PROCEEDINGS OF SEMINAR/TRAINING ON APPLICATIONS OF REMOTE SENSING TECHNOLOGY TO WATER RESOURCES, LAND MANAGEMENT, AND GEOGRAPHICAL INFORMATION SYSTEMS

28th MARCH-29th APRIL (1984)

ORGANIZED BY

National Remote Sensing Center, Nepal
Department of Soil Conservation and Watershed Management

Kathmandu, Nepal

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NRSC Seminar: Remote Sensing Applications to Water Resources, Land Management and Geographical Information Systems

28th to 30th March

APROSC Hall

28 March 1984

09:00	Registration	
10:00	Inaugural Session	
	Welcome: Mr. K.B. Malla, Project Manager National Remote Sensing Center Department of Soil Conservation & Watershed Management	
	Inauguration: Mr. Bishnu Maden Hon. Minister of State for Forest and Soil Conservation	
	Dr. Charles Hash Chief of Agriculture and Resource Conservation Office USAID Mission to Nepal	
	Few words from Hon. Chairman, Prof. U.M. Malla	
	Vote of Thanks: Mr. K.P. Budhathoki, NRSC	
12:30	Refreshments	
	General Session	
13:00	Mr. Brian Carson:	The role of Aerial photography in Developing Management Plans for the Himalayan Village.

13:30	Dr. B.N. Haack:	Spaceborne Remote Sensing Systems A Review.
14:00	B.N. Acharya :	Mapping Practice and Mapping Accuracy in Nepal.
14:30	T.W. Wagner :	Remote Sensing - An Suitable Technology.
15:00	Tea Break	
15:30	Film	

29th March

Vegetation and Landuse Session

11:00	P.L. Maharjan :	General Vegetation Types and Associated Land use in Five Physiographic Regions in Nepal.
11:30	K.R. Basukala :	Vegetation Mapping of the Bagmati Watershed as a case study using Landsat Imagery, through Remote Sensing means.
12:00	B.N. Acharya :	Remote Sensing for Natural Resources Survey.
12:30	Geoffrey King :	Remote Sensing Applications to Land Management.
13:00	Tea Break	

Water and Mineral Resources Session

13:30	K.P. Pradhan :	Spectral Response Studies of Various Land Cover Type using Hand-Held four Channel Radiometer model 100 AX.

14:00	Don Weiesnet :	Water Resource Applications of Satellite Data.
14:30	K.D. Bhattarai:	Remote Sensing Techniques for Geology (in Nepal), - a brief discussion.
15:00	K. Shrestha :	Remote Sensing and its Application to the Interpretation of Soil types.
15:30	T.W. Wagner :	Ground truth procedures for soil and mineral resources.
16:00	J. Jha :	Landsat imagery in the preliminary data preparation of Bheri Watershed.
16:30	Film :	Aerial Photo.

30th March

Geographic Information System Session

11:00	Dr. Barry N. Haack :	Geographic Information System An Overview.
11:30	Geoffrey King :	Mali Landuse Project as a case study.
12:00	Don Weisnet :	Hydrologic Applications of the Meteorological Satellites.
12:30	Tea Break	

Meteorology and Hydrology Session

13:00	S.R. Chalise :	Remote Sensing and Meteorology
13:30	Kiran Shankar : & G. Kite	Hydrology and Remote Sensing in Nepal.
14:00	Dhurba Das Mulmi:	Remote Sensing Application in Hydrology.
14:30	K.P. Budhathoki:	Delination of Snow land deplection.
	Few words from K.B. Malla, Project Manager, Nepal Remote Sensing Center.	
	Summary of training programme.	
15:30	Film.	

INAUGURAL SESSION

INAUGURATION

INAUGURAL SESSION

Welcome Speech
Mr. K.B. Malla
Project Manager, NRSC

Mr. B. Maden
Hon'able Minister of State
For Forest and Soil
Conservation

Dr. Charlesh Hash
Chief of Agriculture &
Resources Conservation
Office, USAID Mission to
Nepal

Prof. U.M. Malla
Member of National Planning
Commission

Few Words
Mr. K.B. Malla
Project Manager, NRSC

Vote of Thanks
Mr. K.P. Budhathoki
NRSC

Registration

Display

Participated 4 Observers

Refreshment

WELCOME SPEECH

- Krishna Bahadur Malla
Project Manager
N.R.S.C.

Hon'able Chairman, Hon'able State Minister, Distinguish guest and ladies and gentlemen.

It is my great pleasure to welcome you all in this Seminar/ Training dealing with the application of Remote Sensing in the particular field such as land use, Water Resource and Geographical Information System. I feel it is very timely in view of the policies and strategies pursued by His Majesty's Government of Nepal under the dynamic leadership of His Majesty the King to accelerate the pace of development both in the field of economy, science and technology in the country. In this pretext it become necessary to give our decision makers and resource scientist a better understanding of Remote Sensing Technology that could be used in great extent in decision making and planning process in the national development.

Allow me to speak a few words about the various type of platforms and sensors that are used to collect information of the earth, which are as follows:-

a. Earth Resource Satellite
b. Polar orbiting & Geostationary Environmental Satellites
c. High Altitude Aircraft
d. Conventional Aircraft
e. Light Aircraft
f. Rockets
g. Balloons
h. Helicopters
i. Data Collecting Platforms (DCPS)

In Nepal we have been using aerial photos for many yearsin our resource surveys in forestry, in geology and in soil survey. We all know that the first artificial orbiting satellite, sputnik was launched by the Soviet Union in 1957. Since then many hundreds of satellite have been launched by several countries for a variety of purposes. As we are concerned with the land resources the earth resource satellite and environmental satellite provides information on:-

- major classes of land use
- surface water areas
- landform and drainage pattern
- siltation, sedimentation
- snowcover and snow melt-rate
- vegetal cover and cropping patterns
- climatic data and rainfall
- distribution of clouds
- cloud structure,height and temperatures height and
- flooded areas
- disaster assessment
- crop yields, diseases and so on

The present and future satellite will provide satellite imagery with substantially improved imagery sensor performances in terms of spectral, spatial and temporal resolution as against the previous landsat imagery which used to have 80 m. resolution with an 18 days cycle:-

Landsat 5 - It is just launched on 1st March 1984 by U.S.A. which has a capability with lFOV of 30 meter resolution in 7 bands. It will be at lower altitude than the last Landsat series and will transmit in both S and X bands.

Spot - This French satellite will provide vertical and oblique imagery. There will be no thermal band but stereoscopic imagery will be received in 3 bands with resolutions of 10 and 20 meters. The same area will be covered by oblique imagery at 5 - 6 day intervals, having 110 km. between tracks and a 26 days cycle for global coverage.

Space Shuttle - It will constitute a space lab in the orbit by U.S., this system will also carry a Large Format Camera which will be used for taking photography of the earth and will provides the stereoscopic view. The resolution will be about 3 m.

TIROS - N, No AA 7-8 - These are third generation of the polar orbiting No AA/ GOES Environmental satellite system, replacing the previous No AA satellites which is carrying improved sensors for temperature soundings and for reading in 4 channel which includes microwave channel for sounding in cloudy areas.

These satellite picture that we get of Nepal are recorded by the satellite scanners and are made up of many millions of cells known as pixels- which stands for picture element. Each pixel has its own sets of grey - scale values that are transmitted to the earth and recorded as signals back on magnetic tape. These tape recorded signals and then played back on a video screen and carefully photographed. The resulting picture preserves the same grey scale relationships that were originally recorded by the scanner.

There are many distinct advantages to obtaining earth resources information in this way. Some of these are -

1. The original data are recorded on magnetic tape and the tape can be used many times without losing the high quality of definition of the picture produced.

2. The data are recorded quantitatively and with much higher sensitivity than our eyes can see.

3. Since the data are recorded quantitatively on magnetic tape, we can use computers to explore and develop a wide range of new processing technique for bringing out subtle details.

Here in the Center we usually get landsat data in the form of 7.3 by 7.3 inch of 1:1 millions scale transparencies.Each transparency shows a 10,000 sq. mile area on the ground in one of four spectral bands. In other words, the same area is actually recorded 4 times in 4 different pictureson the same area. This means that we can view the same features in four different bands and have four chances to distinguish one from another.

We usually select a green band (MSS 4), a red band (MSS 5) and infrared band (MSS 6 or MSS 7) to make a false color composite. Using then veriation in color, it is usually much quicker and easier to identify and interpret features on the ground.

Earth Resource Satellites give a unique and permanent record of the earth's surface and can be used to record data repeatedly on a near 'real time' basis

This is a very brief introduction to this complicated technology, but now let me just speak a few words about our own experience in using this technology at the Remote Sensing Center. This Center was established just 3 years ago and is staffed with more than a dozen technical experts from different disciplines.

The Center is currently makes extensive use of a variety of visual interpretation devices which help in the extraction of information from the images. Most of these instrument were provided through the U.S. assistance.

The Center, during its brief life has conducted several studies using remote sensing data and ancilliary information. These are:-

1. A deforestation map of Terai showing the change in forest cover over 30 year period.

2. Zonal maps showing general areas of forest cover.

3. Natural Resource study of Marsyangdi Watershed.

4. A general land use/ land cover map of Kathmandu Valley.

5. Land cover map of Daraundi Watershed.

6. A wheat acerage estimation of Bhaktapur District for 1983.

7. Bagmati and Karnali Watershed study is still in the process.

Nepal's three- fourth of geographical areas lises in the hills where the communication between one district to another is very difficult and poor therefore the collection of information through conventional means on natural resources is time consuming, difficult, and expensive.

Even if it is collected after spending lot of time and expense it will be out dated to be used. Information concerning to natural resources are vital and provides the basis for economic development.

Despite the effort made by HMG in the past of many decades in various field but as a whole has shown no meaningful improvements of country's economy which is of immense importance for achieving an overall objectives of development goals. This problem could be addressed through the use of remote sensing technology to overcome some of the problem that arises now and then in development work.

Since remote sensing has an important role to play in providing the information base therefore the scientist and technicians of various departmentsand agencies would take the challange to address these issue to the benefit of the country. Let me extend welcome to you all again.

Thank you. Jai Desh - Jai Naresh.

INAUGURAL SPEECH BY HONORABLE MINISTER OF STATE FOR FOREST AND SOIL CONSERVATION

Mr. Bishnu Maden on the occasion of the Seminar/Training of Remote Sensing Technology

Distinguished Guests, Ladies and Gentlemen.

It gives me great pleasure to inaugurate this Seminar/Training on the applications of Remote Sensing Technology to water resources, land use and geographical information systems sponsored by National Remote Sensing Center, Nepal.

I believe this Training/Seminar will provide more exposure on how to use satellite imagery and data to generate basic information for natural resources and assess their condition and extent in Nepal. This technique can be used as a valuable tool for planning our national resources development and for their appropriate utilization. As this subject is highly technical and specialized, it would not be wise for me to make specific comments about the technology. However, I would advice our professionals to make maximum use of the opportunity to receive more knowledge and know-how during this Seminar/Training programme. This will give you the experience and the confidence to make use of this technique in generating useful information in forestry, agriculture, soil, survey, geology, hydrology and many other fields that are of concern in our fragile mountainous country.

At this time, the National Remote Sensing Center has organized the Seminar/Training on geographical information systems, watershed, mapping and landuse planning. Maps and data are scattered in the different departments and units of government. There is a need to utilized these data at this time. I believe it may help policy making concerning natural resources to develop a technological information system from which various types of information will be available. All of us know that many projects cannot be undertaken or conducted systematically due to scarcity of basic data and information. For this reason we pay close attention to Remote Sensing technology and to take advantage of it in obtaining new data and information. I believe it will help to solve problems in the progress of our country.

There is a dearth of basic resource information but such information is needed for implementing various development activities concerning the natural environment. I don't hesitate to say that in the past, we have not achieved the desired progress in some development projects because we did not have enough basic information to effectively launch such programmes. It is now time to pay more attention to Remote Sensing techniques to overcome these problems and to generate the badly needed information in a cost effective manner. A considerable archive of airphotos and satellite data already exist within the country and these must be used for our national development.

As part of own modest efforts to tackle these problems HMG/Nepal established the National Remote Sensing Center under the Department of Soil Conservation and Watershed Management in 1980 with the substantial support extended by the United States Government.

Under the dynamic leadership of His Majesty the King, Nepal is now making vigorous development efforts in various fields. Most of the efforts, in one form or another conservation and proper utilization of natural resources to promote improved economic conditions for our people. Therefore, I urge the technical and scientific manpower of our country to go all out in using Remote Sensing technology, with sincere and vigorous efforts, to support and to bring success to these project and developmental activities.

To our friends who came here from the United States to teach and transfer their knowledge to our professionals, I extend heartest welcome and hope that they will find their stay in Kathmandu both interesting and useful. I hope that the knowledge and know-how that will be delivered during this Seminar/Training from the foreign experts will be great value in solving some of the problems that confront us. Also, I want to add my thank to the organizers of this Seminar/Training programme.

Lastly on behalf of HMG/Nepal and my own I would like to thank the organizers,who invited me to inaugurate this Seminar/Training on Remote Sensing Applications and to all participants that are taking part. I wish that this Seminar/Training to be fruitful and greatful!

Thank you
Jai Desh, Jai Naresh

(28th March 1984)
(15th Chaitra 2040)

Translated from Nepali Verson

Dr. Charles Hash, Chief
Agriculture and Resource Conservation Office
USAID Mission to Nepal

Honorable Minister of State, Prof. Malla, Mr. Project Manager, Ladies and Gentlemen.

I am here as a stand-in for our Director, Mr. Dennis J. Brennan, who could not be here today. But I am sure that he would be pleased as I am, with the large representation by members of potential user organizations, that is, people from agencies and departments of His Majesty's Government who have come to attend this Seminar with a view to utilizing the information and the products of the Center, in order to help accomplish their tooks planning and monitoring of resources use and development of this country.

