COMPUTER ASSISTED CARTOGRAPHY IN DEVELOPING NATIONS

D. R. F. Taylor

Carleton University
Ottawa, Ontario K1S 5B6

ABSTRACT

This paper examines the arguments for and against the introduction of computer-assisted cartography in a Third World context. The general arguments will be considered by using case studies from Nigeria, India and China. Computer-assisted cartography can be an even more appropriate form of technology in developing nations than in industrial societies but it must be seen within the context of a new approach to cartography. In this respect the technological aspects are only one, and perhaps not even the most important issue. Appropriate technology is defined as that most appropriate to the task. In some instances that is simple technology of a labour intensive type and in others it can be the highest technology which can be capital rather than labour intensive. If a new view of cartography and its role in the development process is taken then computer-assisted cartography has much to contribute.

COMPUTER ASSISTED CARTOGRAPHY IN DEVELOPING NATIONS*

Introduction

There is no doubt that computer-assisted cartography has a positive role to play in developing nations but for this to be effective there are problems which must be overcome. This paper will argue that in addition to the normal range of problems in technology transfer, computer-assisted cartography faces special problems not the least of which is the need for a radical reappraisal of the nature and role of cartography in the information era. A "New Cartography" (Taylor 1985) is emerging in post-industrial societies which demands adjustment in a variety of ways. Some have argued that sophisticated technological developments have little relevance to developing nations. It will be argued here that some aspects of modern cartography may be of even greater utility in developing nations than they are in the post-industrial societies of Europe and North America in which they are being developed. Appropriate technology is perhaps best defined as that most appropriate to the tasks at hand. This requires a thorough understanding of these tasks and of the socio-economic setting in which they are to be performed. Cartography for development is quite different from the development of cartography although in some instances there may be a close relationship between the two. The arguments will be developed by looking at three case studies from Nigeria, India and China which illustrate the complex issues involved.

Nigeria: False Start in Africa

Cartography in Nigeria lacks relevance to the developmental problems facing the nation. There is a heavy emphasis on the production of topographic maps but despite this emphasis 20% of the country still remains to be covered by any topographic may series (Duru 1985). Computer-assisted cartography is being introduced into Nigeria but in a way which is not likely to lead to significant improvement. Existing mapping agencies are described as being "...almost incapable of producing thermatic maps" (Adalemo et. al. 1985:228). New technologies are being introduced to substitute capital for labour and to replicate existing manual map production methods by automated means. There seems to be no sustained effort to question the relevance of existing cartographic products to the development process or to use the technology to develop new products. This is not to question the need for adequate base maps but in a situation where one of the main problems for socio-economic analysis is that the census has no accurate enumeration maps, new priorities are needed.

*This paper is an extensive revision and extension of some of the ideas on this topic contained in Taylor 1985.

There is an almost classic "catch 22" situation. The government is accused of being unaware of the importance of maps and failure to provide resources to improve the situation, but cartographers are producing inadequate, outdated topographic maps of limited relevance to the pressing and immediate problems of national development. In these circumstances why should the government put scarce capital resources into cartography? This problem is heightened by the fact that the equipment demands being made are usually for very expensive main-frame based systems of a turn-key type which make heavy demands on scarce foreign exchange.

The recommendation for the installation of such systems often comes from foreign experts and vendors for international companies. The latter are understandably interested in profit not development and are unlikely to take this latter element fully into account except in their sales rhetoric. Business practice in Nigeria leaves much to be desired. The system is fraught with corruption and unscrupulous and unethical behaviour. Foreign experts who understand the technology but not the development context in Nigeria are as much part of the problem as the solution and the frustrations of Nigerian specialists in the field with their activities is understandable (Duru 1985, Adeniyi 1985).

The internal situation in Nigeria compounds the difficulties (Wright 1985). Inefficiencies and lack of cooperation can reach levels bordering on the absurd. In 1984 Adeniyi reported that of 93 Nigerians trained abroad in remote sensing only 22 were in positions dealing with remote sensing and of these only five had equipment to work with (Adeniyi 1985). Nigerian cartographers report that "...it is easier for some Nigerians to study cartography in the Netherlands than at Kaduna Polytechnic" (Adalemo et. al. 1985:236).

