and mapping in relation to the land and water resources of Rwanda. Ongoing is the land tenure regularization process whereby all lands are to be registered and titled. It is also presently compiling and maintaining an inventory of land registration and preparing land use maps and plans for Rwanda [11]. The NLC also received a Special Achievement in GIS award at the ESRI User Conference in 2011 for its leading role in Geo-ICT use in Rwanda.

These and many other efforts actually acted as catalyst in raising awareness as regards the need for GI in Rwanda. As this awareness is increasing, so is the demand for geographic data increasing.

Objectives

The study objectives are to:

- Examine the modalities of producing geographic data and information in Rwanda
- Identify the types of GI based applications
- Identify GI based courses available locally

Geographic data production and availability

The range of existing geographic datasets can be easily deciphered by the different ministries and institutions producing them (see Table 1). Table 1 shows selected datasets being produced. This system of geographic data production in Rwanda is best described as mandate driven because government ministries and institutions produce only datasets relating to their domain. This system differs from that in which NMAs play the primary role of producing various maps and fundamental datasets.

There is an increasing demand for use of GI in Rwanda as in other parts of the world. As a result, an efficient way of accessing existing data is required. In 2009, a web based catalogue service known as the Rwanda Metadata Portal – RMP was developed to ease the discovery of existing spatial data on Rwanda [12]. Prior to the RMP's development, no comprehensive inventory of available geographic datasets existed on Rwanda. Now that the discovery of geographic data is greatly enhanced, it is still a challenge for users to access existing data as most organizations lack explicit policies for data sharing. Also, there is no national spatial policy. In the absence of policies, users experience difficulties in accessing data and data producers cannot properly respond to users' requests [13].

Types of GI applications

Rwanda is faced with many challenges, especially poverty and environmental challenges such as water pollution, soil fertility decline, land allocation and tenure security**,** deforestation, energy shortage, wetland management, protected area encroachment, biodiversity loss and need for conservation, combating soil loss and erosion, forest fires, etc. At the root of most of these problems is natural resource overexploitation due to population increase and pressure on land. There is the tendency to deplete and degrade tropical forest for example, due to clearing for agriculture, pastures, timber products and infrastructure development, as a consequence of the local population depending more on exploiting forest resources for sustenance. Forest degradation is characterized by a reduction in forest quality and biomass by an opening up of the canopy [14, 15, 16]. The situation is exacerbated by the impact of climate change as about 85 to 90% of the population practice rainfed agriculture which is affected by climate variability. For example, change in onset of rain can cause serious crop losses during a planting season, which is a great threat to food security. Farmers must depend on the vagaries of weather and most chronic forms of poverty in Rwanda are related to seasons and availability of rain as agriculture is dominantly rainfed [17, 18]. The impacts of Rwanda's experience of genocide and wars years ago are also significant. In 1993, protected areas covered 15% of Rwanda's total land area, but by 2006, this shrunk to 8% mainly due to the need for land for resettling refugees returning from other countries.

Date	Custodian	Dataset	Attribute
2001	Ministry of Public Works, Transport and Communication (now Ministry of Infrastructure -MININFRA) and CGIS-NUR	Administrative map of Rwanda	Scale 1/250 000
1988 2008	MININFRA – Electrogaz (now Electricity, water and sanitation authority, CGIS-NUR	Power lines	Existing and planned electricity power lines
2007	Ministry of Natural Resources (MINIRENA)	Forest cover mapping	1:40 000 maps at national, province, district levels
		FAO AFRICOVER data for Rwanda	
2009, 2010	National Land Centre (Rwanda Natural Resources Authority -RNRA) under Ministry of Natural Resources	Fundamental datasets - orthophotos - land parcel boundaries - national land use and development master plan - topo maps	Scale 0,25 m with about 97% national coverage 1:2000 for rural and 1:1000 for urban 1:2500 1:50 000
2007	Ministry of Commerce, Industry, Investment Promotion, Tourism and Cooperatives (MINICOM)	Rwanda trade map	- Trading centres/ zones - Days of operation - Major products and services available - Existing channels of distribution - Existing trading opportunities - Categories of traders (wholesalers etc. - Storage facilities
2002, 2008	MINEDUC (Ministry of Education)	Primary and secondary schools	GPS points of schools location
1992, 2000/ 2006	MINAGRI (Ministry of Agriculture and Livestock), [19]	Soil map, digital soil database	Scale 1/250 000, 1/50 000
Many years	National Institute of Statistics - NISR (former National Census Bureau)	Spatial sampling survey frame, administrative boundaries to the 5th level, social and cultural datasets	Population census data, household living conditions survey, demographic household survey

