University of Nairobi

# SURVEYING IN DEVELOPING KENYA:

# THE ROLE AND THE PROSPECTS

## INAUGURAL LECTURE

by

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**Introduction**

Mr. Vice Chancellor, distinguished guests, dear colleagues, Ladies and Gentlemen.

The invitation to give my inaugural lecture was a great honour and pleasure to me. That pleasure soon gave place to doubts about what I could say and finally loss of hope that I would have anything to say. Unlike politicians, academicians usually keep their mouths closed unless they have something to get off their chests. Perhaps by being asked to speak, I was put into the position of a politician.

However, as I have been occupying the chair of Surveying and Photogrammetry for the last 9 ½ years, I chose this title as giving me the greatest possible latitude at a time when I did not know what I was going to say. On such an occasion when the content of the lecture, according to the University Registrar's letter, is required to be "philosophical, yet not too technical; witty, yet not too abstract; broadly based, yet with definite focus on the discipline giving its philosophical foundation, development over the years, and how you see it developing in the department", the lecture has the disadvantage to be comprehensible with the risk of losing at some moments the connection between the title and the content.

**Brief History**

Surveying is one of the oldest professions known in history. It is as old as man himself. Ancient Egyptians, some 7000 years ago, had left records about their use of a rope with equidistant knots to measure distances, a tool which is very much like the still used surveying chain. Gerard Eratosthene, who was the Chief Librarian of the great library of Alexandria more than 2000 years ago, was not only able to prove that the earth is spherical, but to make the first practical attempt to measure its radius. He measured by elementary devices the arc between Alexandria and Aswan and through a simple formula he calculated its radius of curvature. Perhaps it is interesting to note that Eratosthene's findings by applying such crude measurements are only 14% too large compared with recent measurements.

**Definitions**

According to the Oxford English Dictionary Survey (as a transitive verb) "1. to take a general view, 2. examine the general condition of, 3. measure and map out the position, size, boundaries, etc of: (an area of land, a country, coast, etc.)". Surveying (as a noun) "Land-surveying; map or record of this". Surveyor (as a noun) "Official inspector of, person professionally engaged in surveying". Photogrammetry "the art of surveying or mapping with the help of photography".

* *The Lecture was illustrated by 22 diagrams and maps, which are not reproduced here with the text.*

Since the time of the Oxford definition about 100 years ago, the subject of surveying and photogrammetry has considerably expanded and developed. Even the definitions given in the most recent text books have their own shortcomings. There is at present a lot of debate about the definition taking place in many professional and international bodies. The point is that the word "Surveying" does not any longer describe or embrace adequately all the specialities and the different activities of surveyors, which might be summarised as: Geodetic, Topographical, Cadastral, Engineering, Hydrographic, Hydrological, Cartographic, Photogrammetric, Photointerpretation and Remote Sensing.

This might briefly indicate how surveying sciences are dynamically developing. Any definition is likely to be biased to one or more of the branches and to reflect one stage of its development. Historically surveying had developed from an art to a science, then to a technology (in the sense of applied science). However, due to the recent implementation of astonishing technological developments in the science it is driving fast to be a managing function. I shall try to focus more on this point in my lecture.

**Recent developments**

In the last two decades the surveying disciplines have achieved tremendous developments along two main lines: the response to developments in computers and the utilization of space technologies. These new technologies served as a challenge and a stimulant to surveyors. The challenge is to respond to and anticipate change so that the activity of surveying can evolve to provide for new needs. The stimulant is the creation of new procedures, methodologies, techniques, equipment and products.

**Computers**

The use of fast digital computers with large storage capacities enabled the handling of enormous quantities of data in a short time. The problems of adjustment of geodetic networks and blocks of aerial photographs, whatever their size, could now be easily solved, provided that appropriate programmes are available. The end results is a new level of capabilities and new ways of doing things, which were previously uneconomic, excessively time consuming or labourious.

The developments of silicon chips resulted in the manufacture of highly sophisticated microcomputers. Such computers are widely used at present to solve a large variety of surveying problems.

The advances in micro-electronics have revolutionized the construction of surveying instruments, and consequently the approach to solving problems. More automation in instrument setting, observation and recording data is readily achieved. The automatic recording on the "electronic" field book has almost replaced the manual recording on field notes. The automatic reduction of observation data on site, and the interlinkage of data collecting instruments to computers provided with the software for data processing, are routine procedure nowadays. The output of this system will be to any combination of completed maps, data bank, or others. Such systems have attained high level of economy and reliability.

