DIGITAL MAPPING AND GIS EDUCATION IN DEVELOPING COUNTRIES

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ABSTRACT:

Digital Mapping for the purpose of this paper is defined in terms of operational activities involved in Digital Surveying, Digital Photogrammetry, Digital Remote Sensing and Digital Cartography. Its relationship with GIS and Computer Assisted Mapping is explained. A survey was conducted at the country-wide and tertiary institutional levels in order to provide answers to questions such as "How have the developing countries fared in the acquisition and application of modern techniques of Digital Mapping and GIS education?"
The result of the survey shows that developing countries and their tertiary institutions can be divided into four categories in descending order of advanced development of modern techniques. The fourth category represented by least developed countries needs urgent attention.
The survey also portrays North-South technical cooperation between developed and developing countries as a necessity for all developing countries for the acquisition of Digital Mapping and GIS education and its application for mapping projects. Donor countries and agencies involved in this type of cooperation are identified and commended. Possibilities for potential South-South technical cooperation amongst developing countries are also identified. The merits of multinational cooperation through regional centres and multi-institutional linkage cooperation are highlighted and encouraged.

1. INTRODUCTION

Digital Mapping for the purpose of this paper embraces Modern disciplines in the Mapping Sciences such as Digital Surveying, Digital Photogrammetry, Digital Remote Sensing and Digital Cartography. It constitutes that branch of integrated Mapping in which digitized images, digital imagery, or digital data, electronically recorded are used for making maps or for establishing positions on the earth's surface through computer processing. There are therefore two aspects of Digital Mapping - the discrete mode such as GPS whereby ground controls are established or extended and continuous mode, by which maps are produced. The common feature of these various branches of Digital Mapping is that input data are obtained, recorded, analysed and stored in digital form suitable for computer processing. These four branches of Digital Mapping also constitute the major sources of spatial information for Geographic Information System (see Figs. 1.1, 1.2). For the past two decades, the Mapping World has witnessed great strides in the development of these modern techniques of mapping. For example, photogrammetry has witnessed the transition from analog to analytical photogrammetry and from analytical to digital photogrammetry. Surveying has also been transformed from ground to space or Satellite surveying while acquisition of imagery of spatial objects has been extended from aircraft to space vehicles. Metric photos can now be converted to digital form and handled by digital image processing apart from acquisition of digital images directly through digital cameras. Manual cartographic processes have been transformed into computer assisted cartographic processes.

Explanations are given in Figs. 1.1, 1.2 as to how the various operational activities associated with the four branches of Digital Mapping are connected with GIS. The past two decades have also witnessed increased awareness of the importance of GIS/LIS as an invaluable and efficient tool for storing, retrieving, analyzing, updating and displaying spatial data. Most importantly, GIS provides a database from where maps can easily be produced and updated. Figs. 1.1, 1.2 also depict the interconnection between the four branches of Digital Mapping, GIS, Computer Assisted Mapping.

The crucial question is how have the developing countries fared in the acquisition and application of these modern techniques of mapping? What is the status of Digital Mapping and GIS in developing countries? Are these countries aware of these modern trends? Are these countries being marginalized in the adoption and application of these modern techniques? If so, how can they be assisted to come on board the modern trend? What efforts can the countries concerned make to acquire these modern skill of Surveying and Mapping? The paper provides answers to these and other related questions.

2. SURVEY OF FACILITIES AND EDUCATIONAL PROGRAMMES

A survey was conducted to assess the status of Digital Mapping and GIS education in some developing countries of Africa, Latin America, Middle East and Eastern Europe. The survey sought information concerning the availability of hardware and software facilities, training programmes, research work, GIS and Digital Mapping activities and technical assistance which are related to modern techniques in these countries. Two types of questionnaires, country-wide survey questionnaire and tertiary institutional survey questionnaire were administered in about 30 developing countries and over 40 institutions. Only 11 countries responded to the country-wide survey and about 22 responded to the institutional survey questionnaire. The criterion for being a developing country according to the paper is that the country must require technical assistance directly or indirectly to develop facilities (hardware and software) and manpower resources for Digital Mapping and GIS.