I urge you to very aggressively push the Center to respond to your needs for better information on which to goes your plans. I also urge you to carry back to your departments and agencies, information on how you and your colleagues can make continuing use of the facilities and information available at this Center.

We at USAID have just gone through on exercise of evaluating this center and our efforts assist with development. Basically, this group of international experts on remote sensing found the center to be rather unique among such facilities around the world in terms of its focus on practical problems more than on exotic equipment. I think that the center in very much to be complimented on its orientation.

We at AID are very pleased to be able to assist His Majesty's Government in this kind of information available these establishment of this center. Though evaluation exercise point to (from our point of view) a very successful project, you, yourselves, will be the final judges as to whether this joint H.M.G. Donor effort has been successful in establishing this center as a source for useful information for your planning and monitoring of projects.

I encourage you to judge it critically and to pass on your observations of the center to your management. Our hearty best wishes for a successful seminar/training programme.

SPEECH AFTER THE INAUGURATION OF THE SEMINAR/TRAINING ON REMOTE SXNSING APPLICATIONS BY PROFESSOR UPENDRA MAN MALLA - MEMBER OF NATIONAL PLANNING COMMISSION.

Honourable Minister of State for Forest and Soil Conservation, Participants, Friends, Ladies and Gentlemen:

I would like to give cordial thanks to the organizers of this programme for the chance to be Chairman and also to say a few words in this important occasion.

Ladies and Gentlemen, the Seminar/Training on Remote Sensing Applications to Water Resources, Land Management and Geographical Information Systems has been inaugurated. This is a thing of high regard. Remote Sensing is most important and a highly usable technology in increasing the role of science and technology in development. Actually, the fact that I am speaking and you all are hearing me in this meeting hall is one from of Remote Sensing. And if we look from a little above the ground, we can see a green environment on one side and on otherside the different colours of various objects such as houses, foot-trails, rivers, etc. are to be seen. No objects can be seen in great detail from very near. For example a small ant can'nt recognize the pattern and design of a carpet upon which it is moving. Similarily, the tiny people of Lilitput could not recognize Guliver and wished to carry out research after binding his body in the sleeping condition.

But even though the humanbeing is small, he has special abilities of body and brain and unlike most animals, can stand on two legs while keeping all his weight. He can move back and forth, turn his neck to see around and especially, look up and down to see both far and near. He can focus "vision" very far by the use of his eye, mind and understanding. After observation, man can analyze to gain understanding, can interpret what he sees and can report what he knows to others.

Our civilization started many centuries ago with persons like Arya Bhatta, Baraha Mahir, Bhaskaracharya studying the stars and planets with the help of Beda. They tried to learn about the environment of humans by this method, but their information was meager due to the absence of systems like Remote Sensing. With the development of Science and Technology, man became able to see many things. By aircraft even the rounded structure of earth was not clear. Thus, to demonstrate the round earth, teachers use different points and give examples of early voyagers like Drake, Magellan, Cook and others.

Some 27 years ago, artificial earth satellite were first launched in to the sky. Since that time man has reached the moon, Research on Venus and Saturn and launched many new kinds of aircraft satellites to collect and transmit information. With the help of these satellites we can talk with our friends in America and Europe the same way that we call our neighbours from our own house. By such revolutionary means we can better define our basic socio-economic needs. And, if we can utilize this technology to its maximum extent, we can increase the rate of our productivity and development. To give substance to these potentials, we should make our maximum effort and go forward with the development of science and technology. For increased rate of production in the Sixth Five Year Plan and the Seventh Five Year Plan, irrigation for Agriculture and energy for industrialization is most important. These two factors are based on our water resources, which side by side must support our economic development.

In this context, this Seminar/Training on Remote Sensing is most appropriate. Due to the pressures of increasing population, the trend is towards more deforestation for fuel, fodder, and agricultural land. Such land detortation, erosion and drying of water resource decreases the productivity of agriculture. All of these are caused by an unbalance of Nature. Man is destroying the land in various ways (including unsound agricultural practices) day-by-day and very rapidly. Thus policy-makers concerned with resource use and conservationists alike should carefully note the changes -- instant by instant. Bearing these things in mind, decisions should be made and planning should be conducted in accord with these constraints. But the problem has been that the soil productivity is already destroyed before the Manager can plan to do something about it. Thus, for the planning of a project in which the resource base is changing rapidly, up-to-date information must be obtained continuously. Only then can we say what is the true ground condition.

By the technology of Remote Sensing, up-to-date information can be obtained continuously and in a form that managers can understand. By the help of Landsat, we can see parts of earth like a movie film which shows particular areas at different times and in different ways -- year after year. If we need detailed information of any spot on the ground, we can make enlargements of the images. From interpretation of certain colours they may have, and after detailed study and analysis, decisions can be made which are consistant with good management and can be used for better resource utilization. It is important for our decision makers, in setting resources policies if they can properly interpret Remote Sensing images.

Lastly, I would like to give thanks to the members of the organizing committee of this seminar on Resources Water Resources, Conservation, and Landuse and Management for its work in the fulfilling the aims of this programme. Finally, I want to express by best wishes for its success and simply end with two words on this subject.

(28th March 1984 Jai Desh, Jai Naresh
(2040 Chaitra 15)

Translated from Nepali verson

Vote of thanks

Hon'able Chairman,
Hon'able Minister,
Distinguish guests,
Ladies and Gentlemen.

I want to express my faithful gratitude to the Honorable Minister of State and Soil Conservation Mr. Bishnu Maden, who has very kindly accepts to inaugurate this National Remote Sensing Seminar/Training despite of his busy schedule.

I am also grateful to Honorable Chairman Professor Upendra Man Malla, who has spared his valuable time to come and chair the Remote Sensing Seminar/Training and conduct this session.

I extend many thank to Dr. Charles Hash, Chief of Agriculture and Resources Conservation, USAID Mission to Nepal, to be with us.

I thank Dr. B.N. Haack, Mr. G. King and Mr. D. Wiesnet who have come here from U.S. to teach and transfer their knowledge in the sphere of applications of Remote Sensing Technology.

I want to thank Mr. Ruby Joshi, the Director of APROSC for providing all facilities to conduct this seminar session in APROSC Hall.

Again, I want to thank to all distinguished guests to make this session successful by their presence, which makes me deep feeling about your interest in Remote Sensing.

Last I want to express my sincere appreciation to all participants and trainees, who came here to under go four weeks of vigorous training in the application of Remote Sensing for whom this Seminar/Training is organized.

Thank you
Jai Nepal

Kamal Prakash Budhathoki, NRSC

Few words from K. B. Malla
Project Manager
National Remote Sensing Center

Good afternoon

Dear Ladies and Gentlemen:

This seminar is organized to give you a general information, or I should say to get you sensitized to this Remote Sensing Technology which has evolved rapidly for the betterment of mankind. I would extend my thanks again to all the participants who have taken sufficient interest to get themselves informed about this technology that has revolutioned in global information system on obtaining environmental change or natural resource.

This information will lead to the decision-maker or Resource Manager to correct their activities in order to minimise the adverse effects. I am also thankful to the lecturers who have taken great pains to introduce us with this new technology through their well caliborated presentations. I presume this seminar has achieved its objectives. Ladies and gentlemen I will assure you, your presence in this seminar has supported us to take further step to organize such seminar in the future too, so that more people from different field could be make well informed for making use of this technology for their work assigned. Further, on behalf of the Remote Sensing Center, I would encourage every individual to take advantages of the facilities that the Center can provide in the cause of resource mapping or explorat-ion and so-forth.

Thank you again.

GENERAL SESSION

Mr. H.S. Scott
Geologist
L.R.M.P.

Dr. B.N. Haack
Prof. of Geography
Ball State University

Mr. B.N. Acharya
Survey Department/Nepal

Mr. T.W. Wagnor
Adviser, NRSC

The Role of Aerial Photography in Developing Management Plans for the Himalayan Village

by
Brian Carson
Soil Scientist
Land Resource Mapping Project

Aerial Photography, if properly utilized, could become an important tool for the management of the land resources of Nepal. The great advancements in satellite imagery techniques have captured the imagination of land managers throughout the world. Unfortunately there has been a recent trend to down play the utility of black and white aerial photography, which can play a crucial complementry role in developing rational land management plans. Since 1980 the Land Resource Mapping Project has been mapping soil landscapes, land utilization, land capability and geology of Nepal utilizing 1:50,000 black and white aerial photography. By 1985 they will have completed the basic resource inventory for the whole country. The 1:50,000 scale maps provide the appropriate detail for regional and district level planning. The Surkhet District Management Plan produced in 1983 provides an example of the integration of the project's information for developing natural resòurce based management plans. There is a general concensus among users that the maps are playing a useful district planning role.

There is presently a great surge towards "grass roots" level action. The purpose of this paper is to demonstrate a methodology that provides a rational base upon which the detail required for village level planning can be superimposed.

As HMG/Nepal becomes increasingly committed to working at the village level, there is often an information vacuum on how to collect and utilize natural resource data. At the regional level planners are dealing with landscapes and populations, while at the village level workers are dealing with the farm plot and individual peasants. The lack of information transfer results in engineers recommending schemes that are unacceptable to the villagers and economists suggesting ineffective or impossible technical solutions to landscape problems. Ultimately this information must be integrated, all at the appropriate level of detail, so that one can make good decisions at the village level.

One of the most severe limitations for planning at a village level is the lack of an overview assessment for the area. Here the Land Resource Mapping Project Maps can be usefully employed to develop greater understanding of the local conditions. Euqally important, they provide a rational country wide framework that can act as a model for more detailed studies at the village level. However, the existing base maps at the scale of 1:50,000 or smaller are of limited use for village planning. To produce reasonable topographic maps for small, steeply sloping areas is very expensive as well as time consuming. Once produced, contour maps are not easily understood by HMG field personnel. It is for these reasons that aerial photography has a major role to play in providing a base for resource information acquisition. Aerial photographic coverage now extends over the whole of Nepal at 1:50,000, with many areas at 1:20,000. The negatives for these photographs are stored in the Topographic Survey Branch Office, Baneswor, and prints are made available for government sanctioned purposes. They can be enlarged considerably with graininess becoming obvious only after a five times enlargement. Quality of prints varies considerably, however and the purchaser should insist on well developed prints to set maximum value from them.

Aerial photography has one factor overwhelmingly in its favour over contour maps: it records every single visual surface characteristic of the area. Every field, every bush, every home, every path is recorded and readily distinguished by casual observers. It is this factor that will permit rapid assessment of a wide variety of characteristics crucial to the understanding of the village dynamics.

Enlarging 1:20,000 aerial photographs four times to 1:5,000 will provide an appropriate base for village planning. At this scale, one cm. on the photograph represents 50 metres on the ground. Therefore, individual homes will be shown as 1mm. squares and average hillside fields, ½mm by 2mm. Individual trees (such as pipal and banyan) will be prominent features at this scale. The use of a large scale aerial photograph for village planning has a number of very important and useful applications:

1. Rural Nepalese are adept at reading aerial photographs without any formal training. With a few minutes, untrained villagers can pick out their own village, their farm land and other permanent features on 1:50,000 photography. This ability is not common to all peasants; but, as the Nepalese often look off ridges into valleys, they are used to observing the landscape like that presented by an aerial photograph.

2. Aerial photographs are much cheaper than making a map. For approximately Rs. 38 per 30 cm. square of photographic paper, one can have a whole village including grazing and forest lands accurately delineated. Photographic distortions, however will limit the ability to accurately measure distances and areas, particularily in areas of high relief.

3. By photo interpretation and minimal field checking one should be able to distinguish the following to a level of detail suited for village planning:

   a. Flat and terraced irrigated rice land (keht).

   b. Non-irrigated flat and terraced crop land (bari).

c. Grazing land - whether on abandoned terraced or sloping land.

d. Forested areas and degree of forest degradation (individual trees can be counted as well as distinguishing vegetation types).

e. Villagers' home locations.

f. Main gathering places (markets, pipal trees, wells, etc.)

g. Trial location - main thoroughfare trials.
- secondary trials to grazing areas and fodder and wood collection areas.
- minor trials to individual holdings.

4. With field investigation, the location, extent and type of water sources could be pinpointed on the aerial photograph including:

a. The amount of land irrigated in monsoon.

b. The amount of land irrigated in the winter as well as variability of water supply from year to year.

c. Livestock watering places and water hole persistence throughout the dry season.

d. Potable water sources, quality and amount of flow at various time of year.

After the initial basic land resource inventory the next steps is to find but how man presently interacts with his environment. Each day, who goes where for what ? (i.e. fetching water, fodder, fuel, building materials, collecting herbs, etc.) Agronomiç practices such as compost spreading, ploughing, irrigation, terrace maintenance, weeding, harvesting should be documented. In fact, every phase of subsistence agriculture should be considered to understand the dynamics of village econogy.

After this data is collected and overlaid onto the large scale aerial photograph the land manager should be in an excellent position to engineer positive changes for the area. Immediately he can assess the amount and quality of the grazing and forest land and by knowing the habits of the villager he can discern where improved management will bring the most immediate benefit to the village. He can observe trends and predict confidently when a forest will be completely cut making the shortage of firewood a severe problem. Areas of lopped trees would be demarcated as fodder production forest and proper management could quickly enhance that use. The trails to any particular site may be inadequate for the amount of traffic using them. By identifying the major trails on the photograph and studying the movements of people one can come us with a rational choice for upgrading trials.

It may be decided that bringing clear drinking water to a village is a high priority or conversely a sanitation programme on the existing watershed might be most appropriate.

Regardless of the project to be assessed the large scale aerial photograph provides a base from which land managers can develop their strategies. The field worker and villager alike should be able to perceive the dynamics of the environment they are trying to improve and ultimately to achieve a more efficient and sustained utilization of their resources.