Table 1: Selected geospatial datasets on Rwanda. (Source: Akinyemi and Kagoyire 2010).

To combat these and other challenges, the government is promoting evidence-based decision-making within the context of an information rich, knowledge-based economy. Evidence based decision-making requires the use of accurate data in the scientific analysis of a given situation in order to derive results that could feed into government policies [12]. The role of geospatial data and technologies in planning and managing development strategies successfully is evident. About 80% of information used at all levels (local, regional, national, continental and global levels) of development planning and decision making are spatial in nature [20, 21, 22].

GI applications in Rwanda are in numerous fields such as Utility [23]; agribusiness in the coffee sector [24]; land tenure regularisation [25, 26, 27]; spatial data infrastructure [7, 12, 13]; forest cover mapping [28, 29]; education such as K-12 GIS for secondary schools [30, 31, 32]; International GNSS Service (IGS) geodetic network [33, 34]; health geoinformatics [35, 36]. For details, see Table 2.

Year	Sector/ Application	Organisations involved	GI applications	Products/URL
2005 – 2007	Natural resource management/ Forest cover mapping	MINIRENA, CGIS-NUR, Institut des Sciences Agronomiques du Rwanda (ISAR), International Institute for Geo-Information Science and Earth Observation, Netherlands Embassy	- Mapping of forests resources in Rwanda at scale 1:25 000 to support the National Forest Action Plan (2005-2008) - Capacity building in the application of RS and GIS for forest inventory and mapping	National forest map: - Forest status mapping - Forest change map - Developed methodology to evaluate agro-forestry at farm level using very high resolution datasets - Proposed afforestation zones based on three criteria, namely: slope threshold, hilltops, buffer zones around roads, rivers and open water
2007 – present	Education/K-12 ArcGIS in secondary schools project	Ministry of Education (government), *ESRI Inc. (private sector providing software grant), ESRI Germany GmbH (private sector), CGIS-NUR (university)	**Goal: comprehensive integration of GIS in the field of education** - Incorporation of GIS in ICT curriculum in Secondary schools, - Annual Esri summer camps for high school students, - Periodic GIS training for teachers, - Curriculum development/production of Rwandan GIS textbook	2011 - Tourist map for Kigali 2009 Lake Muhazi: -http://www.esri-rwanda.com/downloads/news/articles/2009_RW_group1.pdf - http://www.esri-rwanda.com/downloads/news/articles/2009_RW_group2.pdf - http://www.esri-rwanda.com/downloads/news/articles/2009_RW_group3.pdf - http://www.esri-rwanda.com/downloads/news/articles/2009_RW_group4.pdf
2007	Utility/ Regional Rusumo Falls Hydroelectric and Multipurpose Project	Norwegian Water and Energy Directorate and CGIS-NUR	- Predict the areas that are vulnerable to erosion - Quantify sediments yield from the Rusumo catchments expected to reach the future hydropower reservoir/dam on the Akagera River.	Results are slope gradient, DEM, soil erosion risk map, soil type, soil erodibility, soil loss
2008	Health/Malaria control	National Malaria Control Programme (TRACplus Malaria Unit in the Ministry of Health) and CGIS-NUR	- Capacity building on epidemiology monitoring using GIT technologies - GIS malaria database creation - Estimate epidemiological risks of malaria over time and over space - Guide malaria control interventions	Malaria relationship with environmental factors: - Land cover (tea and rice plantations, permanently or temporarily flooded lands) - Distance to rivers - Elevation and - Rainfall - NDVI (Normalized Difference Vegetation Index)
2008	Utility/ Rwandan Electricity and Water utility sector	CGIS-NUR, Electrogaz (now Electricity, water and sanitation authority - EWSA), Ministry of Infrastructure and Belgian Technical Cooperation	- Mapping medium and high voltage electricity network (1800 km, about 690 km of power lines, 5200 pylons and 323 transformers). - Capacity building by training technicians in the use of basic GPS equipment	
2008 – 2010	Agribusiness/ Use of GIS for the Determination of Rwanda Coffee Appellation Regions	CGIS-NUR, OCIR CAFÉ, USAID Sustaining Partnerships to Enhance Rural Enterprise and Agribusiness Development	**Goals:** - Identify unique coffee zones or appellation regions in Rwanda based on agronomic, environmental and topographic variables - Provide the coffee sector with discrete "branding" parameters to increase consumer recognition of Rwandan coffee for marketing and trace-back to origin.	**Data layers required:** **-** Elevation (slope, exposure) - Soil (nature, texture, Ph) - Climate (pmm, t^0) - Accessibilty to transport and washing stations - Coffee varieties - Cultural practices http://www.new-ag.info/08/05/develop/dev1.php