With the advancements in computer graphics the use of large surveying packages has been greatly facilitated. It is no accident that in surveying the graphical representation of data is a firmly established practice. However, the combined use of large computers and computer graphics provided the greatest potential for increasing the power and the scope of their utility in surveying. The buzz phrase these days is the land information system, whether geographic, topographic, cadastral, or any other. The system consists, on one hand, of a data base containing spatially referenced land related data and, on the other hand, of procedures and techniques for the systematic collection, updating, processing and distribution of the data. The primary component of a land information system, which is a uniform spatially referenced data, facilitates linkage spatial data with other semantic land-related information (e.g. ownership, value, use, soil erosion, degradation, desertification, deforestation, . . . etc.). Such combination of spatial and semantic data is extremely important for legal, administrative and economic decision-making, and therefore it is an essential aid to land planning and management for development. In short the intermarriage of digital computers and computer graphics enables the land information system to reorganize the way of storage, retrieval, cross referencing and analysing data about land. It provides wider scope for applying surveying to develop the existing and create new services to the community.

No doubt that the introduction of computers in surveying instruments and techniques has solved many problems, opened new horizon for applications, and made the handling of data more economical and reliable. I would like to elaborate on the last two items, i.e. economy and reliability. As any new technology, computers have their impact on the profession and the society. It is anticipated that computers would be used to an increasing extent, and it should be so. Therefore we should be aware of the problems imposed by them, and be prepared to face them. The advantages and capabilities of computers are advocated everywhere by the manufacturers as well as by the impressed users. Yet the created problems are rarely appreciated or publicized. As academicians and technologists we should be alert to these problems and that is why I propose to touch slightly on those.

## The Computer Problems

Here is an attempt to briefly highlight the problems associated with the introduction of computers to surveying, and pointing out possible solutions, if any.

(1) The calculator and the loss of the sense of magnitude.

With more sophisticated functions and accessible prices of pocket calculators, they are becoming more widespread among students and professionals. The danger is that the absolute trust in the results of any computation process developed with time on the attitude of the users might lead them to accept erroneous results. Pressing a wrong key is a very common mistake. This has been, however, more noticeable among the new generations and, therefore, there is a danger to lose gradually the sense of magnitude.

The remedy is to emphasize to the user, especially to the young generations, never to use computers unless the answer of the problem is fairly accurately known. This requirement is realistic only if the relationship between the input and output is relatively simple and straight forward. In such case the user could confirm in 'real time" the input/output relationship. This is not the case when the relationship between the input and output is complex and no longer obvious.

(2) Programmes

The high speed digital computer is of the greatest value to surveyors once the relevant programme has been written; and this is the snag. Some programmes may take a long time to devise and test, while the same problem could be completed in less time on a desk calculator. In this case unless the programme is expected to be used repeatedly, it would not be of economic value. Furthermore, an efficient programme can be devised only by someone conversant with the problem itself.

In the last few years there is an increasing availability of computer software packages and suits to perform a wide variety of surveying tasks. This solution in itself brings an increasing risk of errors being introduced at different stages of data collection and processing. Even more serious risk is that such errors might not be discovered by any checking procedure.

To overcome this problem necessitates considerably more training of our students in such areas as theory of errors and other related aspects of mathematics. Also programmes should incorporate filtering routines to identify anomalies in observations, produce statistical criteria for the analysis of the results and to include a variety of inbuilt checks. It might also be a useful practice to test the programme for conformity with the results of a previously solved or standardised problem. This last approach is well known in surveying as calibration, and I do not see why we should not apply the same calibration procedures to ready available programme/packages.

(3) The "black box" concept.

The manufacturers of surveying and photogrammetric instruments are increasingly using electronic component parts in their products. The surveying instruments are steadily approaching the realm of the black box. By this I mean the unquestionable acceptance of the functioning of the electronic device without knowing how it is done. There are two immediate effects of this. When anything goes wrong not only are most users incapable of diagnosing the trouble and correcting it, but the manufacturer may even have a very limited number of technicians who can solve the problem. However, what is worse is that the user is unable to judge whether the black box has been efficiently constructed. For its efficiency and limitations he must take the manufacturer's word.