SPACEBORNE REMOTE SENSING SYSTEMS: A REVIEW

Dr. Barry N. Haack
Professor of Geography
Ball State University
Muncie, Indiana. U.S.A.

Introduction

There have been remotely sensed data of the earth's surface from various spaceborne platforms for over twenty years. These data give scientists a unique view of the earth which can be very useful in providing some types of resource inventory and analysis information. One of the primary advantages of remotely sensed data from space is its synoptic or large area view. This synoptic view provides a regional perpective which can be complemented by selected aerial photography or ground surveys. This large area view generally provides information at a much lower cost than conventional data collection techniques. This article presents a brief summary of the primary spaceborne remote sensing systems. These systems are identified as experimental, operational, or future systems.

Experimental Systems

The early experimental systems were the Mercury, Gemini and Apollo programs of United States. These programs were conducted in the 1960's and consisted of orbiting satellites for short periods of time, some manned and others unmanned. Most of the remotely sensed data collected by these satellites consisted of photographs with different film - filter combinations.

The United States Skylab satellite in the early 1970's collected photographs of the earth and also data from other sensor including a multispectral scanner, microwave sensors and an infrared thermal radiometer. In 1978, the United States SEASAT system collected a variety of data, primarily for hydrologic and oceanographic applications, over a three month period.

Also in 1978 a Heat Capacity Mapping Mission (HCMM) began 2 1/2 years of data collection over much of the earth. This system collected day and night thermal and visible-near infrared images at 500m resolution of interest to geologists and hydrologists.

In 1979, the MAGSAT system obtained information on magnetic anomolies from space. The most recent experimental system is the United States Shuttle flights which have carried several remote sensing systems into space. One of the more important sensors on the shuttle has been an L-band spaceborne imaging radar. These experimental systems provide extremely valuable information on the relative usefulness of various sensing systems in space for resource analysis. This information is useful in designing operational systems.

Operational Systems

The most useful spaceborne sensing systems have been the meteorological satellites. These systems began in approximately 1960 and consist of both orbiting and geostationary platforms, generally obtaining data at very coarse resolution images using various sensors. The principle meteorological satellites included TIROS, NIMBUS, NOAA series and GOES. These satellites are useful for examining global climate, heat balance, atmospheric pollution and, most commonly, for weather forecasting.

The most important land resources satellite series is LANDSAT. There have been five Landsat satellites launched since 1972, the most recent in March, 1984. These are orbiting satellites covering all of the earth's surface between 81 degrees North and South latitude on a 16 or 18 day repeat cycle. The sensor package on these systems have changed slightly from satellite to satellite. The most important sensor has been a four band multispectral scanner (MSS). The MSS collects data for an 80 meter resolution cell. Other Landsat sensors have included a return beam vidion camera (RBV) and a thematic mapper (TM). The RBV was a single band system with a 40m resolution. The TM has only been on Landsats 4 and 5 and is a seven band multispectral scanner with improved spatial, spectral and radiometer resolutions. The Landsat series of satellites have provided an extremely useful set of data for resource inventory and analysis for essentially the entire earth. These data are repetitive, planimetric, relatively inexpensive and generally easy useable.

Future Systems

There are a number of future spaceborne remote sensing systems planned by various governments and organisations. These include RADARSAT by Canada in 1986/87, the Japanese ERS-1 in 1989, a CHINASAT series, and proposed system by Brazil and a joint Indonesian-Dutch satellite among others. The French intend to launch a SPOT satellite in early 1985. Spot will be capable of provided imagery with 10m resolution in a single band, 20m from a three band MSS and also stereoscopic images.

Summary

Spaceborne remotely sensed data were first obtained over twenty years ago. The variety of experimental sensors on these platforms have provided scientists with some understanding of what types of information can be obtained from space. There is, however, a great deal which is still unknown about these spaceborne sensing systems. There have been many examples of the usefulness of spaceborne remote sensing and unquestionably scientists and decision makers will increasingly make greater use of those data sources in the future. It is important that scientists and administrators who are concerned with resources be familiar with the capabilities and limitations of spaceborne remote sensing.

MAPPING PRACTICE AND MAPPING ACCURACY IN NEPAL

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Introduction

The history of map making is older than the history if we take the history as beginning with written records. The history shows that the history of map making is advancing due to the following cause i. Wars ii. Travelling iii. Property rights 8 iv. Migration.

Map is the representation of earth surface or part of earth's surface on a piece of paper. Globe is the model of earth or actual representation of earth surface. We cannot use globe for our planning execution and day to day work. So we need a comfortable and handy map which serve our purpose and maintain the accuracy. Any large area of spherical surface cannot be represented on a flat surface without distortion (shrinking breaking or stretching). So earth a spheroidal surface cannot be represented on a plane surface, involves streching or shrinking resulting in distortions. Different techniques of representation are applied to achieve representation which poses certain properties favourable for the specific purpose at hand and considering the size of the area to be represented. The techniques of representation is commonly called "map projection."

Three principal cartographic criteria are applied to an evaluation of map projection properties as 1) Equidistance II) conformity (true direction) III) Equivalency (equal area). The major projection are of three types, : 1. Zenithal II. Conical and III. Cylindrical. These projection are classified in different sub categories according to their properties etc. In mapping we compute horizontal control on one surface known as spheroidal surface and vertical control on Geoidal surface.

Nepal uses a cylindrical projection which is known as the Universal Transverse Mercarator (UTM) projection. This projection is useful for small area to be mapped at large scale especially for cadastral mapping. The topographical maps of Nepal were originally prepared by Survey of India in conical projection but are now prepared in Nepal in cylindrical projection. There is no good scientific logic or reason to use this projection for topographical mapping. By seeing geography and properties of projections, it seems that for Nepal conical projection with two standard parallels is very useful and scientific.

Classification of Maps

Maps are classified according to scale and purpose. Classification according to scale of maps includes:

1. Geographical maps: a. with contour (Scale smaller than 1:1M)
   b. without contour
2. Topographical maps: Scale 1:2000 to 1:1M.
3. Plans: Large scale maps upto the scale 1:2000

Classification according to the purpose of maps includes:

1. Land use/land cover maps
2. Land capability maps
3. Climatological maps
4. Forest maps
5. Geological maps
6. Soil maps
7. Transportation and Communication maps
8. Hydrological and Meteorological maps
9. Cadastral maps
10. Landform maps
11. Engineering maps, plans and charts
12. Gravity maps
13. Other maps

The use of maps: The maps are used mostly for the following purposes:

1. National Security
2. Development of mineral resources
3. Highway development
4. Protection of public properties
5. Irrigation, drainage, water power and dam construction.
6. Industrial developments
7. General purposes.

Now let us discuss the different kinds of surveying and mapping. The following are some examples of different types of surveying and mapping commonly used:

1. Land or property surveying
2. Engineering surveys for design and construction
3. Geodetic surveying
4. Cartographic (or Topographical) surveying
5. Aerial survey and services
6. Cartography
7. Land resources surveying using land observation technology

Surveying and Mapping Practice in the Kingdom of Nepal

The main surveying and mapping agency in the Kingdom of Nepal is Survey Department which has three branches to conduct different surveying and mapping works. The three branches are:-

- Geodetic Survey branch
- Topographical Survey branch
- Cadastral Survey branch

The survey department by its name and organizational set up has as its main objective to prepare different scale topographical maps, cadastral maps and plans.

The objectives of Geodetic Survey branch are to spread Geodetic horizontal and vertical control points all over the country. This branch is also working for lower order (not geodetic) control points. These geodetic control points control the basic accuracy of all the maps. So geodetic work plays a vital role in achieving the accuracy standards in mapping. Geodetic control points are the skeletons of maps, and all other details are the flesh.

The objectives of Topographical Survey branch are to produce topographical maps at different scales which can be used by engineers, planner, researchers, tourists, etc.

Topographical Survey branch, which was formed a little less than one decade ago, is now well established. Topographical Survey branch has been doing only revision of topographical maps originally prepared by Survey of India without ground verification. The accuracy of these maps is not known or mentioned on the maps.

The objectives of the Cadastral Survey branch are to conduct property survey of whole country. The technique applied to the cadastral survey is the graphical method using alidade and plane table. This is a rigorous ground survey method. This branch is working since last four decades has not still finished the cadastral mapping of the country.

"In the science of cartography France is not as advanced as a country like Germany because it does not have topographical map series of the country at a scale of 1:2500. We have only 1:5000 scale coverage of country but Germany has National series of topographical maps at scale 1:2500." This was the statement of a French cartographer who was conducting a seminar on SPOT satellite system. Now a days a country's advancement and civilization is measured by the history and advancements of her mapping activities.

According to the above mentioned statement one can evaluate our advancement and civilization, where we do not have our own topographical maps prepared by us, even at scale 1:50,000. Our friends have reached to other planets for search of resources and mapping the earth from the space but we still restrict our people to use the aerial photographs. The topographical maps of our country prepared by other nation are prohibited to our citizens who need them for research or other civil works. This is a serious matter for researchers and scholars who want to use these maps for the planning and appraisal of their research projects.

Surveying and mapping play a vital role in preparing the infrastructure for development of nations. Surveying and mapping are a basic and most useful tools for regional development planning.

The other organizations which use the surveying techniques to prepare maps and charts are:

1. Department of Mines and Geology
2. Forestry Resources Research Office
3. Electricity Department
4. Roads Department
5. Irrigation Department
6. Department of Water Supply and Sewerage
7. Department of Housing, Building & Physical Planning
8. Ministry of Local Development
9. Nepal Remote Sensing Center
10. Nagar Bikas Samittee
11. Others

Except for the Nepal Remote Sensing Center and Forestry Resource Research Office almost all the organization prepare either plans, charts, or large scale topographical maps using ordinary field observation instruments such as level, theodelites etc.

Forestry Resources and Research Office has photographs of the whole Terai area and some strips of hilly area taken in 1955 at scale 1:12000. This office has sophisticated steroplotter instrument such as wild A8 etc. Which are not in use.

Nepal launched land reform programme before two decades ago. That time if survey Department could have been able to introduce photogrammetric method to prepare cadastral maps, at that time programme would have been implemented more scientifically. Consequently more benefit could have achieved for the nation. Survey Department still not interested and not able to adopt photogrammetric method for such large scale mapping (cadastral survey). The reason given by the authority for this is that "if we adopt photogrammetric method for property survey then where shall we put the medium class man power?" If this reasoning is valid then why should we not close the Remote Sensing Center, which applies the technology faster than photogrammetry?

Mapping Accuracy in Nepal

The word 'correct' is not available in the surveyor's dictionary for we know a surveyor can do only an accurate survey; not a correct one. There is always an error; however we say "accurate", because avoiding all error is beyond the capacity of human beings. But this goal makes the human being dynamic: always searching for correctness. So we must compromise for the accuracy how much is necessary and upto how much can be tolerated.

Errors are of three general types:

1. Blunders
2. Systematic and
3. Accidental

Accuracy depends upon three elements - precise instruments, precise methods, and good planning and execution.

Precise instruments are not absolutely necessary but they save time and therefore provide economy. Precise methods must be used. They eliminate or reduce the effect of all types of errors. Good planning is the most important element in economy and a very important element in obtaining accuracy. Accuracy is classified in two groups- Relative & Absolute accuracy. Mapping accuracies discussed here are all under the heading of relative accuracy. When considering the accuracy of any map we have to include all errors accumulated from the beginning of mapping steps.

- Map projection: distortion due to representing a spherical surface into a flat surface.

- Ground control points: Accuracy of any control point depends upon the order of the control point, method used, instruments used, etc.

- Plotting errors: These are the error due to omitting details or inaccurately plotting on the ground or from photograph or image.

- Drafting and printing errors:

Accuracy of thematic maps or other maps prepared by using land observation satellite products depends upon the following factors:

1. Data acquisition
2. Data processing
3. Scene-dependent
4. Interpretation
5. Drafting and Printing

The mapping accuracy in Nepal is generally not defined except that in some organization the accuracy of observation of horizontal, and vertical angle and distance are defined. There is no committee to decide on National mapping accuracy standards. In all Asian countries, no map shows or indicates its accuracy; one has to guess the approximate accuracy according to the scale of the map.

Because we do not have recorded map accuracy standards, it will be better to mention here the national map accuracy standards of the USA which are often adopted by other countries as well.

Geodesy (control surveys) is the common denominator that relates and co-ordinates the nation's and the world's activities in a physical three dimensional mode. The more commonly used geodetic data include latitudes, longitudes, elevations, deflections of plumbline and gravity values.

One of a multitude of uses for these data is the construction of maps and charts which in turn, relate the horizontal and vertical positions between all cartographic features on a given map, with those features on any other map of the earth. The accuracy of cartographic presentations then is directly related to the accuracy of the National geodetic control networks.

From maps for tax assessment constructions, transportation system, co-ordination to maps of social and environmental data adequate and accurate positioning is fundamental. The control survey covers - Horizontal, Vertical control, gravimetric survey and astronomic survey.

Horizontal control surveys determine geographic positions referred to a national datum and provide the basis for rectangular co-ordinate systems. Vertical control survey determine elevations referred to a national datum, which is based on sea tidal level measurements (Geoid).

Measurements of gravity and Astronomy provide data for the establishment and adjustment of the national control networks. Surveys of large area must take account the curvature of the earth. Larger areas must surveyed by methods which recognize that the mathematical figure of the earth is slightly flattened sphere or an ellipse of revolution.

The accuracy of the horizontal control is defined after classifying the horizontal control survey into different order, such as superior order lst order IInd order & IIIrd order. The accuracy for these different order are defined as:

Superior	lst order	II order		III order	
		Class I	Class II	Class I	Class II
1:1,00,000	1:100,000	1:50,000	1:20,000	1:10,000	1:5000

The accuracy of vertical control surveys is also decided according to the order.