			- Determine the capacity of Rwanda's coffee zones to provide sufficient quantities of quality water, sufficient supply of coffee, energy, road access, and inexpensively treat washing station effluent.	http://www.itu.int/ITU-D/emergencytelecoms/events/kigali/presentations/cgis_nur_disastermanagement_2008.pdf
2009	SDI/ Rwanda metadata portal	CGIS-NUR/GSDI	- Improve the metadata status of existing geospatial datasets on Rwanda - Raise awareness about the benefits of web-based metadata catalogues	**-** Inventory of existing geospatial data on Rwanda - Creation of a web-based metadata catalogue allowing advanced search - Eased geospatial data discovery http://www.cgis.nur.ac.rw/geonetwork/srv/en/main.home http://memberservices.gsdi.org/files/?artifact_id=809
2009 to present	Land tenure regularisation	NLC	**Goal: Establishing rights to land,** establishing the legal basis for occupancy of a given piece of land, and granting of rights to land to entities (people, organizations, etc.) by issuance of legal title documents formalising their existing rights to land. - Use of high resolution orthophotos and satellite imagery in field work for demarcating land parcel boundaries - Training local residents to use images to identify their lands	- GIS and remote sensing has a key role enabling the demarcation of about 50 parcels per day by a single team on the field - Produced index maps - Digitized the parcel boundaries
2009	IGS Network station (NURK) located in Kigali	CGIS-NUR, German Research Centre for Geosciences (GFZ) Potsdam	- Generating precise data for correcting GNSS data differentially - True global navigation satellite systems (GNSS) station transmitting both GPS and GLONASS data	ftp://igs.ensg.ign.fr/pub/igs/data
2009	Health Geoinformatics/ Spatial dimension of public health: Access to clean water	University of Redlands, Loma Linda University (www.llu.edu/llu/sph), CGIS-NUR, Millennium Villages Project (www.millenniumvillages.org).	Mapping Mayange sector water sources and collecting water use information	Providing accurate locations of where people get water. E.g. identifying areas of water contamination and support decisions about improving water quality, such as protecting an open pit water source or where to dig for water http://www.esri.com/news/arcwatch/0909/rwanda.html
2012	Construction permit online portal, Training by ESRI Rwanda.	One stop centre, Kigali city council	MIS integrated with GIS	Construction permit application all online processing, integrated with GIS to map areas where development is ongoing for use in infrastructure planning for Kigali City.

Table 2: Some GI applications in Rwanda. (Jack Dangermond, CEO, Esri Inc. during his visit to Rwanda in 2006 granted every secondary school the free use of ArcGIS software licence.)*

GISci. based education and training programmes

A major goal for developing GISci. based education and training programmes locally is to create a critical mass of GI technicians, professionals and specialists at various levels. However, a major challenge being faced is the near absence of GI experts in the country. It is not uncommon to place advertisement for recruiting GI specialists in some fields and not get any response at all. The demand for GI specialists is by far beyond the supply. It is evident that for any programme or project to take off successfully, the initial step is to focus on building human capacity in GI. This is a challenge that requires huge investment in time and finance.