The use of a "black box" is not a wrong attitude in itself. But surveyors must take a far greater interest in the working of their instruments. If this means acquiring knowledge they must acquire it. At the same time manufacturers must be compelled to give technical details of how the tool functions and not just to provide words describing what is done.

(4) The loss of "Prime Record".

The prime records are the field notes, where field or laboratory observations are recorded. Such records are of fundamental importance as the reliability and the truthfulness of the whole survey product is absolutely dependent on them. With traditional instruments surveyors used to take great pains in carefully recording and keeping these field records. But in the case of the "electronic field book", being a part of the automated electronic chain of data transfer and processing, it is not known what is the "prime record". Moreover the more lowly trained and lowly paid operator who will increasingly be used on such "simple" work is more likely to be less responsible.

The solution might partially be to have more redundant observations. The cost of such extra work in data collection and in processing must be paid for from the greater productivity of automated devices. Another response is to increase the inflexibility of specifications and instructions to field surveyors. This also has its drawback. In my view alternative strategies should be put into place to retain the reliability of records and an individual responsibility for them.

(5) Too dense graphical output.

The success of the application of computer graphics in surveying depends on the efficiency with which humans can assimulate data when presented in graphical form. It is very easy to put too much information on a map or a screen. This has the disadvantage of losing the required information in the mass of data.

The solution is either to devise methods to extract required data only or to identify optimal data density for best perception.

Due to their advantages computers should be used more extensively. Our task is to prepare our students—the future professionals—to handle the technology appropriately. In applying this concept of appropriateness, we do our best to emphasize the critical professional function of ensuring that the results are accurate and reliable.

## SPACE TECHNOLOGY

In the last 30 years, since man's interest was directed to exploring space, a new unlimited horizon has opened for science and technology to develop. Space technology has indeed brought about spectacular advances in the methods of position determination and of obtaining imageries of the earth's surface, but it has also brought up unprecedented problems. Here is an attempt to highlight the achievements, limitations and the associated problems.

Positioning.

It is a prime function of surveying to determine the position of one point on the earth relative to another whether the two points are few meters apart or many hundreds of kms. In an interesting speculation about the future of geodetic networks it is foreseable that in the distant future, people will walk around with "wrist locators", costing less than the present value of ten dollars, that will provide instantaneous positions to say, 1 mm accuracy. However, more immediately, i.e. by the year 2000 there are likely to be highly portable locators costing a few thousand dollars which will define almost instantaneously positions good to 1 or 2 centimetres.

(1) Doppler techniques.

Position fixing by TRANSIT earth satellites has been in practice for the last decade or so. These techniques have been developed and successfully used in extensive geodetic projects. The achieved accuracies varied widely according to the methodology used and other circumstances. A campaign to fix positions by this method in Africa (ADOS), a few points in each country, was being initiated some few years ago with certain standardized specifications. Some of the observations and computations have not been finalized yet. The TRANSIT system is due to be discontinued shortly in favour of the more advanced Global Positioning System (GPS).

(2) GPS System.

This system is scheduled to be fully operational before the end of this decade. The operational system of 18 satellites will provide two distinct services. The Precise Positioning Service (PPS) corresponding to the P-code, and the Standard Positioning Service (SPS) corresponding to S-code. Only the latter would be available to non USA military users, and its accuracy in positioning is expected to be almost 50 m.. Different manufacturers are very active at present to produce the suitable receivers.

However, greater accuracies might be obtainable by more costly techniques such as Very Long Base Interferometry (VLBI) or Satellite Laser Ranging (SLR).

The technical and economic problems which have been born and grown up with the use of satellite techniques for positioning could be summarized as follows:

(1) The satellite life time is relatively short (up to 5-7 years).
(2) The cost of the receivers is still too expensive
(3) The attained accuracy is too low.
(4) Stations several hundreds km apart are only suitable for surveying of very large areas, or to strengthen the adiustment of existing networks.

Other administrative problems are of no less significance.

(1) The ephemeries of the satellites is only available through the US Defence Mapping Agency (DMA)
(2) Users are advised that dependence on these satellites is at ones own risk.
(3) The Department of Defence can contaminate the satellite signal or switch it off altogether.
(4) A user fee will be levied, and the user will be required to obtain an operating key renewable on an annual basis.