3. RESULTS OF SURVEY

3.1 Country-wide Survey

The Purpose of the country-wide survey was to identify the state of the art of Digital Mapping and GIS in some developing countries. The result of the survey as presented in Table 1 shows that developing countries can be classified into four categories.

The first group of developing countries are those in which modern techniques of Digital Mapping and GIS have been introduced in many of their mapping operations. In these countries exemplified by Brazil and South Africa, manpower development is at an advanced stage with quite a substantial number of people trained at a high level of competence in Digital Mapping and GIS. In this group there are institutions offering educational programmes in aspects of Digital Mapping and GIS up to M.Sc. or Ph.D. level. See Tables 1 and 2 for the training programmes of Brazil and South Africa. Countries in this first category are also engaged in activities covering aspects of Digital Mapping techniques such as GPS, DIP, GIS and Computer Cartography.

The second category of developing countries from Table 1 consists of countries with a lesser number of qualified people in

Digital Mapping and GIS. Their educational facilities have developed up to awarding post-graduate diplomas and M.Sc. degrees in modern techniques apart from offering courses in these techniques as an integral part of other degree programmes (see Table 2). This second group is exemplified by Nigeria and Madagascar in Table 2. Singapore should belong to this group but there was no response to the country-wide survey. In this second group of countries, manpower development in sophisticated techniques such as DIP in Photogrammetry and Remote Sensing and Inertial Surveying methods is heavily dependent on technical assistance.

Developing countries in the third group have acquired hardware and software facilities for Digital Mapping and GIS through technical assistance but are yet to develop indigenous training programmes within their countries. They are therefore still heavily dependent on technical assistance for their manpower development in modern techniques. Countries like Ghana, Chile, Bolivia, Guinea (Conakry), Ethiopia and Turkey are typical examples of this group.

The fourth category of developing countries is well illustrated by Namibia where manpower development and availability of both hardware and software facilities are almost nil. Such countries are very few but they exist as a large proportion of Least Developed Countries of the world even though this survey has not covered them. In such countries awareness of GPS, Digital Image Processing, Computer Cartography and GIS is almost nil and there is hardly any individual who has a specialized qualification in modern surveying techniques.

3.2 Institutional Survey

At the institutional level (see Table 2), four categories of tertiary institutions can also be identified. Those with advanced level training up to M.Sc. or Ph.D. level such as South Africa (University of Cape Town), Nigeria (University of Lagos), and Singapore (Nanyang Technological University) constitute the first category.

Institutions with facilities for training programmes at technologist or post-graduate diploma level form the second group. Regional Centre for Training in Aero Space Surveys (RECTAS), Ile-Ife, and the University of Ibadan, both in Nigeria, belong to the second category. The first two categories also have modern techniques as part of existing programmes at undergraduate and postgraduate levels.

The third category of institutions consists of those whose facilities are only enough to support modern techniques as an integral part of the existing degree programme such as B.Sc. (Surveying), M.Sc. (Surveying) or Inginieur Geometrie Topographie. The following institutions illustrate the third category: Institute Geographique et Hydrographique National (Madagascar), University of Science and Technology, Kumasi (Ghana),Instituto Geografico Militar, La Paz (Bolivia), University of Nairobi (Kenya) and Institute of Geodesy, Poland.

The fourth group of institutions is constituted by those without any training programme such as the University of Namibia and Al-Azhut University, Cairo (Egypt). They have no hardware or software facilities or lack the technical skills or both. From the responses to the institutional questionnaire, some of them have the manpower resources but no equipment to work with.

It is good to note that technical cooperation is an important feature of this survey and will now be discussed in the next section.

4. TECHNICAL COOPERATION

There are two types of technical cooperation covered by the survey viz. North-South cooperation existing between developed and developing countries and South-South cooperation which is sometimes desirable amongst developing countries. North-South cooperation was also surveyed at the country-wide level as well as at the institutional level.