Ist order		IInd order		III order
Class I	Class II	Class I	Class II	
0.5mm $\sqrt{k}$	0.7mm $\sqrt{k}$	1.0mm $\sqrt{k}$	1.3mm $\sqrt{k}$	2.0mm $\sqrt{k}$

Where k is the distance in kilometers between points.

The standard error is computed by:

$$6\ m = \frac{r^2}{n(n-1)}$$

Where 6m is the standard error of the mean, r is a residual that is difference between a measured length and the mean of all measured lengths of line, n is the number of measurements.

The accuracy of topographical maps at publication scale are specified as follows:

With regard to horizontal accuracy, it is required that for maps at publication scale larger than 1:20,000 not more than 10% of well defined points tested shall be in error by more than 1/30 inch, measured at the publication scale, and for maps at publication scale of 1:20000or smaller 1/50 inch. Well defined points are those that are easily visible or recoverable on the ground, in general those which are plotable on the scale of the map to within 1/100 inch.

With regard to vertical accuracy it is required that no more than 10% of the elevations tested shall be on error more than 1/2 the contour interval, The apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error. The accuracy of a map may be tested by comparing points whose location or elevation are shown on it with corresponding points as determined by surveys of a higher accuracy.

The errors are specified as root mean square planimetric or vertical according to the scale.

RMS Planimetric = $5.7 \times 10^{-4} \times Sm$ for scales 1:20,000 and larger.

RMS P = $3.4 \times 10^{-4} \times Sm$ for scale smaller than 1:20,000.

Root mean square error of height.

RMSh = $0.34 \times CI$, Where CI is contour interval and Sm is Scale number.

Most interpretation oriented analysis of Landsat data have as their goal the identification of specific individual ground features (lakes, fractures, faults, and airports) or classification of land cover types. These identification or classified categories are usually expressed on maps that show the geographical location of each category at any point on the earth's surface and its boundaries with respect to adjacent categories.

The accuracy of classification from Landsat data may be tested in four ways - 1. Field checks at selected points (Non - rigorous): The total number of ground checks depends in part on the number of classes but ideally, to achieve a quantitative status, should be a minimum of twenty per class for a full Landsat scene. 2. Estimates of agreement between Landsat and reference maps or photos (non rigorous): This method is commonly performed by overlaying correctly registered Landsat and reference maps. The degree of correspondance between similar themes, features, classes and class boundaries is estimated or calculated by an appropriate statistical measure.

3. Statistical Analysis (rigorous): This method works on numerical values developed in measuring sampling or processing data. Various statistical devices or tests applied to accuracy assessment may be applied to the basic data and or the end results. Among these tests are root mean square, standard error analysis of variance, correlation coefficients, linear or multiple regression analysis and Chi-square test.

4. Confusion matrix calculation (rigorous): In this method after taking a random sample of the classified pixels and with photo classification or ground verification as the standard, the number of pixels correctly assigned to each class and those assigned to other classes arranged in a confusion matrix. The table derived from the matrix is a summary of omissions, commissions and overall classification accuracies. Mapping accuracy for each class is stated as the number of corretly classified pixels (equal to the total in the correctly classified area) in terms of all pixels affected by its classification (equal to this total in the displayed area as well as the pixels involved in errors of commission and omission). This can be illustrated by the table:

Photo/ Ground Classi- fication	Landsat Classes* Corn	Soybeans	Forests	Other	Total Possible	Omission	Commission	Mapping Accuracy of each class
Corn	25	5	10	3	43	$\frac{18}{43}$=42%	$\frac{7}{43}$=16%	$\frac{25}{25+18+7}$=50%
Soybeans	2	50	6	5	63	$\frac{13}{63}$=21%	$\frac{11}{63}$=17%	$\frac{50}{50+13+11}$=68%
Forests	3	4	60	5	72	$\frac{12}{72}$=17%	$\frac{18}{72}$=25%	$\frac{60}{60+12+18}$=67%
Other	2	2	2	100	106	$\frac{6}{106}$=6%	$\frac{13}{106}$=12%	$\frac{100}{100+6+13}$=84%
Total	32	61	78	113	284			

Overall Landsat classification Accuracy = $\frac{25+50+60+100}{284}$ = 83%

Mapping Accuracy for class X, MAX = $\frac{\text{Pixels of X Correct}}{\text{Pixels of X Correct + Pixels of X Omission+Pixels of X Commission}}$

Pixels of Omission = all other class in row

Pixels of Commission = all other class in colum.

* Landsat tutorial work book.

Suggestions

1. There should be a coordination committee to co-ordinate between all the surveying and mapping agencies to maintain the accuracy standard and to check the duplication of work

2. There should be A committee to decide the National standards of map accuracy and to test or do research works in the field of mapping and surveying. The committee should also test new developed technologies of mapping introduced in Nepal.

3. Topographical Survey Branch of survey Department should start mapping National series of topo maps at larger scales of Terai area than hilly areas. The projection to be adopted for topo mapping should be decided.

4. The geodetic survey work in Nepal should be done as soon as possible to spread the geodetic control points over the country.

5. Nepal Remote Sensing Center should develop the technique for topographical mapping upto scale 1:50,000 using the future third generation land observation satellite products such as SPOT and Spacelab photography.

6. All agencies which are involved in surveying and mapping activities should follow the minimum requirement of National standards of map accuracy and write it on the constructed maps.

7. A long term plan for surveying and mapping should be decided.

8. There should be a central data bank where all surveying and mapping data should be stored and made available to all users.

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Remote Sensing: A Suitable Technology

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Introduction

Is modern remote sensing a "high technology" and if so, is it "suitable" for use in such a country as Nepal? Should developing countries ever be engaged in acquiring remote sensing facilities and expertise and should the industrial countries of the North promote the transfer the remote sensing to the less developed countries of the Third World? These are questions frequently raised about remote sensing.

There are some that might suggest that remote sensing is a highly advanced technology and, therefore by definition, inappropriate for use in developing countries. However, a brief look at recent experience and the consideration of a system context of remote sensing indicates otherwise. While remote sensing may indeed contain elements of high technology and not meet all of the classical requirements of so-called "appropriate technology", it can be and often is an entirely suitable technology for the needs and capabilities of developing countries and most certainly for Nepal.

A System Context

In discussing the role of remote sensing in developing countries in general and within Nepal in particular, it's important to take a good look at remote sensing as an information supplying technology and one of many technologies which make-up what amounts to a world-wide information revolution: (Last year at this seminar, I described remote sensing as being the "eyes" of this world-wide information revolution and a vital component of modern methods for collecting geographical information in both developed and developing countries alike. Remote sensing gives us the ability to see our environment and to monitor and record its changes on a remarkably detailed basis.

As in the new Manual of Remote Sensing, Second Edition 1983.

"At the highest level of government, decisions on capital investment and resource development are made in an atmosphere of greater or lesser uncertainty, and with value judgements strongly conditioned by political circumstances. The uncertainty is almost always greater in the developing than the developed world, because of the weaker information base. As a result, with almost all development projects in the developing world, unexpected, and usually undesirable outcomes are found economically, socially, and environmentally. Since the major bases for economic development in most developing nations lies in their natural resources, improved information on these resources, derived from remote sensing, will reduce some of the uncertainty of decision making."

The true suitability of remote sensing as a component of national economic development, then, can be assessed in part by the timeliness, the accuracy, and most of all the use of data and information within the processes of decision making both national and sub-national (regional and local) i.e., clearly the timeliness, the accuracy, and the use are increasing with time. This in turn, leads to the subject of "geographical information systems", which will be explored in great detail subsequently during this seminar and training program. But in what context is remote sensing appropriate or suitable for Nepal ?

Suitable versus Appropriate

The term "appropriate technology" came into vogue in the early 1970s when some economists and ecologists started to question the "contributions" of large-scale, centrally - organized development programs and projects to individual well-being. "Appropriate technology" or simply AT, is a child of the "small is beautiful" movement, which was authored by the late British economist, E.F. Schumacher. At question was the role of scale and infrastructure in relation to the objectives of using technology. Specifically, Schumacher said that you can best help people by developing technologies that they can create and use directly. This means concentration on direct improvements to such primary activities as subsistance farming, near-shore fishing, and small-scale manufacturing. His point was that the scale of the technology must be related to the scale of the institutions and the level of social organizations that already exist within a country and not vice-versa. In applying this definition "appropriate technology" several principals emerged.

1. AT is adaptable and its particular manisfestation is often location specific.

2. AT is labor-intensive and capital-saving scarcest resource generally available.

3. AT is directed at helping poor majorities (mostly peasant farmers) directly-without the support or involvement of higher authorities.

For the above reasons, AT has sometimes been preceived as slightly subversive and labled as "second-rate technology" because it tends to decentralize the means of production and is oriented towards small-scale local consumption.

Perhaps a more serious criticism of AT is that it seems to challenge the obvious benefits that large-scale or centrally organized development can make to national economic progress, and therefore, presumably to the well-being of society at-large. Simply stated, frequently it is national institutions within both the private and public sectors that are the mobilizers of significant resources for national or regional-scale developemnt. This is certainly the case with remote sensing technology wherein data sources are found in the foreign and international scientific communities, (i.e. Nepal data is collected by foreign satellites and received from foreign receiving or data processing centers) and the duplication of data reproduction and desimination facilities would be redundant and needlessly costly if carried-out by more than one national agency.

Therefore, remote sensing is not AT but it is, I believe, highly suitable for a country like Nepal that doesn't have a highly developed resource information base, but seeks rapid and ecologically-sound economic development. The term "suitable technology" can be used without the conotations of small-scale which seem to limit the conceptions of "appropriate technology".

But why do we need technology and better information at all ? Haven't we been able to get along without such things as telephones, airplanes, hydroelectric dams, computers and remote sensing for many centuries ? Are we not better off without such things ? The answer is certainly no.

The Nobel-laureate Theodore W. Schultz maintains that "significant opportunities for change become available only through changes in technology". From his work and that of other modern economists the critical role of new technology is explicit--technological innovation is not merely response to the demands of an evolving society. It is the very engine of change and of economic progress. In many countries without technological change, improvement in social and economic well-being is seen to be impossible.

Information Technology

"The demand for information is derived from a demand for a certain quality of decision making, the assumption being that good decision making is in some way dependant on good knowledge and that better decision making requires better knowledge." (N-

Rosenberg, in Perceptives on Technology, 1976). Thus, in looking at the role of remote sensing in society, it is important to remember that the real demand is not for specific products per se, but rather for a certain quality of decision making and for great latitude for the substitution of information products and methodologies, and for combining and recombining them in different ways. They must be continually tailored and retailored to meet society's changing needs.

The actual use of information in decision making results, not in the generation of new ideas or plans (which are usually available in abundance), but in some process of authentication -- the testing, reshaping, and selecting of ideas and plans in the light of experience and facts. Information allows us to make decisions "rationally"-- rationality in its original sense "to make a ratio", to weigh one plan or idea against another, (T. Sowell, Knowledge and Decisions, 1979).

Decision making is the process of deciding between alternatives (including the one to delay a decision), and information helps to authenticate our choices. In this respect, too often information is selectively used only after a decision is made, in order to justify that decision rather than to help choose between alternatives. This practice greatly reduces the contribution and value good information can make to the decision process.

Development and the planning for development are decision making processes, and one in which geographical information assumes an important position. Thus, since remote sensing provides certain types of geographical information, it's easy to postulate that remote sensing is important for development. However, such has not been the case in the past and the ability of geographical information, or any kind of information, to influence the future may be limited by its (lack of) distribution.

Distribution

Without well developed distribution processes, the role of information is limited. Information by itself may give the illusion of authority or control; but information seldom provides authority per se, nor does it automatically bestow control over the resources necessary for development -- as many well-informed but ineffective "decision makers" come to recognize. Information is effective only when it is in the hands of those that have control over the resources (the land and/or the tools of production). For this reason many countries have developed national centers for the archiving and distribution of remote sensing data.

National Centers

Many developing countries have recognized the importance of remote sensing technology to their economic development. Although its difficult to establish a precise formula for a national remote sensing effort, as the needs and political structures differ from country to country, there are certain principles which seem to apply if such efforts are to be successful. According to a study by the U.S. National Academy of Sciences (1977) the following principles are of greatest importance.

1. A remote sensing center should have trained personnel with a concentration of scientific skills.

2. Data analysis should be conducted through an interaction among personnel with diverse disciplinary training.

3. There should be strong ties between the remote sensing center and the user agencies concerning the level of data flow, and the priorities of data collection and processing.

4. The remote sensing center should have ground truth studies for conformation of remote sensing studies.

5. The center should have the capability of handling remote sensing data from a variety of platforms.

6. The center should have the facilities for efficient data storage and retrieval, and

7. the center should have the capacity for making an overview analysis on a national or regional scale.

Conclusion

In conclusion, I'd like to invoke the adage of the optomist and the pessimist observing a cup only partially filled. The pessimist states that the cup is "half empty"-- and see only that part that holds no opportunities himself. On the other hand the optimist sees the cup as half-full and draws hope and sustainance for himself and other from the fact.

Today in Nepal I'd like to describe our remote sensing cup as "half-full" -- for the moment not choosing to worry about all the technology that we don't have and is yet to come. The simple fact is that we have, through the National Remote Sensing Center,an outstanding capability to use remote sensing and to grasp from it useful insites and information concerning Nepal's environment.

In addition to being half-full (in a technological sense), our remote sensing cup itself continues to grow larger providing us with new and better data and products upon which to base an information system and to affect development decisions. So even with the vigorous growth which remote sensing in Nepal has achieved over the last two or three years, and will achieve in the future, the growing cup will always result in some difference between what can be achieved and the current capabilities.This is as it should be and provide us with an ongoing challenge.
So this seminar and the training program to follow,will not only help define the cup of current remote sensing technology, but help add to its contents in Nepal.