I am sorry to disappoint you by saying that I am not able to propose any solution to these problems. Although this technique is very promising in Kenya environment as it does not require the expensive monumentation of points and the more expensive process of keeping them up, yet it seems that the traditional method of geodetic position fixing by triangulation and traversing will still be employed for some time to come.

Remote Sensing.

Perhaps one of the most significant products of space technology is remote sensing. This technique has the potential of producing a broadly consistent data base about the earth's surface at a certain spatial, spectral and temporal resolution. Such a data base has proved to be extremely useful in the identification, measurement and inventorying of the earth's resources.

Aerial photographs have been with us since the invention of the balloon and aeroplane, but it was not until the launching of the first earth satellite (Landsat-1) in 1972 that the acquired information about earths' surface exceeded in volume and contents all expectations. This very fact has led to the accelerated development and establishment of the theoretical principles of remote sensing. The results of very many successful experiments have been widely published. The technique has proved to be useful in a wide range of applications: studies of weather and climate, marine environment, water resources, land use, geology, engineering applications, agriculture, forestry, rangeland applications, archaeology and even sociology.

Generally speaking, in remote sensing the sensing device records the reflected or emitted electromagnetic energy in some band of the spectrum. The sensing systems which are in common use at present are black and white photography, colour photography, infarred photography (black and white or colour), thermal imagery, side looking airborne radar (SLAR), and microwave radiometry. The mode of data acquisition is either through line by line scanning (e.g. multispectral scanner MSS, SLAR) or by instantaneously recording a full scene from some position in space (photo camera). The sensors are mounted on board a satellite or a space shuttle. However, other platforms such as aeroplanes, are not excluded.

From 1972 until now the launching of 5 Landsat spacecraft by US has proved that space imageries are practical and economical for land resources inventory, expecially for large extended areas. The launching of the European satellite SPOT with its special pay-load gave another dimension and flexibility to the application of the technique. The distinctive contribution of remote sensing in providing land resources data lies primarily in its spatial comprehensiveness, accessibility, flexibility, comparability of data, synoptic view and multiconcept (date, spectral, scale, stage, . . . ). Although these are remarkable contributions, data collection at ground level is certainly not eliminated by the use of remote sensing. Remote sensing does not completely replace traditional methods, but it complements other methods, and thus an integrated approach greatly improves the efficiency of data collection.

However, the limitations of remotely sensed data from space should not be ignored. These include political, economic and technical barriers.

The political problem is that governments are very sensitive about the general availability of detailed aerial surveillance data over their own territories.

The cost of acquiring the data, especially when orbiting space vehicles are involved, is so great. The essential cost elements are the space craft, the payload and the launching. The cost of the spacecraft is usually the major component and it amounted to \$570 million in Landsat 4. The cost of multispectral scanner (MSS) is @ \$80 m., thematic mapper (TM)—\$30 m., large format camera (LFC)—\$10 m., making the cost of payload \$120 m. The launching costs are about \$70 m. The operational costs include the ground receiving station capital expenditure—\$10–15 m., the running costs \$30 m/year. If the average operational lifetime of a Landsat is 3 years, then the total cost will be \$860 m./3 years. In 1982 the US more than doubled the price of sales of Landsat data. The price for a colour composite of MSS (cheapest product) amount to US \$220, yet the annual income from sales and fees from foreign stations (\$0.2 m/year) comes to about \$15 m., not much more than half the running costs. If the policy now is to make Landsat a money-making venture, then the price of the products would increase by 20 times, provided that the same rate of orders and purchase shall continue!

From a technical standpoint the problems are:

(1) Lack of penetrating ability of most sensors through cloud cover (except the SLAR which is not used in Landsat).
(2) The spatial resolution is still low (pixel size 80 m improved to 20 m). If it is intended to display the cultural details, it is necessary to acquire data with ground resolution 2–3 m.
(3) The ever increasing volume and diversity of data available from the sensor systems. To deal more efficiently with such data, computers are the essential tool, and the challenge is to develop more efficient and quantitative methods for using the data.
(4) There are computational complexities encountered in trying to deal simultaneously with the spectral data together with the spacial and/or the temporal data.
(5) The potential benefits to be gained from the development and use of complex land data bases are considerable and may be essential to the inventory of land resources. Yet these data bases will not qualify as powerful land information system until the analytical tools are available to assist the user in extracting the necessary and useful information locked up in them.