4.1 North-South Cooperation

The result of the country-wide survey shows that all the eleven countries surveyed in Table 1 have enjoyed North-South type of cooperation in modern techniques such as GPS, GIS, Digital Photogrammetry, Digital Remote Sensing and Digital Mapping. The survey also shows that assistance received from developed countries were to facilitate manpower development and to acquire hardware and software facilities. In some cases the purpose of cooperation is to execute a defined Digital Mapping project. Thanks to donors involved in such cooperation including the World Bank, the Dutch, Canadian, French, Japanese, German, British and US governments, the UNDP and the European Union (see Table 1). At the institutional level, technical cooperations were also established usually as a tertiary institutional linkage programme sponsored by donor agencies to link tertiary institutions in developed countries to their counterparts in developing countries. All the donors mentioned above in addition to Swedish International Development Agency (SIDA), are involved at the fifteen tertiary institutions surveyed in developing countries. The purpose of cooperation is usually similar to that of the country-wide cooperation.

The cooperation between regional centres in Africa and Asia and their respective donors have also linked their participating countries in such centres with advanced technology in the developed countries. This is a very important aspect of institutional technical cooperation

4.2 South-South Cooperation

The survey questionnaire specifically requested institutions to indicate what type of technical assistance they can offer other institutions within or outside their region. It is encouraging to note that some institutions in the developing countries are quite willing to offer assistance to their counterparts within and outside their regions (see Table 2. continued). South-South cooperation is very beneficial in that a developing country or institution is more likely to adapt a new technology following the example of its counterparts in another developing country than that of its counterpart in a developed country.

5. GENERAL OBSERVATIONS AND CONCLUSIONS

The following general observations and conclusions can be made:

(a) Most developing countries have been slow in catching up with modern techniques while only a few are moving fast.

(b) Without technical cooperation (North-South), new techniques would have been near impossible in most developing countries. Thanks again to donors, Table 2 shows that institutions which have no technical assistance are also devoid of modern techniques in their training programmes.

(c) Areas where there is very little or no advancement in most developing countries are in Digital Photogrammetry, Digital Remote Sensing, and Digital Cartography. Most countries do not have higher degree training programmes in these areas.

(d) The regional centres in Africa and Asia contribute an important linkage between their participating countries and the modern technologies in developed countries. Some donors regard this as a multinational cooperation and do favour it. The regional centres at Ile-Ife, Nigeria and Nairobi, Kenya constitute a good example of this type of cooperation. Developing countries should therefore consider their participation in these centres if they have not already done so.

(e) A multi-institutional linkage of tertiary institutions in developing countries with their counterparts in the developed countries is also very crucial for developing institutions. Some donors also favour this type of cooperation.

(f) Curriculum for modern techniques can be established by institutions using the Modules established for Curriculum Development by the author (see Ayeni, 1992).

Most developing countries and institutions still require technical assistance. However, some countries and institutions which have been classified as grossly underdeveloped in this paper require special attention from both developed countries through a North-South technical cooperation and from advanced developing countries through a South-South technical cooperation.

REFERENCE

Ayeni, O. O., 1992 "Curriculum Development for Developing Countries". International Archives of Photogrammetry and Remote Sensing, Washington, DC, USA. Commission VI Vol. XXVII, pp. 227 - 234.

1. Digital Surveying (DSU)
   - 1.1 Global Positioning System (GPS)
   - 1.2 Digital Leveling
   - 1.3 Inertial Surveying

2. Digital Photogrammetry (DPH)
   - 2.1 Digital Photography
   - 2.2 Digital Image Processing (DIP)
   - 2.3 Digital Orthophoto

3. Digital Remote Sensing(DRS)
   - 3.1 Digital Imagery
   - 3.2 Digital Image Processing (DIP)
   - 3.3 Digital Image Map