The beginning of this century saw a huge leap in the right direction with the design and development of GISci. courses (both short-term and long-term). A short-term course could run for a week (5 working days), whereas a long-term course spans 2 years such as MSc. programme. GI education and training programmes are now available focusing on providing training on the job (short courses), national diploma (2-years), undergraduate (4-years) and post-graduate (certificate, diploma and MSc.) (see Tables 3, 4 and 5). It is noteworthy that these courses are either completely focused on GISci or GISci courses are being offered as part of undergraduate or post-graduate programmes in various fields. GISci. courses are introduced in various undergraduate programmes in recognition of the fact that GISci. technical skills are needed and applicable in virtually all fields of human endeavour. Upon graduating, a bachelor's holder would have acquired some GISci. skills due to the courses undertaken. Some students are thereby inspired to go on for further studies in GISci. while specialising in their background fields.

Conclusion

The creation and use of geographic data and information at all levels of society for socio-economic planning and development is well recognized the world over. With focus on a developing world context, this paper examined the development and use of GI in Rwanda. It also examined the education and training situation.

As awareness of the importance of GI is currently high in Rwanda, so is the increasing demand for geographic information. To successfully man a GIScience (GISci.) based project or programme, the need for capacity building aimed at training needed GI specialists is evident. In other words, this is the first necessary step to ensure the successful implementation of projects. In order to develop a critical mass of GI technicians and specialists, Rwanda has initiated and supported the design and development of different educational and training programmes locally in the field of GISci. These programmes are in the form of on-demand short courses which target staff from ministries, NGOs, etc. for training on-the-job, or long-term in nature which are either focused entirely on GISci. fields or incorporates GISci. courses into various undergraduate and post-graduate programmes. The paper further described the development of several initiatives which served as catalyst to the adoption of geographic information technologies in Rwanda.

Year	Programme	Exit award	Objectives/content	Institution	Eligibility
2011	Introduction to GIS in Health Informatics including epidemic monitoring and control	MSc. Health Informatics (HI), Post-graduate diploma HI, Post-graduate certificate HI	Acquisition of skills in various data, networking, and enterprise architecture in healthcare system	Kigali Institute of Science and Technology (KIST), Faculty of Engineering, E-Health Centre of Excellence	Bachelor in science, technology or a medical/public health area
2009	Applied Geo-Information Science	Post-graduate short-courses (certificate, diploma) in Applied GISci.	Introduction/Advance GIS, Remote Sensing (RS), Cartography, applications (environmental management, urban planning, land administration, etc.).	National University of Rwanda (NUR) (Centre for GIS and Remote Sensing)	Bachelor from any field of science, engineering, agronomy, social sciences, medical sciences
Proposed	Geo-Information Science for Environment and Sustainable Development (GIS-ESD)	MSc. GIS-ESD	Improving GI skills to meet environmental related challenges in Rwanda	NUR (Dept. of Geography, Fac. of Science - FS)	Bachelor Geography, Agriculture, Biology, Chemistry, Physics, Civil Engineering or related fields.
2009	Applied Mathematics	MSc. Applied Mathematics	Principles of RS	NUR, FS	
2006	Agro-forestry	MSc Agro-forestry and Soil Management	Applied GIS and RS for Erosion, Soil and Water conservation.	NUR, Faculty of Agriculture	
			Soil analysis and erodibility mapping.		
			RS for soil conservation		
2007	MSc. Water Resources and Environmental Management (WREM)	MSc WREM	GIS and RS and Water Resource Modelling	NUR, Faculty of Applied Science	
2009	Public Health (PH)	MSc PH	Introduction to GIS	NUR, School of PH	

Table 3: Selected post-graduate GISci. courses available locally. (Source: author's compilation.)