Satellite imageries proved to have great interpretational capabilities for the inventory of land resources. However, their value for topographic mapping is still very limited. The first problem is the geometrical properties of the MSS image. The distortion induced by satellite attitude deviations make geometrical positioning unreliable. This has been partially overcome by introducing a return beam videcon (RBV) camera. However, the ground resolution of the image from such a camera is too low (pixel size 80 m improved to 30 m) and it does not give stereocoverage, which gives information about heights.

An attempt to overcome these shortcomings was to mount on a space shuttle mission a metric camera (MC) or a (LFC) very similar to the one used with aeroplanes to produce aerial photographs for photogrammetric purposes. The image resolution of the camera is 80 1p/mm. and the focal length is 305 mm giving a scale 1:800,000–1:1,000,000 depending on the flight altitude (230–300 km). The camera gives stereocoverage. An attitude reference system (ARS) composed of two cameras synochronized with the main camera has the function to photograph the star field. By the ARS the accuracy of attitude of LFC is $\pm 5''$ in each of the three axes. Such system has good technical and economical feasibility for topo-mapping in scale 1:100,000 and possibly 1:50,000. Yet the system is still subject to some limitations:

1. There is no assured source of photography
2. The user have little control over the circumstances and dates of photo acquisition.
3. Some technical problems do exist and experience for actual procedures has to be gained. Provision of suitable control is one example.
4. The method is cost effective if, and only if, it is applied at a continental or subcontinental size.

I have tried briefly to synthesize the recent developments and the problems in surveying. Surveyors are aware of the challenge of the new technologies, and their political, social, economical, technical and professional implications. For years surveyors have taken the attitude that their role is simply to provide information. Now, in the information age, they are becoming more involved in the application of the information they provide. They are capable of such involvement as they are the experts in collecting, analysing and presenting this information. The contribution of surveyors is significant in the scientific modelling of relations and facts of our environment. There is no doubt that the involvement of surveyors in the application of information about land (dam construction, highway construction, power plant siting, urban development, mineral excavation, . . . ) would enhance the decision making. Surveying is not a tool anymore. It is a basic and essential component of the development process. This perhaps explains the recent tendency of surveying to becoming a managing discipline, without losing its technical concept.

**Achievement of Surveyors and Future needs**

Surveyors in Kenya have contributed a lot to the development of the country. In the geodetic control, which is the backbone for any surveying and mapping work, a primary triangulation network of 550 points has been established. Another secondary network consisting of more than 1000 points has been constructed. The average annual number of new monumented points in the last 10 years has been 7 for the primary network and 13 for the secondary. To keep up and expand the networks it might be necessary to increase the number of newly established and re-established points to 200/year. Thirty four Doppler fixes spread all over the country have been determined. A levelling network of 3000 kms total length has been observed with more than 30 first order bench marks. To cover the rest of the country there is a need to run levelling lines up to 1000 km/year. There is also necessity to set up tidal observation stations along the coast.

There is aerial photographic coverage for almost every part of the country. The scales vary from the large scale of 1:3,000 to small scale—1:80,000. This coverage has accelerated the mapping process. At present about 60% of the country is covered by 1:50,000 topographic sheets. However, some of the published sheets are over due for revision and updating. There is a complete coverage of Kenya in the topographic scales 1:100,000 and 1.250,000, although some of these maps require updating and conversion from imperial to metric units. Other special maps are published in varying scales; e.g. tourist maps, route maps, boundaries maps, maps of national parks and reserves, municipalities and townships, different thematic maps, beside the National Atlas of Kenya.

The Department of Surveys has conducted adjudication surveys for 6.5 million ha. of land with an annual average of 64 sections consisting of 50,000 parcels totalling 0.3 million ha. and 2,300 completed mutations. However, the target of 0.5 million ha. and 6,600 mutations/year needs far more facilities than exist at present. In the cadastral section the average number of title deed plans checked and signed/year is 1,700. The surveying of new settlement schemes is proceding at an average rate of 10 settlement schemes consisting of 2000 parcels totaling 16,000 ha. per year.