To borrow René Dumont's phrase, cartography is off to a 'false start' in Nigeria and entirely new approaches are required. A first step towards an improved role for cartography in socio-economic development is a reappraisal of their role by cartographers themselves. There must be a move away from the traditional role of surveyor or draftsman towards that of an information manager. The driving force for a New Cartography in developing nations must be the provision, analysis, representation and transmission of timely spatial information central to the needs of a developing economy. Exciting new technologies exist to facilitate this task but these technologies are in themselves a necessary but not sufficient step towards a better solution.

India: Effective Technological Transfer

India has a long cartographic tradition and a good topographic mapping program. The current Surveyor General, Major-General Agarwal is well aware of the need for new initiatives for cartography (Agarwal 1984) although movements in this direction have been slow and still face many problems.

The Indo-French Compu-Graphics and Planning Project which began in 1979 (Chappuis and de Golbery 1984) is one of the more successful examples of the use of computer-assisted cartography in the development process.

The project is centred in the Planning Department of the Bureau of Economics and Statistics of the Government of the Indian state of Andhra Pradesh. It is designed to provide timely information to both planners and to the people affected by planning decisions.

The project uses microcomputers to process and map data and the output includes both graphic analysis and presentation and statistical analysis. A cheap microcomputer graphic laboratory was installed in 1980 and began functioning early in 1981 despite the difficult physical environment. As is the case in many developing countries, in addition to the problems of heat, humidity and dust, there are sudden surges in voltage and frequent power cuts. These can play havoc with sensitive computer equipment and as a result many mainframe computer installations are only to be found in major cities where a controlled environment can be more easily provided (Taylor and Obudho 1977). Even in these circumstances the machine is usually down as often as it is up. The expense involved in such mainframe installations is very large and ongoing running and maintenance costs are high.

The project uses a Hewlett Packard 9825 microcomputer with a 64K memory. Power problems are alleviated by the use of a power modulator with a battery backup. Other elements of the system include a Summagraphics digitizer, two four pen plotters and two graphic printers. None of these is expensive and the system has worked very well indeed.

The system links data banks of information on various geographical units at different scales such as districts or villages with statistical information which has not been organized on a spatial basis. The programs allow easy use by non-specialists and fast retrieval of information by means of a key-word library system.

Base maps are digitized in a variety of ways to allow output of points, zones, matrices, lines and combinations of these. Maps are output either on the plotter or on the graphic printer.

Data can be output either as straight lists or after various standard statistical manipulations. With maps, simple distributions can be shown or the data can be mapped after statistical manipulation.

It takes about three weeks for an individual with no computer experience to be in a position to fully utilize the system. The Indian participants working with the project are mainly villagers with educational levels ranging from two or three years of high school up to bachelors degrees and in some instances, people using the system are producing graphics the first day they are on the machine.

The main applications are at two scales. Andhra Pradesh is a state of over 60 million people and there is a need for state wide analysis of data of a variety of different variables by district, taluk, or other appropriate geographical unit.

The second scale is the regional one where a comprehensive village data base for one of the districts, Guntur, has been built. Guntur district has a population of around three million people in 730 villages and the data base includes almost 300 parameters. These data are up-dated seasonally whenever possible. A planning atlas of over a hundred thematic maps was produced in less than two months with output on plastic sheets at the same physical size as the standard administrative file (22 x 34 cm.). This allows the planner and administrators at the local level to carry the map along while visiting villages and to use them in situ.

The system is not without its problems and is, of course, only as good as the data which is fed into it. Data reliability and comparability also varies over both time and space. Much of the village data was collected by village officers, for example, and that position has now been abolished. Despite this, impressive results have been obtained and particularly noteworthy is that data for rural development have been made available at the micro-level in a timely, effective manner and by careful use of Bertin's Semiology of Graphics, good graphic illustrations have been produced. The information is both statistically and graphically accurate within the limitations of the accuracy of the raw data and has been produced in a form that people can both understand and use.

As a result the Government of the State of Andhra Pradesh has decided to strengthen the state laboratory and to put compu-graphics laboratories similar to that described here in each of the 22 rural districts. Each of these will be equipped with a microcomputer produced in India and data bases will be maintained for the village, hamlet and household level. A new system of agricultural data collection has been proposed to replace the village officers. Sample field and farmer surveys will be used together with aerial photographs plus satellite imagery analysed using the microcomputer. Adequate image processing systems for microcomputers now exist (ACSM/ASPRS 1986) and are being improved all the time. It remains to be seen if adequate data can be collected and updated utilizing these new methods in the Indian setting.