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VEGETATION AND LANDUSE SESSION

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GENERAL VEGETATION TYPES AND ASSOCIATED LAND USE IN THE FIVE PHYSIOGRAPHIC REGIONS OF NEPAL

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1. Introduction

This paper presents some general information on the natural vegetation, current land use and associated land system units in the five physiographic regions of Nepal. Further it describes some human influence/farming systems and associated land degredation problems and suggest some corrections measures.

2 Short Description of the Five Physiographic Regions of Nepal

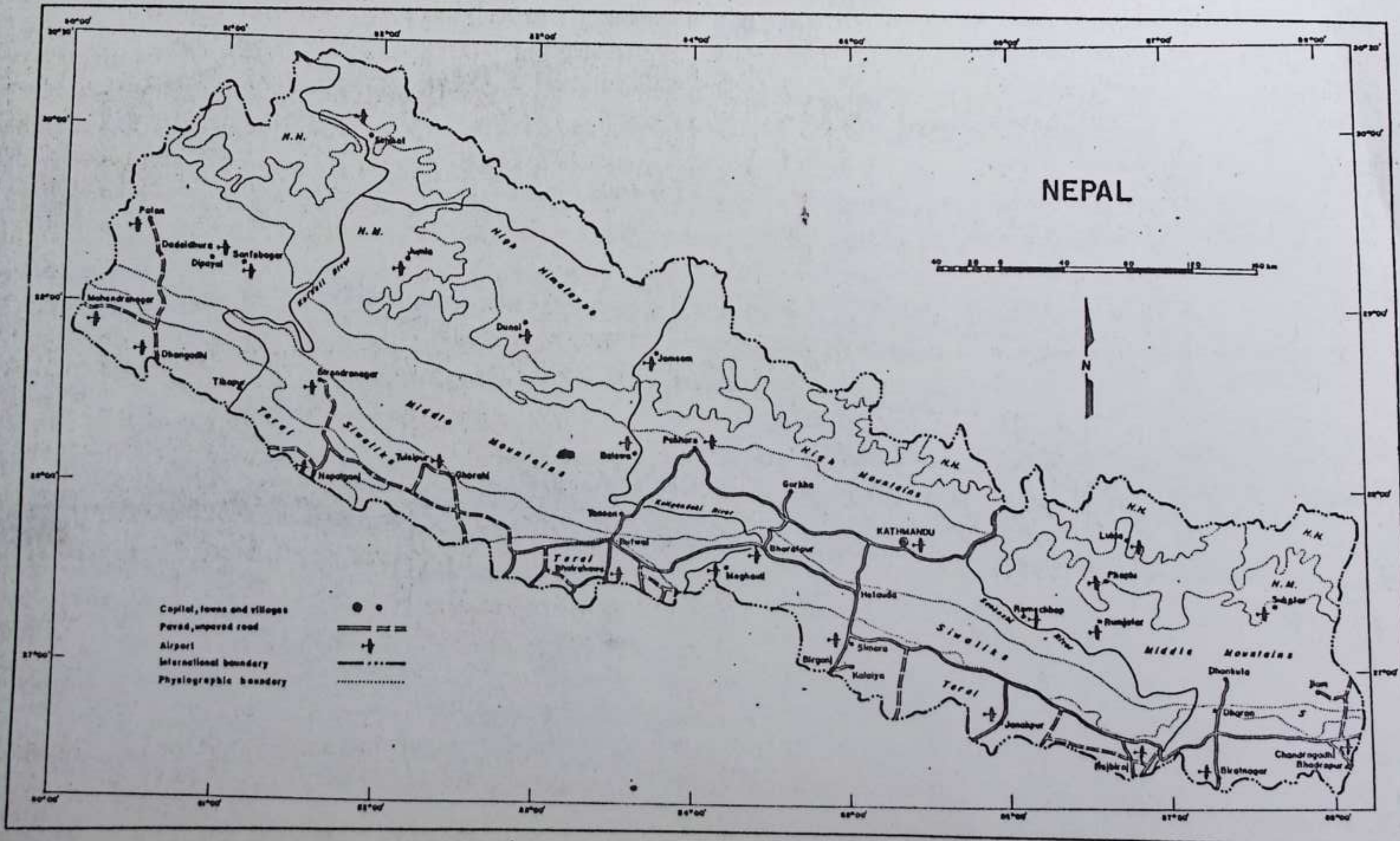
On the basis of studies carried out on geology, soils landscape, forest and land use etc. by the current phases of the Land Resource Mapping Project (LRMP), Nepal can be devided into five physiographic regions running approximately east west as shown is figure 1. From south to north they are:

Terai
Siwaliks
Middle Mountain
High Mountains
High Himal

The cross section of the Mid Western Development Region is given is figure 2. A schematic relationship of altitude/climate, mean annual air and soil temperature, forest zone and land use limits for the Far Western Development Region is illustrated in figure 3.

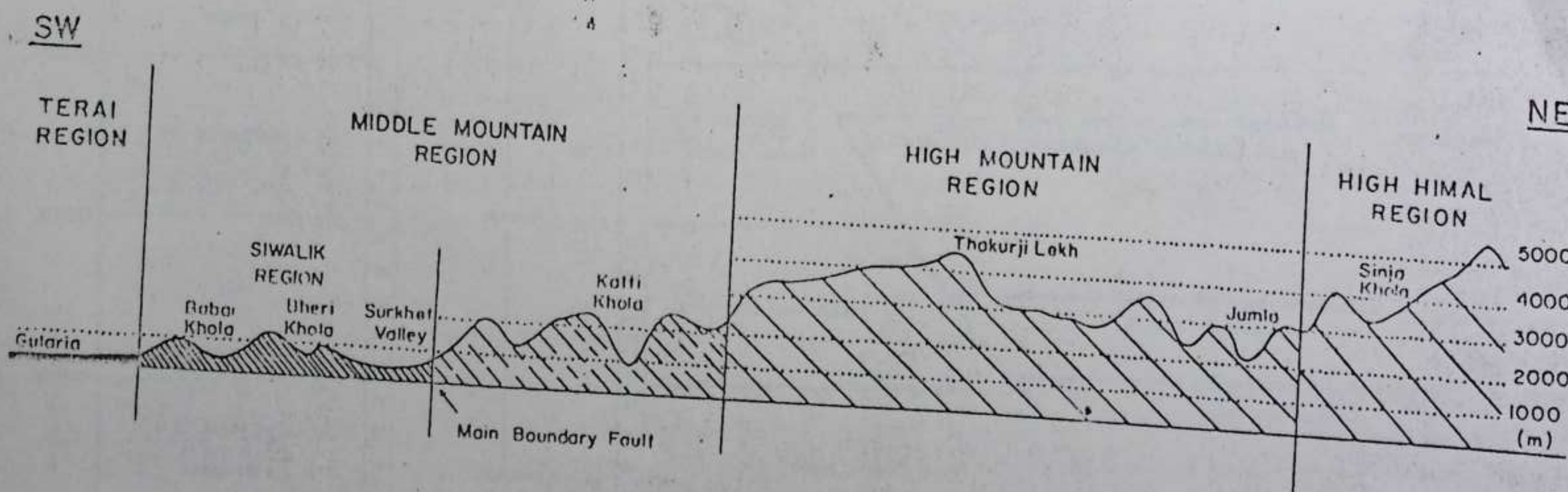
1. NATURAL VEGETATION, LAND USE AND ASSOCIATED LAND SYSTEM UNITS AND
2. HUMAN INFLUENCE/FARMING SYSTEMS IN THE FIVE PHYSIOGRAPHIC REGIONS OF NEPAL

PHYSIOGRAPHIC REGIONS



FIG

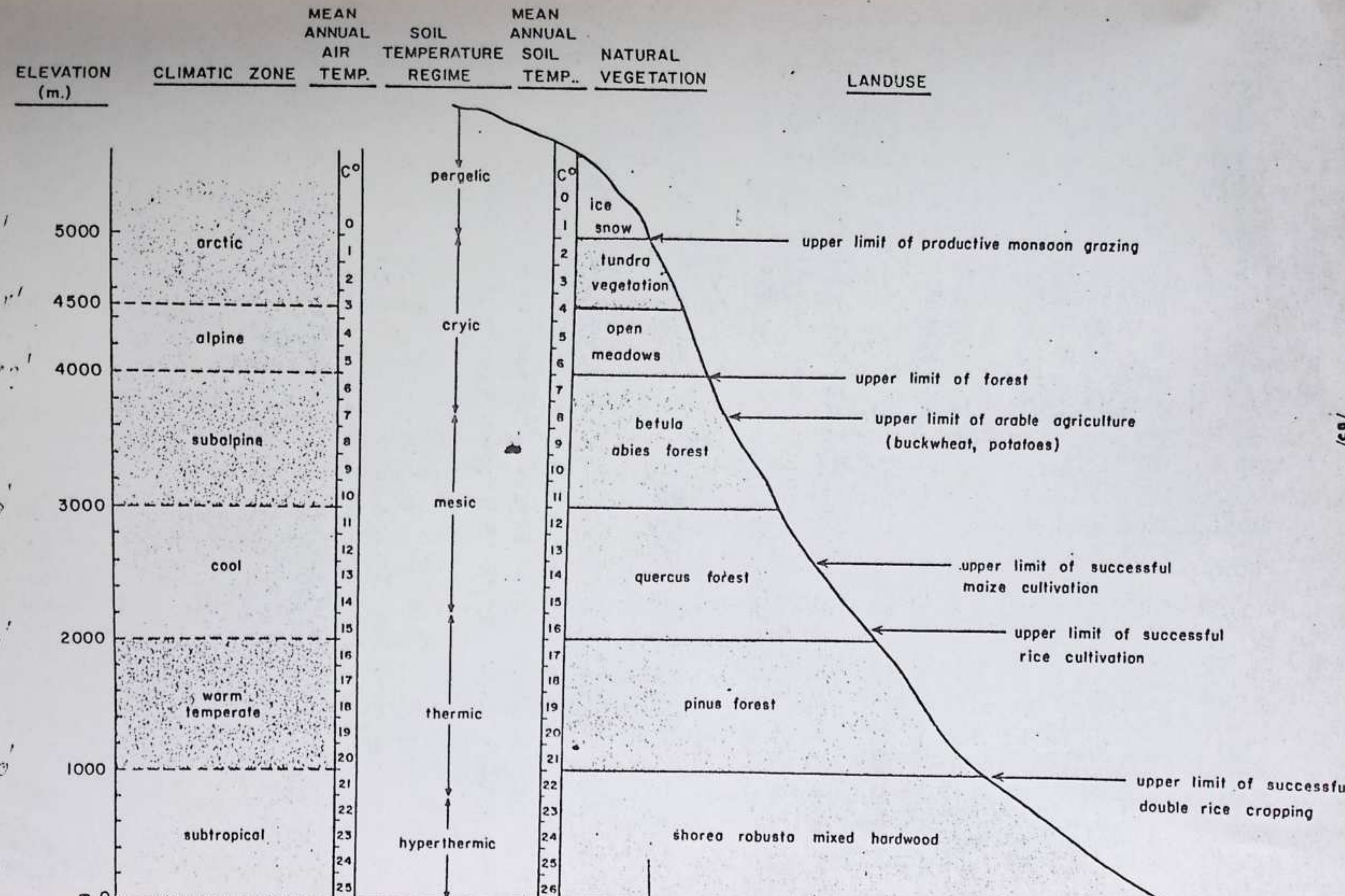
PHYSIOGRAPHIC REGIONS
Mid Western Development Region
Cross Section SW–NE



Horizontal Scale 1 cm represents 8 km
Vertical Scale 1 cm represents 2 km

Fig. 2

RELATIONSHIP OF ALTITUDE, MEAN ANNUAL AIR AND SOIL TEMPERATURE, FOREST ZONE AND LAND USE LIMITS FOR T - FAR WESTERN DEVELOPMENT REGION*



* all limits are averages only variability is generally quite high.

Figure 3

Natural Vegetation, Land Use and Association Land System Units in the Terai

The Terai region can be divided into three land systems active alluvial plain, recent alluvial plains and alluvial fans or older alluvial deposits. The active alluvial plain (Land System 1) is associated with khair - sisoo (Dalbergia siscoo - Acacia catechu) vegetation, some winter grazing and occasional cultivation of maize, wheat, mustard, pigeon pea etc. The recent alluvial plains (Land System 2) occupy a stable landform with occasional open stands of simila (Bombax malabaricum and Sal vegetation and are intensively cultivated to rice, wheat, maize, millet, tobacco, pigeon pea etc. On the otherland, alluvial fans (Land System 3) occupy Bhabar region of upper piedmont. It support a dense sal (Shorea robusta) and sparingly cultivated to maize, mustard, cotton, tobacco, sugarcane, pigeon pea, jute etc.

Human Influence/Farming System in the Five Physiographic Regions of Nepal

Most farmers hold land in two or more land types mentioned earlier (see land system map) and uses a number of cropping pattern or rotation (see land utilization map). Besides a varifying number of livestock cattle, buffaloes, sheeps, goats are also used for draft, manure, meat, milk, wool, hides, etc. There are six farming system practiced in Nepal. These will attempt to describe the entire farming system as viewed by the farmer.

Human Influence/Farming System in the Terai

Three farming systems have been recognized in the Terai: main terai, active floodplain and upper Terai.

Main Terai Farming Systems are a stable paddy-based cultivation with minor rotation of wheat in winter and less common double cropping of paddy. Both cattle and buffalo are used for draft e.g. transportation and ploughing as well as for milk production.

Livestock are fed on crop residues or graze on crop stubbles in winter. The system is relatively independent of forest and public grazing land except for timber and fuel-wood. In many cases cow dung and crop residues are substituted for fuelwood with a negative impact on farm fertility level. Thus chemical fertilizer is constomarily required to maintain the current levels of fertility.