The surveyors of the department have also been closely involved in a number of development projects such as Masinga dam, Bura irrigation scheme, Mombasa—Nairobi pipeline, Nairobi water project, Kitui arid and semi-arid land project, construction of highways and others.

The significance of these figures to development might be more appreciated if they are compared against the available facilities. If we consider the manpower, which is the straightforward factor correlated with our production of University graduates, the maximum accumulated number of graduate surveyors employed by the Survey of Kenya at present is 70. This number is associated with some 300 technicians and 350 supporting technical staff. Here I can not resist quoting Churchill's say "Never . . . was so much owed by so many to so few". The so many are the people of Kenya, the so few are the surveyors, and the so much are the services rendered by the surveyors to the community. However, I believe there are many constrains, such as lack of funds, equipment, transport and others. But I shall leave these to the Director of Surveys to highlight in his annual report, hoping that some responsible body might read it and react positively.

Here I should mention that other governmental and parastatal bodies have their own surveying sections; e.g. Ministry of Roads and Transport, Telecommunications, City Council. Also the contribution of the private sector should not be forgotten.

### The Prospect

The increased importance of the role of surveyor and surveying in developing Kenya should be appreciated from the simple fact of the increased importance of land and other natural resources.

### The Increased Importance of land

There is no doubt that land is one of our most important natural resources. Awareness of varying qualities of terrain resources goes far back in the history. Genesis 13:10 says "And Lot lifted up his eyes and beheld all the plain of Jordan, that it was well watered everywhere . . . ". In spite of the very primitive technological level prevailing in the past, the understanding of land capabilities undoubtedly formed one of the most important aspects of the acquired and transmitted knowledge of early man. But whatever long-standing knowledge of the significance of terrain governed man's activities through the ages, it was not until the 20th century that formal attempts were made to document land resources systematically in ways which permit scientific predictions of their capabilities under various proposed utilizations.

In Kenya there are about 583,000 km$^2$ of land. Of this 5% is arable crop land, 6%—perenial crop land, 6%—forests. The majority of the land—83%—is range land, 3% of which is improved grazing land, and the rest 80% is by no means all readily convertable into arable land or grazing land. Broadly speaking the land is needed for food and fibre supply, grazing for domestic animals, water resources, energy supply, engineering resources, recreation, nature and scientific site conservation.

The most pressing problems of land utilization and management in developing countries are generally associated with the increasing population and demand for food and water. In contrast many people in the developed countries are more concerned with environmental degradation, and the need to protect or conserve existing resources from harm of changing impact. But it remains to be seen whether the developed countries themselves can afford such luxury.

Knowledge of physical terrain resources forms the most basic factor, which need to be considered in making decisions about the utilization and management of land. Economic, social, cultural and political factors are of varying significance. Nevertheless, increasing pressure on land resources as a result of both the rising population and the higher per capita use of resources, means that plans must be devised to improve renewable resources and to use non-renewable resources economically. And here lies the vital role of surveyor in land management and future planning.

**Population**

The rapid population growth (3½%/year!), which follows an exponential curve, is clearly a principal root of the Kenya problems. The estimated present population is about 21 million and by the year 2000 is expected to be 35 millions. It seems that the biblical injuction "be fruitful and multiply" has apparently already achieved its objectives. However, this is not the forum to oppose arguments for zero population growth, legalized abortion or other forms of population control. But to me it seems a great tragedy that the one limitless resource, is the one we have not learned to utilize.

Of more immediate impact than the eventual number of total population, is the changing pattern of population distribution. Anyone travelling through North or North East of Kenya would hardly believe that overpopulation is a problem. If the population of Kenya would even rise to 40 million, the average density would only be 70 persons/ $km^2$. The Netherlands for e.g. has at present population density of 400 persons/$km^2$. The real difficulty is that 90% of the people have been concentrated on 12% of the land. The attendant urban problems of transportation and communication, power and light, water and sewage, police and fire protection, housing and job creation, education and health, overlapping administrative responsibilities, ethnic concentration, unplanned suburban extensions, are almost more than the simple mind can comprehend. Moreover rural development has no less problems.