4. Digital Cartography (DCA)
   - 4.1 Digitization
   - 4.2 Automated Mapping
   - 4.3 Digital Map

Fig. 1.1: Types of Digital Mapping Operational Activities

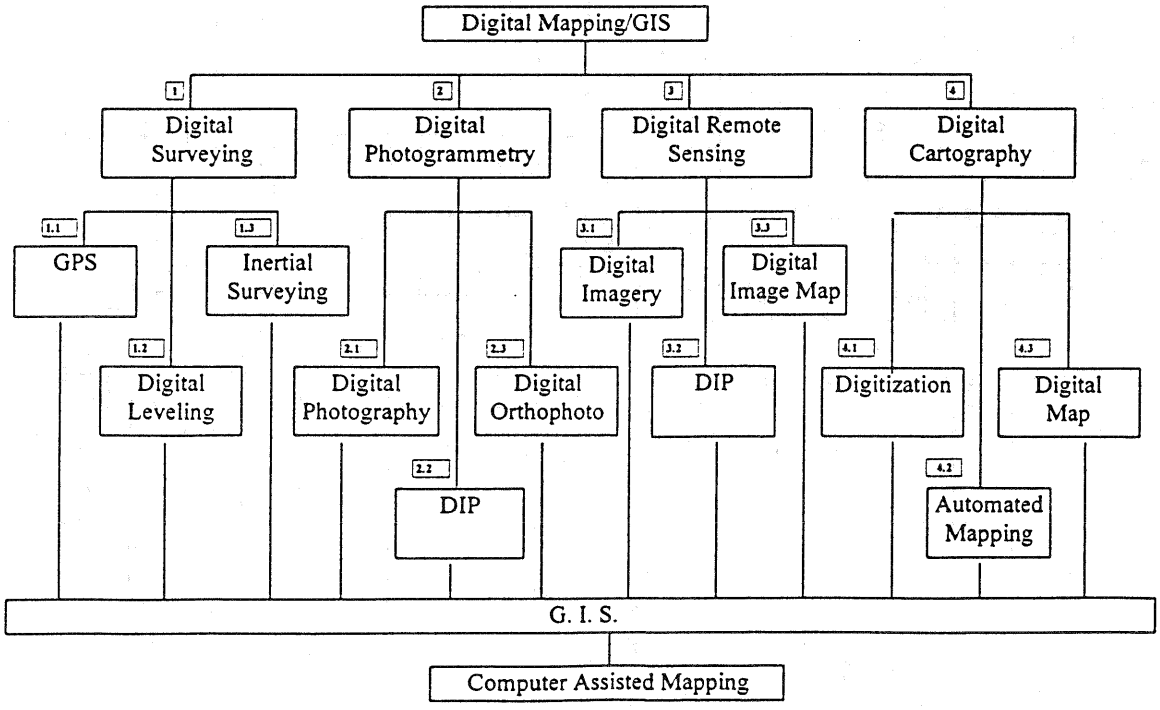

Fig. 1.2: DIGITAL MAPPING AND GIS

TABLE 1: DIGITAL MAPPING EDUCATION IN DEVELOPING COUNTRIES (COUNTRY-WIDE SURVEY) *

Country Wide Survey	Level of Understanding of					Number of Tertiary Institutions with Facilities and Training Programmes for																
	GPS	DPH	DCA	DRS	GIS	DSU			DPH			DCA			DRS			DM			GIS		
AFRICA (South of the Sahara)						PGD	MSc	PhD	PGD	MSc	PhD	PGD	MSc	PhD	PGD	MSc	PhD	PGD	MSc	PhD	PGD	MSc	PhD
1. Nigeria	VW	NW	FW	NW	VW		2								1						1	1	
2. South Africa	FW	NW	NW	NW	FW					1	1											1	
3. Ghana	NW	NW	NW	NW	FW																		
4. Guinea (Conakry)	FW	NW	FW	NW	FW																		
5. Madagascar	FW	FW	FW	FW	FW				1			1			1						1		
6. Ethiopia	NW	NW	FW	VW	FW																		
7. Namibia	NW	NW	NW	NW	NW																		
SOUTH AMERICA and the CARRIBBEAN																							
8. Bolivia	NW	NW	NW	NW	NW																		
9. Brazil	FW	FW	VW	VW	VW	1			1			1	2	2	1	4						2	1
10. Chile	FW	FW	VW	NW	-							1											
MIDDLE EAST																							
11. Turkey	FW	NW	FW	FW	FW																		