The project has also attracted interest from the Land Record Department in the state and the cadastral survey maps are now being put on the microcomputer in three stages beginning with village outlines and then farmers' plots. Finally these will be linked with crop information. It is hoped in this way that an 18 year backlog created by the inadequacy of existing cartographic methods can be cleared up.

Arguments for the use of microcomputer based cartography in developing nations have been made before (Taylor 1979; Prashker and Taylor 1983)

and demonstrations made, but the example for India clearly demonstrates the potential in an operational fashion.

India has a long cartographic tradition and good base map coverage. There is, in fact, a large multi-coloured Atlas of Andhra Pradesh produced on the model of European regional atlases but this product of traditional cartography is of very little value to the development process. As Jacques Bertin comments, the data on which the atlas was compiled is seriously outdated and the atlas itself difficult to consult and use (Bertin 1984).

The contrast with the micro-based system is a startling one. Bertin argues that the system gives administrators the maps and matrices they need for planning purposes; the state of the last rice harvest, the last use of irrigation water, the real distance (non-linear) of each village to fertilizer depots, seed stores, milk collection centres, health services, etc. The micro system is powerful and reasonably cheap and will utilize computers produced by Indian industry. Indians involved in administration and planning at the grassroots scale can use the system to solve real problems and can interact with the system to produce analyses and new maps to their own specifications. The system as currently configured is a highly decentralized one but it can be considerably expanded while preserving the necessary homogeneity required to central planning and comparative purposes. A network in this case can be constructed from the "bottom up" rather than from the "top down" as is more often the case. Bertin argues that the cartographer's role is to define the smallest possible number and types of maps and diagrams with four objectives: to answer the pertinent questions posed by the decision makers; to take into account the human constraints of India; to take into account the physical constraints of "micro-graphique"; and to propose together with the computer programmer an electronic architecture adapted to modern graphics.

Although foreign experts have been involved, the key individuals lived and worked with the project for several years rather than flying in to give "expert advice" and then departing. Bureaucratic barriers in India were also reduced by carrying out the project at the grassroots level.

Graphic presentation of information has particular strengths in an environment where literacy levels are low. Chappuis and de Golbery provide concrete examples of how the presentation of information in map form has made information more comprehensible to Indian villagers in a way which has better facilitated explanations of planning problems and increased awareness of prevailing social and economic inequities.

China: Indigenous Technological Adaptation

Cartographic developments in China over the last several years have been impressive and are an integral part of the development process. The central goal of cartographic production in China is to aid in

economic reconstruction. Given the role of the rural areas in China's economy it is perhaps not surprising that "...China pays special attention to agricultural mapping" (Hu and Liao 1984:2) and has produced a series of maps and atlases at the country level for agricultural regional planning. Special attention is paid to composite mapping and to analysing and presenting spatial interrelationships between different factors. The digitized data base of China's 2300 countries is a basic part of the Population Atlas of the People's Republic of China which "...will mainly be compiled by computer-assisted cartography." This same country data base has played an important role not only in population mapping but also in the compilation of an Atlas of Local Diseases. Remote sensing imagery is being used for thematic mapping especially of vegetation, soils, geology and environmental change.

Major attention in topographic mapping is being given to agricultural areas. It is interesting that large scale mapping at 1:10,000 and 1:5,000 was concentrated on intensive farming areas with over 750,000 square kilometres being mapped. This is in marked contrast to many other countries where priority is given to urban areas and no large scale maps of rural areas exist.

Cartographic education at all levels "has been restructured to meet the new demand of national reconstruction" (Hu and Liao 1984:4). To modernize Chinese cartography a major approach used has been to send postgraduate and visiting scholars abroad to update their expertise and then to use these scholars to develop new education and training programmes within China itself.

The contrast between the national situation in China and that in Nigeria is marked. In China cartography plays a central role in national socio-economic development and new cartographic ideas have been introduced by Chinese rather than by foreign experts. In Nigeria many cartographic projects have been carried out by external agencies and foreign consulting firms while in China the effort has been overwhelmingly indigenous. The decision on what is appropriate for China is being made by Chinese.

CONCLUSIONS

The evidence from the three case studies supports some general conclusions:

1) The challenge for cartography is the relevance of the discipline and its products to the development process. Where the contribution is clearly demonstrated to be of value (India, China) there is no lack of support or response from government. Where this is not so, support is unlikely to be provided (Nigeria), expecially in situations where resources are limited and foreign exchange is a scarce and valuable resource.