There is another aspect of population that is of particular importance to us as scientists and engineers; that is the distribution of skilled manpower, specially among the youth. If we take as an example a training institution of high learning like the University of Nairobi, we find twice as many students enrolled in arts as in science. The number of students reading law exceeds that doing electrical engineering by three times. The number of graduates from commerce is as much as seven times the architects. There is at present one graduate surveyor from this University for every 136,000 population. If our graduate surveyors are distributed equally over Kenya land, then each will get 3,800 $km^2$ . . . to survey. Is that a sign of indifference to science and technology?! Is there a mistrust of rational, conceptual, calculative and abstract mode of thought. The logical minded managers, technologists, engineers, planners, experimenters; are not they the professionals who keep our society running? Is everybody aware of the complicated technological base upon which every moment of his comfort and daily survival depends? On What basis can we speak about "closing" or "bridging" the ever widening gap between the developing and developed countries?

One might ask what is the relation between population and surveying, or whether surveying could offer solutions?! Surveyors are concerned for they are part of the society. Surveyors are concerned for they can play an essential role in any population studies, by providing base maps, and by monitoring changes of population patterns by aerial photography. Surveyors are concerned about the increase in population and the associated increase of demand on natural resources, and need for shelter and food for everybody.

**Food**

Provision of an adequate diet for the present population and for the tens of millions of additional people who will live in this country in the next few decades, is the most important reason for acquiring information about land resources. The increase in agricultural production might be achieved principally by opening up suitable large areas of land, increasing the yields of existing cultivated land and increasing multiple cropping. To improve the distribution of agricultural commodities has no less significance.

Recent techniques in remote sensing and photo-interpretation are capable of successfully acquiring data in many fields.

1. Agricultural weather data: collection of meteorological data for agricultural purposes can be extremely valuable for short term crop forecast. It has a possible bearing in agricultural policy, specially in drought seasons.

2. Progress of crops and harvest prediction: provision of continuous information on the state of growth of the main crops and the degree of damage caused by pests, disease and other agents which affect the actual harvest yield.
3. Survey of areas cultivated annually by main crops: aerial photographs can be obtained in a very short time, to provide data on the last phenological stage, which makes a significant contribution to the final biological yield.
4. Soil classification: for new potentially agricultural areas, the type of soil, moisture content, topography, drainage and others are important elements. These elements could be identified from aerial photographs. Soil degradation due to water and wind erosion, salination and other factors are also possible to monitor by the same technique.
5. Extent and state of grazing land to support cattle is important for estimation of meat, milk, hides, . . . etc. It is possible by appropriate design of remote sensing system to predict overgrazing and desertification due to extreme climatic conditions.
6. Livestock information: as large population of livestock in Kenya are kept outdoors, this could be done by aerial photographs.
7. Fishery: Kenya is blessed by having about 600 km of Coast on the Indian Ocean, and also about 350 km shore on the freshwater of Lake Victoria. The introduction of the new sea law, extending national territories up to 200 miles into the sea increased the potential for exploitation of the ocean. It is claimed that remote sensing techniques, under certain circumstances, can be used to determine the abundance of stocks in the fishing grounds.



**Water**

Fresh water is necessary for domestic consumption, as well as for agricultural and industrial uses. Water supply problems restrict significantly the economic growth of the entire nation. The hydrologic cycle is easily under stood qualitatively, but a quantitative assessment depends on measurements of all components and their continuous interaction. Remote sensing can significantly contribute to accurately and efficiently measuring the land phase of the hydrological cycle, i.e. precipitation, stream flow, underground flow; and how it is affected by human activities.

Accumulated (historic, non-real time) hydrological data are being collected and archived for: planning, designing, constructing and operating water resource systems and the forecasting of hydrologic conditions ranging from droughts to floods. Such data are used mainly for designing dams, reservoirs, water supply sources, waste treatment facilities, irrigation projects, navigation facilities, flood prevention structures and flood plain management plans. Remote Sensing is more effective in acquiring real-time data for instantaneous decision making. Such data is usually introduced to computer models that attempt to predict conditions and optimize the operation of water resource systems. These models involve flood control operations, flood warnings and forecast, water forecast for management of electric power generation, navigation, water supply, irrigation and water quality.

Experiments have shown that remote sensing could be successfully applied to monitor the impact of land cover changes on water supplies, the impact of new rural water schemes on land degradation, the estimation of hydrological properties where direct observations are absent, preliminary hydrological investigations for locating surface and subsurface water supplies and estimating the need for irrigation water, delineation of water shed boundaries, derivation of surface characteristics for catchment modelling.