TABLE1: CONTINUED

Country Wide Survey	Number of Specialists in Modern Techniques						Technical Cooperation (T.C.) Received							
							Type of Technical Cooperation							Source of T.C.
	DSU	DPH	DCA	DRS	DM	GIS	SI/AP	GPS	DPH	DCA	DRS	DM	GIS	
AFRICA (South of the Sahara)														
1. Nigeria	20	6	4	8		15	YES	YES			YES		YES	WB, DG, EU, USAID,CG
2. South Africa	43	>20		>25		10-15	YES				YES			FG
3. Ghana	1	1	2	2		2	YES	YES				YES		USA, WB, JG, BG
4. Guinea (Conakry)	15	2	3	5		15	YES	YES		YES	YES	YES	YES	EU, USAID, FG, WB
5. Madagascar	23	8	6	11		8								
6. Ethiopia				4			YES	YES		YES	YES			DG, SIDA, FG, UNDP, GG
7. Namibia												YES		LUXEMBURG
SOUTH AMERICA and the CARIBBEAN														
8. Bolivia	20			2		5	YES	YES			YES		YES	FG, GG, EU
9. Brazil	160	40	25	10		80		YES	YES	YES	YES		YES	DG, FG, USA
10. Chile										YES				EU
MIDDLE EAST														
11. Turkey												YES	YES	FG, DG

*Footnote:

VW	- Very Well	FW	- Fairly Well	NW	- Not so Well
GPS	- GLOBAL POSITIONING SYSTEM	DSU	- DIGITAL SURVEYING	DPH	- DIGITAL PHOTOGRAMMETRY
DCA	- DIGITAL CARTOGRAPHY	DRS	- DIGITAL REMOTE SENSING	DM	- DIGITAL MAPPING
GIS	- GEOGRAPHICAL INFORMATION SYSTEM	AP	- AERIAL PHOTOGRAPHY	SI	- SATELLITE IMAGERY
BG	- BRITISH GOVERNMENT	GG	- GERMAN GOVERNMENT	EU	- EUROPEAN UNION
WB	-WORLD BANK	DG	- DUTCH GOVERNMENT	CG	- CANADIAN GOVERNMENT
JG	- JAPANESE GOVERNMENT	FG	- FRENCH GOVERNMENT		

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TABLE 2: DIGITAL MAPPING EDUCATION IN DEVELOPING COUNTRIES (INSTITUTIONAL SURVEY)*

Institutional Survey	Whether Digital Mapping Hardware and Software are available?					Which Post Graduate Programmes with Specialization in Modern Techniques?																	
	DSU	DPH	DCA	DRS	GIS	DSU			DPH			DCA			DRS			DM			GIS		
(A) AFRICA (South of the Sahara)						PG D	M. Sc	Ph. D	PG D	M. Sc.	Ph. D	PG D	M. Sc	Ph. D	PG D	M. Sc	Ph. D	PG D	M. Sc	Ph. D	PG D	M. Sc	Ph. D
1. University of Lagos, Nigeria	Y/	Y/	Y/		Y/Y		Y															Y	
2. University of Ibadan, Nigeria	Y/Y																				Y		
3. Regional Centre, Ile-Ife, Nigeria				Y/Y	Y/Y										Y								
4. University o f Science and Technology, Ghana	Y/				/Y																		
5. University of Ghana, Legon, Ghana	Y/Y																						
6. Survey Department, (GSS), Accra, Ghana			Y/Y		Y/Y																		
7. University of Malawi, Malawi																							
8. Maef Direction Nie Forets et Faune, Guinea	Y/Y		Y/Y		Y/Y																		
9. N. I. S. M. H., Antananarivo, Madagascar	Y/Y	Y/Y	Y/Y		Y/Y																		
10. Al-Azhat University, Cairo, Egypt																							
11. Ethiopian Mapping Agency, Ethiopia	Y/Y		Y/Y		Y/Y																		
12. University of Namibia, Windhoek, Namibia					/Y																		
13. University of Nairobi, Kenya																							
14. University of Cape Town, South Africa										Y	Y					Y						Y	
(B) SOUTH AMERICA																							
15. Comando de Industria Militar e Ingenieria, Chile	Y/				Y/Y																		
16. Instituto Geografico Militar, La Paz, Bolivia	Y/Y		Y/Y		Y/Y																		
(C) ASIA																							
17. Institute of Geography, Hanoi, Viet Nam			Y/Y		Y/Y																		
18. Nanyang Technological University, Singapore	Y/Y		Y/Y		Y/Y		Y												Y			Y	
19. National Chian-Tung University, Taiwan R.O.C.	Y/Y		Y/Y		Y/Y																		
(D) MIDDLE EAST																							
20. Royal Jordanian Geographic Centre, Jordan	Y/		Y/Y		Y/Y																		
21. Milli Savunma Bakanlizi Komutanlizi, Turkey	Y/	Y/Y	Y/Y		Y/Y																		
(E) REFORMED COUNTRIES																							
22. Institute of Geodesy and Cartography, Poland	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y																		