Commenced	Programme	Exit award	Content	Institution
2009	Civil Engineering (Year 4)	BSc. Civil Engineering	Introduction to GIS and Remote Sensing (RS)	Kigali Institute of Science and Technology (KIST), Faculty of Engineering
2011	Estate Management and Valuation – EMV (Year 2), Construction management – CMGT (Year 2)	BSc. EMV and BSc. CMGT	Introduction to Land Surveying	KIST, Faculty of Architecture and Environmental Design
2011	EMV (Year 2)	BSc. EMV	Land Information Systems	
2009	Applied Physics (Year 4)	BSc. Applied Physics	RS and GIS	KIST, Faculty of Applied Science (FOS)
2009	Applied Chemistry, Environmental option (Year 4)	BSc. Applied Chemistry	RS and GIS	KIST, FOS
2005	Agricultural Economics and Agribusiness (AEA), Soil Science and Environmental Management (SEM), Crop Science (CS), Animal Science (AS) (Year 2)	BSc. AEA, BSc. SEM, BSc. CS, BSc. AS	Geosciences and Land Use Planning	National University of Rwanda (NUR), Faculty of Agriculture (FA)
2005	AEA, SEM, CS, AS (Year 3)	BSc. AEA, BSc. SEM, BSc. CS, BSc. AS	Introduction to GIS and RS	NUR, FA
2001	Geography (Year 1)	BSc. Geography	Principles of RS. Introduction to GIS and Cartography.	NUR, Faculty of Science (FS)
2001	Geography (Year 2)	BSc. Geography	Principles of RS and Photo-interpretation. Advanced GIS and RS. Introduction to Land Administration	NUR, FS
2001	Geography (Year 3)	BSc. Geography	GIS for Urban and Regional Planning. GIS for Environmental Management	NUR, FS
2007	Biology - Botany option and Zoology option (Year 3)	BSc. Biology	Introduction to GIS	NUR, FS
2008	Civil Engineering (Year 2)	Civil Engineering	Introduction to GIS and RS	NUR, Faculty of Applied Science
2008	Applied Statistics (Year 4)	BSc. Applied Statistics	Introduction to GIS and Spatial statistics	NUR, Faculty of Economics and Management
-	Surveying and Geomatic Engineering (SGE) (4 years)	BTech SGE	---	Umutara Polytechnic (UP)
-	Building and Construction Technology (BCT) (Year 2)	BTech BCT	Surveying for construction II	UP
2010	Land survey (5 years)	BEng Land survey	Surveying, Topometry, Geodesy, Photogrammetry, RS, GIS, Cadastre	Ruhengeri Institute of Higher Education (INES)
2010	Land survey (3 years)	Advanced diploma in Land Survey	Surveying, Topometry, Geodesy, Photogrammetry, RS, GIS, Cadastre	INES

Table 4: Undergraduate GISci. courses available locally. (Source: author's compilation.)

Programme	Duration	Exit award	Target group	Institution
Introduction to GIS applied to e.g. health, agriculture, coffee sector, etc.	10 days	Certificate of attendance (COA)	Ministries, NGOs	CGIS, National University of Rwanda (NUR)
ESRI certified GIS courses	varies	COA	Ministries, parastatals, etc. e.g. KCC on the construction permit portal Apr.-June 2012 and REMA Dec. 19-23 2011	Esri, Rwanda
Introduction to GIS and spatial databases	10 days	COA	Project partners, ministries	CGIS - NUR
GIS and GPS training	5-10 days	COA	Project partners, ministries	CGIS - NUR
Introduction to GPS and instrument data collection	5 days	COA	Parastatals, district technicians, coffee sector, pyrethrum sector, electricity, regional partners focusing on biodiversity, agriculture	CGIS - NUR
Introduction to GIS and RS	5 days	COA	District staff	CGIS - NUR

Table 5: Selected on-demand short courses available locally. On-demand short courses are tailor-made and specific to the needs of the client. (Source: author's compilation).

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Contact Prof. Felicia Akinyemi, Kigali Institute of Science and Technology, felicia.akinyemi@gmail.com