2) Computer-assisted cartography is likely to be most useful when introduced selectively by indigenous cartographers (China) who understand the complexities of the development context of their own nation. It is likely to be least successful when introduced by foreign experts and consulting firms and can be counter-productive in many instances (Nigeria). Cooperative projects are particularly successful where there is a high indigenous component and an ongoing commitment to development aims by the foreign participants (India).

3) There are some advantages to the adoption of the most modern concepts and techniques of cartography if these are appropriate to the tasks at hand and are feasible in the particular set of circumstances and constraints each developing nation faces. The development of cheap micro-computer technology increases the feasibility of such an approach. New data collection technologies such as remote sensing can provide information vital to survival in a timely and continuously updated fashion. When cloud cover limits the utility of remote sensing radar can be useful for crop yield forecasts (Paul 1986). New communications technologies can be used to disseminate information more efficiently than existing technologies. Modern cartography may be more appropriate for developing nations than "traditional" cartography especially where existing cartographic products are inaccurate, outdated or non-existent. New technologies may allow cartographers to 'leapfrog' over existing approaches in a way which will make their products of more direct utility to development problem solving. A judicious mix of new and existing techniques is required. If computer-assisted techniques are seen primarily as a replacement for labour in the production of existing cartographic products then there is little justification for their introduction.

4) The technology itself is not the central issue; it is the use made of that technology. A micro-based Geographic Information System can be just as inappropriate as its much more expensive mainframe predecessor as an interesting case study by Cowen for Curacao has shown (Cowen 1986).

5) If the role of computer-assisted cartography in developing nations is primarily "technology driven" it is unlikely to make a significant contribution. It must serve as a means to an end rather than as an end in itself. By coming relatively late to the field, developing nations may be able to avoid the many mistakes still being made in Europe and North America in this respect.

REFERENCES

ACSM-ASPRS (1986) Remote Sensing, Technical Papers 1986, ACSM-ASPRS Annual Convention, Volume 5, Washington, D.C.

Adalemo, I., O.O. Ayeni and O.Y. Balogun (1985). "Cartography in the Developing Nations: The Case of Nigeria." Chapter 11 in Taylor, D.R.F. (ed.) Education and Training in Contemporary Cartography, John Wiley and Sons, Chichester, U.K.

Adeniyi, P. (1985) "Remote Sensing, Resource Development and Education in Africa." Chapter 10 in Taylor, D.R.F. (ed.) Education and Training in Contemporary Cartography, John Wiley and Sons, Chichester, U.K.

Bertin, J. (1984) Personal communication.

Chappuis, Anne and Luc de Golbery (1984). "Un atlas regional, outil d'aide à la decision en Inde." Paper read to the 12th International Cartographic Conference, Perth, Australia.

Cowen, D. (1986) "Barriers to Successful Export of Personal Computer Based GIS." Paper to ACSM-ASPRS Convention, Washington.

Dumont, R. (1966) False Start in Africa. Praeger, New York.

Duru, R.C. (1985) "Status and Constraints of Automated Cartography Training in Africa." Chapter 12 in Taylor, D.R.F. (ed.) Education and Training in Contemporary Cartography, John Wiley and Sons, Chichester, U.K.

Hu, Yuju and Liao Ke (1984). "The Advance of Cartographic Undertaking in the People's Republic of China 1980-1984." Report to the 12th International Conference of the International Cartographic Association, Perth, Australia.

Paul, C.K. (1986) "Mapping and Remote Sensing Educational Requirements in Developing Countries." ACSM-ASPRS Technical Papers, Volume 1 and Cartography and Education, Washington, pp.229-236.

Prashker, S. and D.R.F. Taylor (1983). "MIGS: A Microcomputer Mapping System for Cartography in Developing Nations" in Wellar, B. (ed.) Proceedings of the Sixth International Symposium on Automated Cartography, Volume I, Ottawa, pp.480-488.

Taylor, D.R.F. and Robert Obudho (1977). The Computer in Africa: Application Problems and Potential. Praeger, New York.

Taylor, D.R.F. (1979) "Development Atlases Using Computer Techniques." Cartographica, monograph 23, pp. 67-78.

Taylor, D.R.F. (ed.) (1985). Education and Training in Comtemporary Cartography, John Wiley and Sons, Chichester, U.K.

Wright, John (1984) "The Problems and Solutions of Providing Technical Assistance to Developing Survey Departments." Chapter 13 in Taylor, D.R.F. (ed.) Education and Training in Contemporary Cartography, John Wiley and Sons, Chichester, U.K.