Active Flood Plain Farming Systems are similar to main terai system except that they are subjected to occasional flooding. Here the land holding are larger and livestock number are higher in view of utilizing riverine grazing areas and to compensate high risk of crop failure loss due to flooding.

Upper Terai Farming Systems are prevelent on recently opened resettlement areas and siwalik footslopes. They resemble main Terai system but maize crops are shown in areas where paddy cannot be cultivated. Fertility in these areas are declining rapidly and the system cannot be considered sustainable in its present form. How many hectares of forest areas are required to supply fertility to each hectare of cultivated land ? It is still to be documented.

Natural Vegetation, Land Use and Associated Land System Units in the Siwaliks

The Siwalik region can be divided into two parts 1. dun valleys (land systems 4,5 and 6) and bed rock controlled hills (land system 7 and 8). The dun valleys are associated with khair-sissoo vegetation on active and recent alluvial plains (land system 4); dense sal and tropical mixed hard-woods on fans, aprons and tars (land system 5) and to some extent in depositional basins (land system 6). To a smaller extent all of these land system 4,5 and 6 are cultivated to paddy, wheat maize, mustard, pulses etc. On the other and of the bed rock controlled hills, hillslope cultivation is practiced on slopes less than 20° (land system 7) and Sal and Chirpine (Pinus roxburghii) forest on slopes greater than 20° (land system 8).

Human Influence/Farming System in the Siwaliks

There is one farming system recognized in the Siwalik Physiographic Region-Dun Valley.

Dun Valley Farming Systems are on depositional valleys of the Siwalik. They are similar to adjacent terai areas but slightly cooler with higher rainfall. Farming systems are similar to main terai system but farm holdings are smaller and livestock numbers higher. This is more likely because of better access to forest and public lands.

Natural Vegetation, Land Use and Associated Land System Units in the Middle Mountain

The Middle mountain region is divided into river valleys (land system 9 and 10) and bedrock controlled hilly areas (land system 11 and 12). The river valley are associated with Khair and mixed forest trees on alluvial plains and fans (land system 9) and dense sal and tropical mixed hardwoods on ancient river terraces or tars (land system 10). The cultivation is limited to rice, wheat, maize, millet, mustard, pulses and sugarcane etc. On the otherhand, the bed rock controlled hilly area is associated with Hillslope cultivation of rice, wheat, maize, millet, mustard, and tobacco on slopes less then 30° (land system 11) and mixed forest trees Sal, Pines, Oaks, Rhododendrons and shrubs on slopes greater then 30° (land system 12).

Human Influence/Farming System in the Middle Mountain

There is one farming system recognized in the middle mountain Physiographic Region - middle mountain.

Middle Mountain FArming Systems occupy majority of arable hill and mountainous areas of Nepal. Here the most farmer have lowland suitable for paddy production as well as upland"bari"suitable for maize. Both paddy and maize are rotated with a winter crop of wheat, mustard etc. Ploughing is usually done by bullocks and both cattle and the buffaloes are milked.

Here the reliance on forest or public land are heavy. It is estimated that about 2-5 hectares of degreded hard-wood forest are required to supply fertility for a hectare of agricultural land. Here compost are generally added to bari land than paddy land where seasonal flooding provide some new fluvial sediments.

Natural Vegetation, Land Use and Associated Land System Units in the High Mountain

The high mountain region can be divided into 1. mountain valleys (land system 13) 2. past Glaciated mountainous areas below the upper altitudinal limit of cultivation (land system 14) and 3. The same as 2. but above altitudinal limit of cultivation (land system 15).

The area is dominated by deciduous mixed broad leaved (Betula, alnus, Acer, Jugelans, prunusceltis) and coniferous-blue pine, rhododendrons, cyprus etc. the cultivation is limited to narrow valley floors-alluvial plain and alluvial/colluvial fans (land system 13) and lower hill slope cultivation on slopes less then 30° (land system 14). Barley, wheat, millet, potatoes and maize at lower elevations and paddy at valley floor are the dominent crops grown below 3000 meter elevation. The areas above 3000 meter are generally limited to forest vegetation (land system 14b&15b) and natural pasture (land system 15a).

Human Influence/Farming System in the High Mountain

There are two farming systems recognized in the high mountain physiographic region - 1. High Mountains and 2. High mountain Valleys.

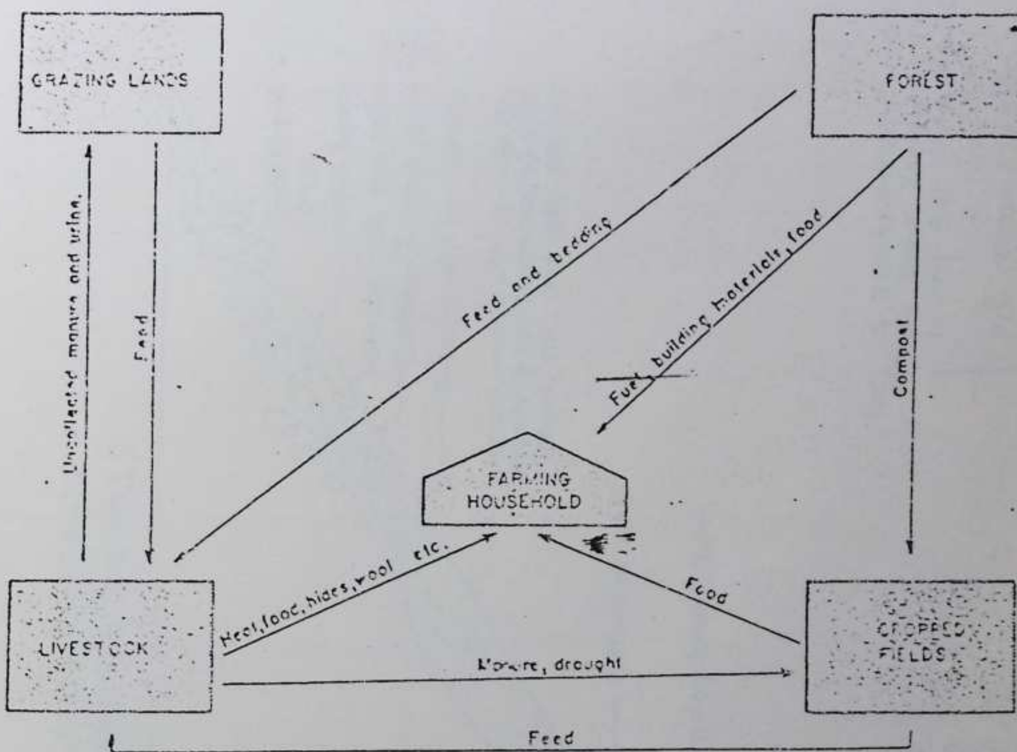
High Mountain Farming System are on areas too high (elevation) or lack irrigation facilities to produce paddy. Main crops are winter barley or wheat, potato, millet, buck-wheat and at lower sites maize. People are heavily dependent on livestock since part of their income is derived from trading of livestock, their produce and transportation by them. Livestock include Yak, Yak/Cattle crosses, sheeps etc. Yak and Yak/Cattle crosses are milked and sheeps for meat and wool. Ploughing is done by bullock. The system is heavily dependent on forest for fuelwood, fodder and access to migratory grazing land. Compost is collected from considerably large areas and concentrated on relatively small areas of arable land located on areas of suitable soil and microclimate.

High Mountain Valley System are similar to High Mountain System but the farmer have some land for paddy production, where most of compost are concentrated. Paddy is most important because it trade with 2 or 3 times its weight for other cereal produced in the area. Farmers are less migratory, holds lower animal, and concentrate most of the efforts and inputs (compost) on monsoon paddy. The paddy is rotated with winter crop of wheat or barley. The timing of rotation is very tight. When the winter crop matures late, it is harvested as green fodder for livestock. Livestock include cattle for draft as well as milk and buffalo for milk. The reliance on forest for fuelwppd fodder, grazing and litter collection are heavy and distance to forest land are critical factor. It is estimated that about 50 hectares of coniterous forest are required to maintain fertility of one hectare of paddy in these areas.

The Land Degradation Problems and Suggestion for Corrective Measures.

Land Degradation

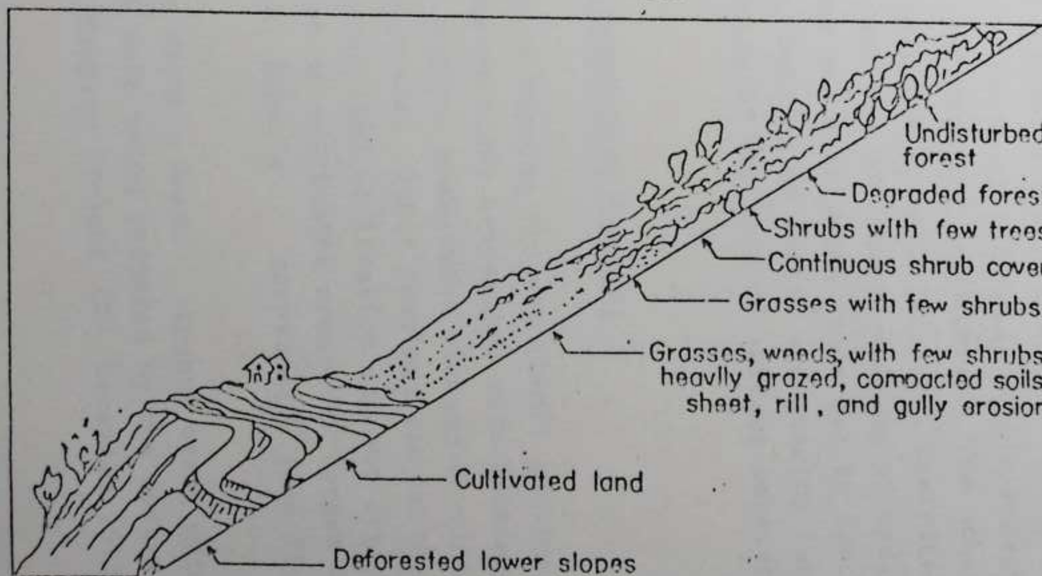
A simplied schematic model of a Nepalese Hill Farming System is illustrated in figure 4.



Simplified Schematic Model of a Nepalese Hill Farming System

Fig. 4

PATTERN OF LAND DEGRADATON NEAR SETTLEMENTS IN THE HILLS



Ref. A Reconnaissance Inventory of the Major Ecological Land Units and their Watershed Condition.

FO: DP/Nep/74/020 Tech. Rep. 1, 1980

Figure 5

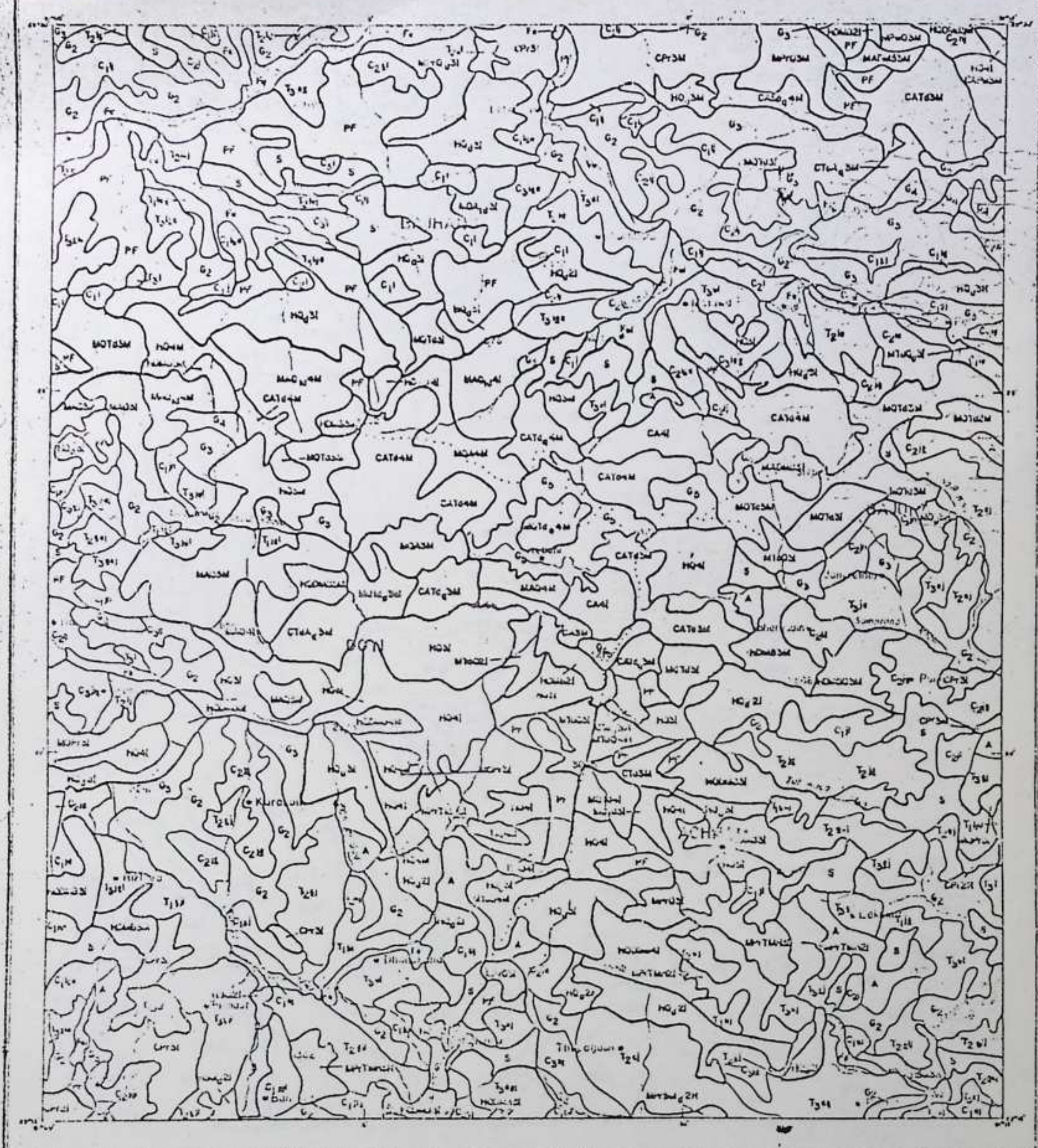
As mentioned in various farming systems earlier that there is a heavy reliance on forest and public grazing land for fuel wood, timber, fodder and litter collection (for bedding) etc. How long this can continue when people tends to chop off most branches of a tree on public land? The result as illustrated on figure 5 - which shows land degradation near a human settlements-land degredation, deforestation This is a obvious picture in any farming system practiced in Nepal. Further, the farming house-hold which consume significant portion of the concentrated farm produce does not seem to provide anything back to the system either. How about using night soil as bio-fertilizer ? Obviously, it needs public consensus and harmless processing and handling techniques. The other problems and continued soil losses which is not illustrated in the system (figure 4) are the continuous washing of sediment from forest, grazing land and cultivated lands due to faulty management system etc. burning of forest and grazing lands and clean cultivation- scraping of any bits of surface vegetation even on steep slopes.