*Footnote: Blank Cell = No or None

PGF = Post Graduate Fellowship
PDF = Post Doctoral Fellowship
PRI = Project Implementation
EQU = Equipment (Supply of)
LIT = Literature
SES = Secondment of Staff

DM = Digital Mapping
DSU = Digital Surrveying
DPH = Digital Photogrammetry
DCA = Digital Cartography
DRS = Digital Remote Sensing
GSS = Ghana Survey School

SG - SWISS GOVERNMENT
WB - WORLD BANK
JG - JAPANESE GOVERNMENT
BG - BRITISH GOVERNMENT
GG - GERMAN GOVERNMENT
EU - EUROPEAN UNION
SIDA - SWEDISH INT. DEV. AGENCY
DG - DUTCH GOVERNMENT
CG - CANADIAN GOVERNMENT
FG - FRENCH GOVERNMENT

TABLE 2(Continued): DIGITAL MAPPING EDUCATION IN DEVELOPING COUNTRIES (INSTITUTIONAL SURVEY)*

Institutional Survey	Which Modern Techniques are Part of Existing B.Sc. or Post Graduate Programmes					Reasearch or DM/GIS Projects		Types of Technical Assistance available to other Institutions (South-South Cooperation)						Source of North-South Cooperation received
	DSU	DPH	DCA	DRS	GIS	DM	GIS	PGF	PDF	PRI	EQU	LIT	SES	
(A) AFRICA (South of the Sahara)														
1. University of Lagos, Nigeria	M.Sc				M.Sc		YES						YES	CG
2. University of Ibadan, Nigeria	PGD						YES							USAID
3. Regional Centre, Ile-Ife, Nigeria					PGD									EU, FG, DG, UNDP, SG
4. University o f Science and Technology, Ghana	B. Sc				B.Sc	YES								WORLD BANK
5. University of Ghana, Legon, Ghana														WORLD BANK
6. Survey Department, (GSS), Accra, Ghana						YES	YES							WORLD BANK, JG
7. University of Malawi, Malawi														
8. Maef Direction Nie Forets et Faune, Guinea							YES		YES	YES	YES			WB, EU, FG,
9. N. I. S. M. H., Antananarivo, Madagascar	B.Sc				B.Sc		YES			YES				WB, USA,FG,DG,GG,UNDP
10. Al-Azhat University, Cairo, Egypt														
11. Ethiopian Mapping Agency, Ethiopia														SIDA, FG, UNDP, DG
12. University of Namibia, Windhoek, Namibia														
13. University of Nairobi, Kenya	B.Sc				M.Sc								YES	
14. University of Cape Town, South Africa														
(B) SOUTH AMERICA														
15. Comando de Industria Militar e Ingenieria, Chile	B.Sc				M.Sc									WB, GG, FG
16. Instituto Geografico Militar, La Paz, Bolivia														DG, EU, DMA
(C) ASIA														
17. Institute of Geography, Hanoi, Viet Nam							YES	YES				YES		UNDP,GG,FG,JG
18. Nanyang Technological University, Singapore	M.Sc				M.Sc	YES	YES	YES		YES				
19. National Chian-Tung University, Taiwan R.O.C.	B.Sc				M.Sc/ Ph.D	YES	YES	YES	YES	YES	YES	YES	YES	
(D) MIDDLE EAST														
20. Royal Jordanian Geographic Centre, Jordan						YES	YES							UNDP, DG, FG, CG
21. Milli Savunma Bakanlizi Komutanlizi, Turkey						YES	YES							DG, FG
(E) REFORMED COUNTRIES														
22. Institute of Geodesy and Cartography, Poland		Ph.D		Ph.D		YES	YES			YES				FG

*Footnote: Blank Cell = No or None

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