The new techniques of remote sensing have been successfully applied for other fields like forestry, engineering applications, planning and management of energy resources. These new survey methods are much more easily accessible for computer analysis. However, they do not replace the conventional methods completely, but rather supplement them. The cost effectiveness of these methods can be demonstrated only for large projects.

### The Necessity for an Information System

I would like to take the opportunity to propose to the Survey of Kenya to start introducing a computer based land information system. The wealth of land information in this department necessitates the immediate initiation of such system. If the only benefit of the system is the safe keeping of the information and preventing the risk by improper storage, destruction by fire, rain, wear, undetectable fraud, it still pays to introduce the system. Moreover the system is capable of providing easy and quick access to data, and as a central store for information it helps to avoid unnecessary costs of duplication. To start with, it is necessary to consult with the parties who are the main map users in the country to identify the most suitable characteristic features for the system. It is preferable if the system could be started as simple as possible and on an experimental small scale to demonstrate its function and effectiveness in the shortest possible time. The extension of the system is effected after politicians are convinced with the importance and rationale of the system in the long run, and appropriate funding therefore should be provided. The hardware development should not be an obstacle especially with the progressively decreasing cost of computers. But the software would definitely require a lot of effort. Another problem might be the training of the existing officers to develop the system. As for the new graduates it would not be difficult to introduce a course in the University. The important issue is to start now, then perhaps after five or even ten years we might have the system.

**The Department of Surveying and Photogrammetry**

The department is unique not only in Kenya, but in East Africa. It has the role of producing University graduate surveyors for the nation. So far in 18 years 154 Kenyans, 49 Tanzanians, 25 Ugandans and 7 others have been graduated. The undergraduate course is designed to provide a broad knowledge in all surveying disciplines, yet with adequate depth.

The curriculum emphasizes the fundamental principles of surveying subjects and includes relevant foundation courses as mathematics, statistics, adjustments, electromagnetics, computers and others. The course content embraces the most up to date techniques as well as the traditional methods. For a developing country many important functions can be performed with very simple tools and methods, subject to a creative approach suited for problem solving under the prevailing social and economic conditions. A good surveyor must be able to do the job with simple chain or with satellite, for each of which he ought to know the capabilities and limitations. The department attempts to train these good surveyors with solid foundation, who are capable of advancing surveying in Kenya environment.

In spite of the shortage of academic staff, the department is also involved in nationally oriented research. One Ph.D. and six M.Sc. degrees have been awarded. Some of the research topics were on the cadastral system, the use of aerial photographs for cadastral control, the use of remote sensing in assessment of the areas of tea, coffee and sisal plantations, and on the investigation of suitable datum for Kenya. The department is involved in a long term project to study the variation in Lewis Glacier of Mt. Kenya in connection with secular changes in meteorological and climatic changes. Another long term project is being initiated to monitor the crustal movements across the rift valley.

I would like to conclude this lecture with few remarks on the role of a Professor. I do not agree with what had been said before from this tribune that professor can go to a lecture unprepared, he can even commit mistakes and he might just leave his students to learn. I believe that a professor should, be very well prepared to his lectures. Comitting of mistakes is prohibited. To develop minor "errors" of "accidental" nature, even not "systematic", might be tolerable, provided that such errors be "adjusted" in time. But mistakes are never permitted, at least in surveying. Students in a University should be encouraged to learn, but a professor should teach them how to learn and supervise their progress in learning. Professor should lead the research in his department. This is a very important aspect and the University should create the proper atmosphere and provide facilities.

This lecture has been a mixed bag: some history, some statistical figures, some thoughts to accelerate development, some propaganda and some controversy. Whether it is what you had in mind, I do not know, but I shall try to get some feed back. If this lecture has opened the eyes of one of the decision makers to the necessity and importance of surveying for development, and of giving surveying its deserved recognition it will have achieved my objective. As for the University it can help to set a precedent even if this amounts only to informing your next lecturer to "read Rostom's lecture and you will see what we want you to avoid".

Mr Vice Chancellor, I would like to thank you for entrusting the chair of surveying and Photogrammetry to me. I have utilized my humble knowledge and experience to make what I feel is a potentially important contribution to developing Kenya. Finally I would like to thank you distinguished guests, ladies and gentlemen for your patience and attention.

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