Suggested Corrective Measures

Land Resource Mapping Project (LRMP) provides basic information for solving problems associated with farming system mentioned earlier. Surkhet management plan was developed as an example towards this end. Other problems can be bought by simple colouring the land utilization map and trying to find out the interaction of cultivated areas VRS forest land grazing land as to type, density access etc. (see figure 6).

There are about a dozen report being written and about 600 copies of maps being prepared by the current phase of Land Resource Mapping Project (to December 1985). The reports include geology, water resources, forestry, land use, agriculture, land system, land capability, economics and summary report. The maps include geology at 1:125,000 scale, land system at 1:50,000 scale, land utilization at 1:50,000 scale; and land capability at 1:50,000 scale.

For information please call on Land Resource Mapping Project P.O. Box 1611, Baneswor, Kathmandu, Nepal. Tel. Ph. 2-13742. The project office is located at Topographical Survey Branch of Department of Survey, HMG/Nepal, Baneswor, Kathmandu, Nepal.



LANDUSE LEGEND

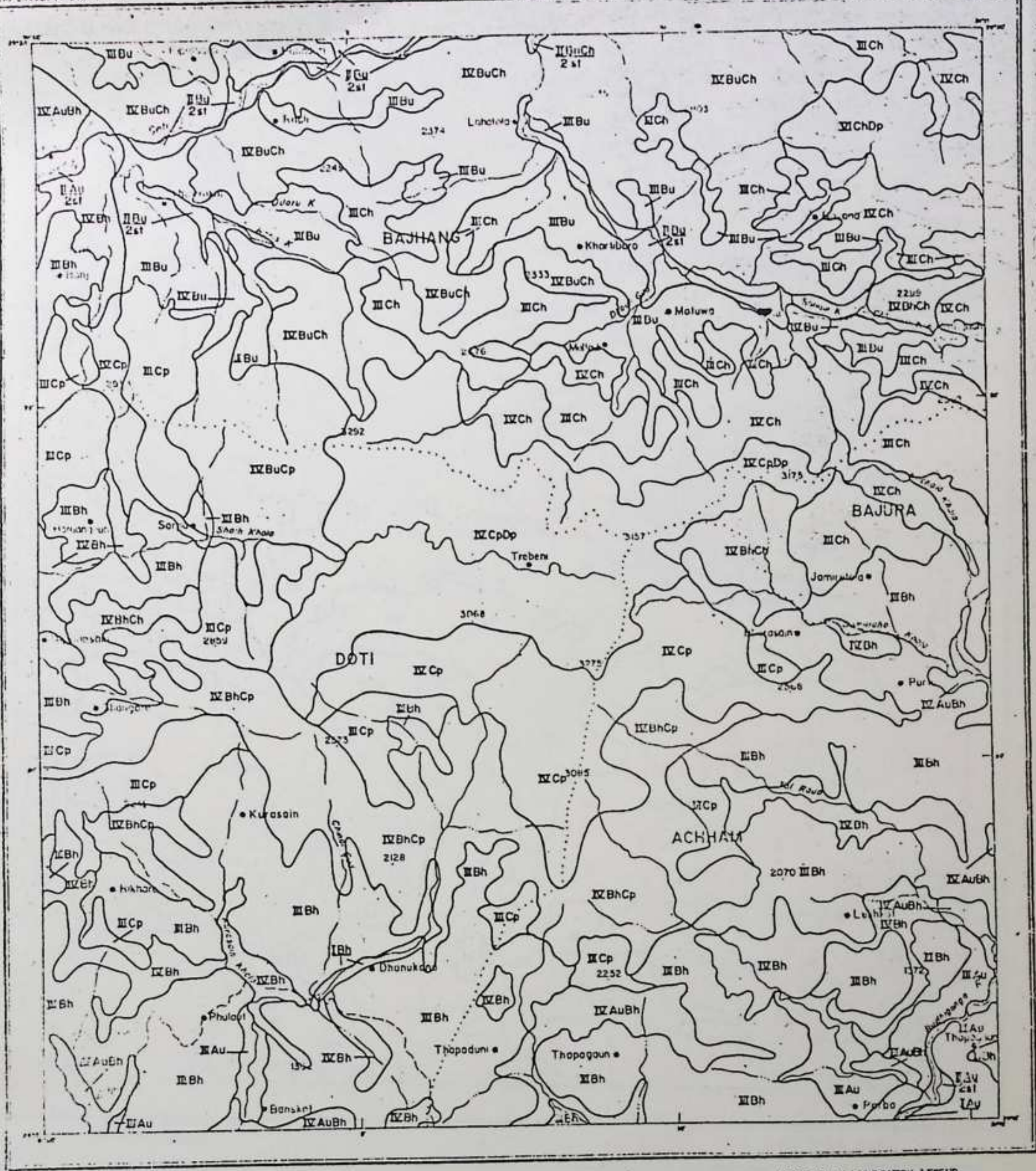
LEGEND

JEEP ROAD
MAIN RIVER
STREAM
INTERMITTENT STREAM
TOWN
VILLAGE
SPOT HEIGHT (metres)
DISTRICT BOUNDARY
INTERNATIONAL BOUNDARY

SHEET HISTORY

FORESTRY LEGEND

COVER TYPE



LAND CAPABILITY LEGEND

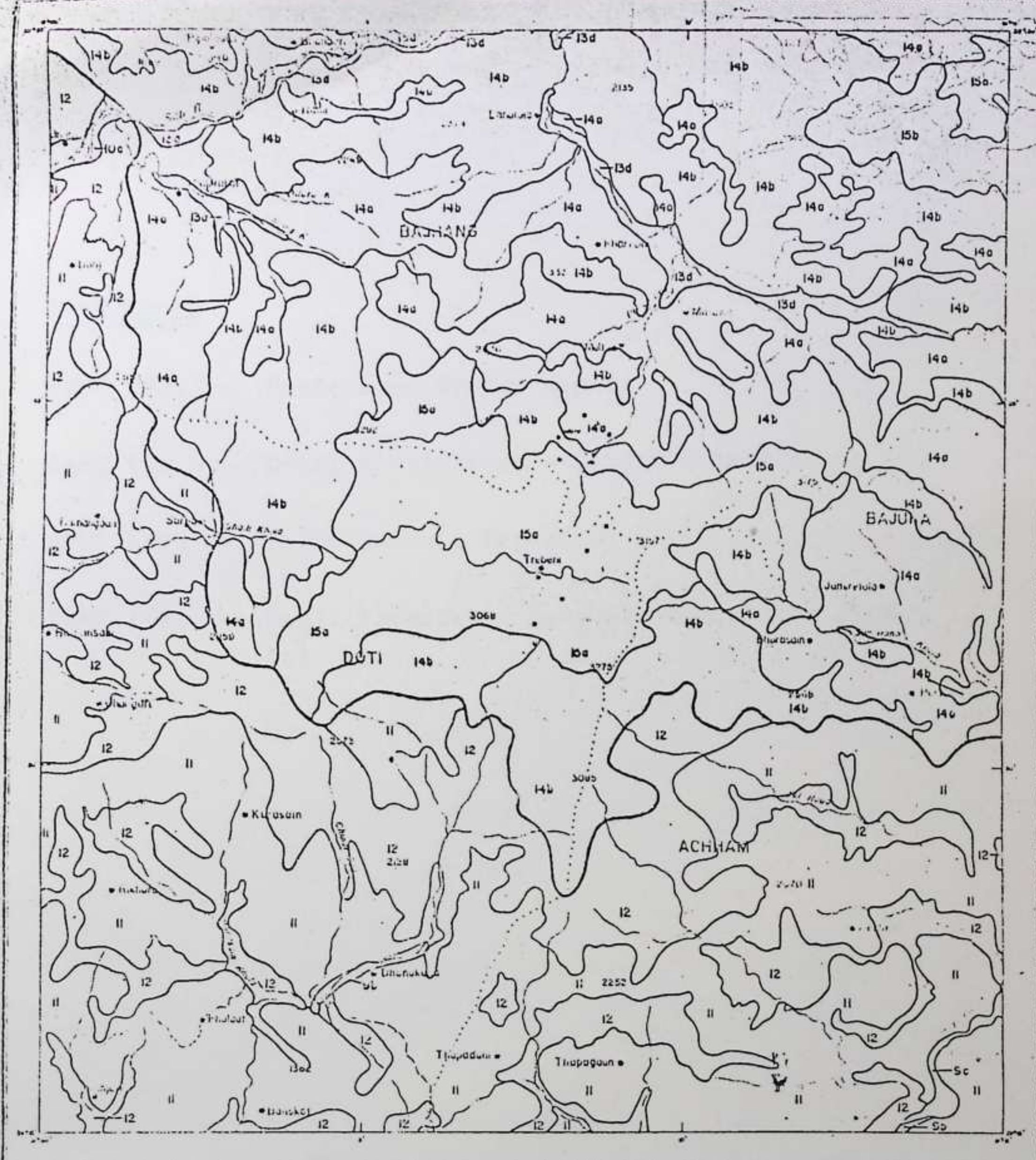
LEGEND

MAIN ROAD
MAJOR TRACK
MAIN RIVER
STREAM
INTERMITTENT STREAM
TOWN
VILLAGE
SPOTHEIGHT (metres)
DISTRICT BOUNDARY
INTERNATIONAL BOUNDARY

SHEET HISTORY

IRRIGATION CLASSIFICATION LEGEND

MAP SYMBOL EXPLANATION



LAND SYSTEMS LEGEND

LEGEND

MAIN ROAD
MAJOR TRACK
MAIN RIVER
STREAM
INTERMITTENT STREAM
TOWN
VILLAGE
SPOT HEIGHT (M)
DISTRICT BOUNDARY
INTERNATIONAL BOUNDARY

SHEET HISTORY

LAND SYSTEMS LEGEND

REFERENCES

LRMP 1983 - Draft Land System Report

LRMP 1982 - Draft Agriculture - Land Use Report

LRMP 1983 - Draft Summary Report

LRMP 1982 - Draft Forestry - Land use Report for FWDR Vol. 1.

VEGETATION MAPPING OF BAGMATI-WATERSHED AS A CASE STUDY USING LANDSAT IMAGERY THROUGH REMOTE SENSING MEANS:

BY

K.R. Basukala,
Forest Officer
NRSC

Introduction

Remote Sensing is not a new technology. For many decades man has been flying above the earth in order to observe it from a distance and thus learning more about its nature. Aerial photographs have been used extensively for this purpose, and over the years a sophisticated technology has evolved using photographic sensors for remote sensing. Remote Sensing techniques have been used in Nepal for the purpose of vegetation mapping, land-use mapping, forest area estimation, detection of deforested areas and other similar studies.

Satellite imagery at the scale of 1:100,000 up to 1:500,000 can be used for a number of forestry purposes, including the assessment of natural forest resources and the monitoring of environmental impacts.

In order to study vegetation with remote sensing techniques three bands of light in the visible and infra-red parts of the spectrum are generally used. The first spectral band is green, (corresponding to a high reflectance of green vegetation), the second one is red (corresponding to minimum vegetation reflectance due to chlorophyl absorption) and the third, is a near infrared band where the reflectance of active vegetation is very high.

A Landsat Application to Vegetation Mapping

Landsat imageries can be applied to forest cover classifications and mapping for the following reasons.

1. A Landsat satellite image can be regarded as a picture of a given area which is taken in at least four different wavelength bands simultaneously. Black and white images from different bands can be used separately or in combination to give false color pictures of details of interest.

2. Previously, Landsat completed coverage of the earth every 18 days and repeated observationsof the same area at 9 day intervals (when observed by two satellites). Therefore in this case, information about the changes of the earth's surface can be easily detected. Currently, Landsat 4 covers the earth every 16 days and this allows up-to-date data to be obtained quickly and easily.

3. Each frame of Landsat data cover an area of 182x178sq. km. This allows study and comparison of very large areas.

4. The data collection system (or MSS) of Landsat is specifically designed for high altitude observation. The image has good resolution even though it is taken from a height of 914km. for Landsats 1-3 and 800km. for the current Landsat 4.

Description of Forest Vegetation in the Bagmati Watershed with Reference to the Use of Landsat Imagery:

The principal native vegetation in the watershed is forest. However, little of the original composition remains in any areas. The native vegetation is composed mostly of broad-leaved and conifereous forests. Most of the original vegetation has practically disappeared, notably around densly populated areas.

Our aim is to study different types of forest classification in the Bagmati watershed using the Landsat imageries (1977, 1983) at a scale 1:100,000 as a main source of information. Existing forest maps at scales of 1:250,000 and 1:500,000 were prepared with ground truth data provided by stratified sampling spots, aerial photos at a scale of 1:50,000 and Dobremez's ecological classification is references.

Objectives:

Now let us generalise some possible objectives for using Landsat imagery for categorising forest lands.

a. To test the ability of Landsat imagery in the study of forest classification in the Bagmati watershed.

b. Delineate existing forest lands.

c. Estimate changes and the depletion rate of the forest cover.

d. Prepare a map showing forest areas, and

e. Select good areas for forest plantation.

The total forest areas in different ecological zones (see map no. 1) of the watershed have been calculated and are listed as below.

Terai region	Siwalik Region	Mahabharat lekh	Mid-land valley	Total forest area
220.69sq.km.	978.96sq. km.	389.50sq.km.	332.84sq. km.	1921.99sq.km.

Deforested area from 1977 to 1983 in terai region (only) = 13.30 sq.km.

i.e. Deforestation in terai region = 6.02% (during that six years period).

Methodology

We have performed visual interpretation by using false color composite Landsat prints at the scale 1:100,000 for 1977 and 1983. The interpretation was made on the basis of the spectral, spatial and temporal characteristics of the image features. We delineated the forest area from Landsat imagery (1977) and calculated the total area, which is found to be 1921.99 sq.km. within the total watershed area of 3808 sq. km.

In addition, the characteristics of vegetation types in the Bagmati watershed were also studied by computer analysis by other senior center staff. In this method the data processing consists of selection of almost 50 training sets for different forest and other vegetation types and the categorization of vegetation in the scene using a PDP 11/70 mini-computer. For the computer classification multiple training sets for the same vegetation types were were necessary owing to illumination differences on different slopes and aspects. Using the computer analysis method, the forest area of the watershed was found to be 1939.58 sq.km, which is very near the area obtained by visual interpretation, i.e. 1921.99 sq.km.

Forest Types

Based on the ecological zone and the climatic condition the natural vegetation types of the watershed study area can be classified as follows:

1. Tropical Forest

This types of forest is found in the terai and on the footslopes of the siwalik hill range (also called Bhabar belt). Here there is an excess of rain-fall with a tropical monsoon type of climate. This type of forest also occur in the northern part of the terai plain, in the inner terai valleys and hills of the lower Himalaya, up to an elevation of nearly 1000 meters above sea- level. It is composed of deciduous tree, chiefly Shorea rebusta. In the terai plain and in the inner terai valley this species is associated mainly with Terminalia tomentosa, Terminalia belerica, and Anogeisus latifolia. This forest type can be easily distinguished in Landsat imagery as a brownish red uneven tone. The appearance of an uneven red tone in an image appears to be due to improper management of the forest, a presence of diseased trees, damaged by fire, or having a mixed forest species. There has been heavy pressere from the migrating hill people to the Terai/Bhabar forest in search of agricultural and resettlement land. In the terai region most parts of the forest are being encroached by people obtaining fuelwood and fodder species. In a developing country like Nepal production of industrial raw materials should not get higher priority than the production of fuel, fodder and timber for rural house-holds. So forest management programs for the Terai/Bhabar should consider not only the industrial and export needs, but also the local rural requirements. The Bhabar belt is generally unsuitable for continuous crop production, so this belt should be protected under permanent forest. From a soil and water conservation point of view, forested land unsuitable for agriculture such as Bhabar belt should be identified and managed for forest products to minimised the impact of erosion, the raising of steam beds, and the rapid changing of steam courses on settlements.

Near river courses in the terai plain and the inner terai valley a riverine forest of Dalberjia sisoo and Acacia Catechu predominates. Other component species are Bombax malabaricum Adina cordifolia, and Terminalia belerica etc. In some part of the terai e.g. in Murtia Jungle (i.e. Sal forest associated with T.T., Jamun, and Bakain etc.) of Rautahat district, the regeneration is doing well, but fire hazards and heavy grazing are the main interference in regeneration.

2. Sub-tropical Forest

This type of forest is included in the Siwalik zone and some parts of the Mahabharat lekh. This forest covers extensive areas in the lower Himalaya between 1000-2000 metres a.s.l. In the lower and drier areas pinus roxburghii is the main species and is usually associated with many types of shrubs and bushes. In higher, more humid areas Pinus is superseded by Schima Wallichi, Castanopsis indica, Lagerstromia parviflora, and is mixed mainly with Rhododendron species and quercus species. In this types of forest most areas are covered by evergreen forest, so that it appears as a dark reddish tone in Landsat imagery. In the Mahabharat lekh some portion of the area is occupied grassland. Such areas mostly have been by converted into agricultural areas. It will be a very important application of Landsat data if we could delineate the grasslands in imagery for the purpose of pasture management. But it is intricate job to delineate grasslands in such most Landsat imagery. Most of the area is siwalik zone is extremely steep, highly erodable, and very inaccessible. Therefore it should be maintained under forest cover. There should not be further reduction of the forest area in the siwali zone for agricultural resettlement. The siwalik forest should be generally protected, but where the slopes are more gentle and access is easy it could be managed under a system at selective cutting. In other words, removing only dead and overmatured trees and enriching the area with artificial regeneration wherever necessary.

3. Temperate zone forest

This type of forest is mostly included in the mid-land valleys and some parts of the Mahabharat lekh. The temperate forest is composed of both conifer and broad-leaved trees and occurs on a series of mountain ranges between 2000-3000 metre in elevation. The main component species are Pinus excelsa, Quercus lantana, Q. semicarfifolia, usually in association with Rhododendron arboreum. Some artificial pine plantations are found in the Kulekhani and the Daman areas. In the Daman and the Palung areas generally blue pine forest, associated with Quercus species, has been found. A dense mixed Oak forest also is found in the Chitlang area, which appear to be brownish red on landsat imagery. The main associates are Q. semicarpifolia, Q. incana and Q. lamelosa, etc. In the Sim Vajyang, near Daman, more Quercus species have been found than pine species.

Result

The result of some field observations during a ground truth study are as follows:

As it has been already mentioned, in the terai region most of the forest area has been burned and cleared, which can be earily seen in Landsat imagery of 1983 as a bluish-black color. According to the 1977 Landsat imagery there is a riverine forest of Simal and Khair which is located in southern part of the watershed and is locally called "Suraksha Peti". Now this forest has completely vanished and this area is converted into agriculture. The deforested area can be easily detected in 1983 Landsat imagery as bluish black color. (see map No. 3)

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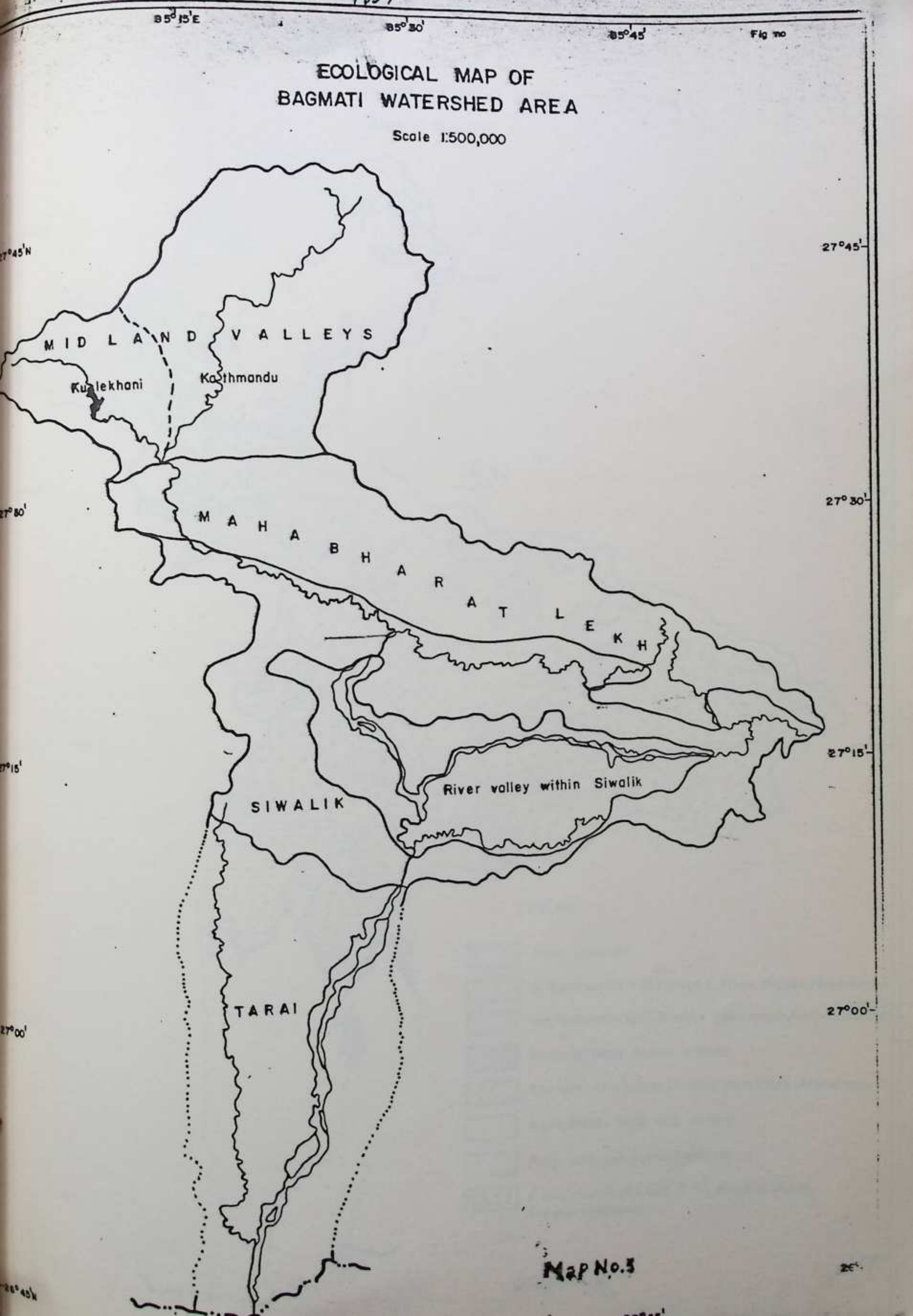
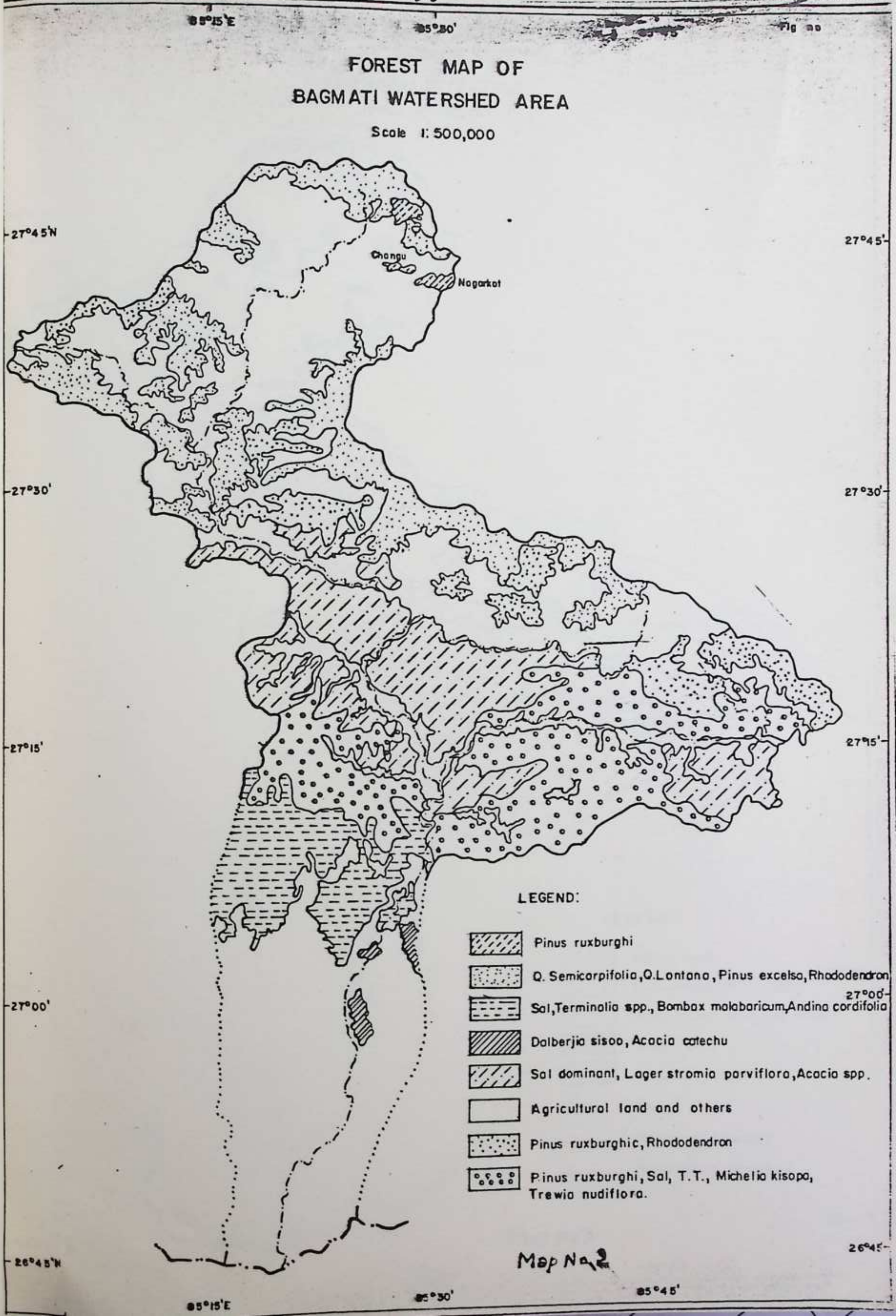
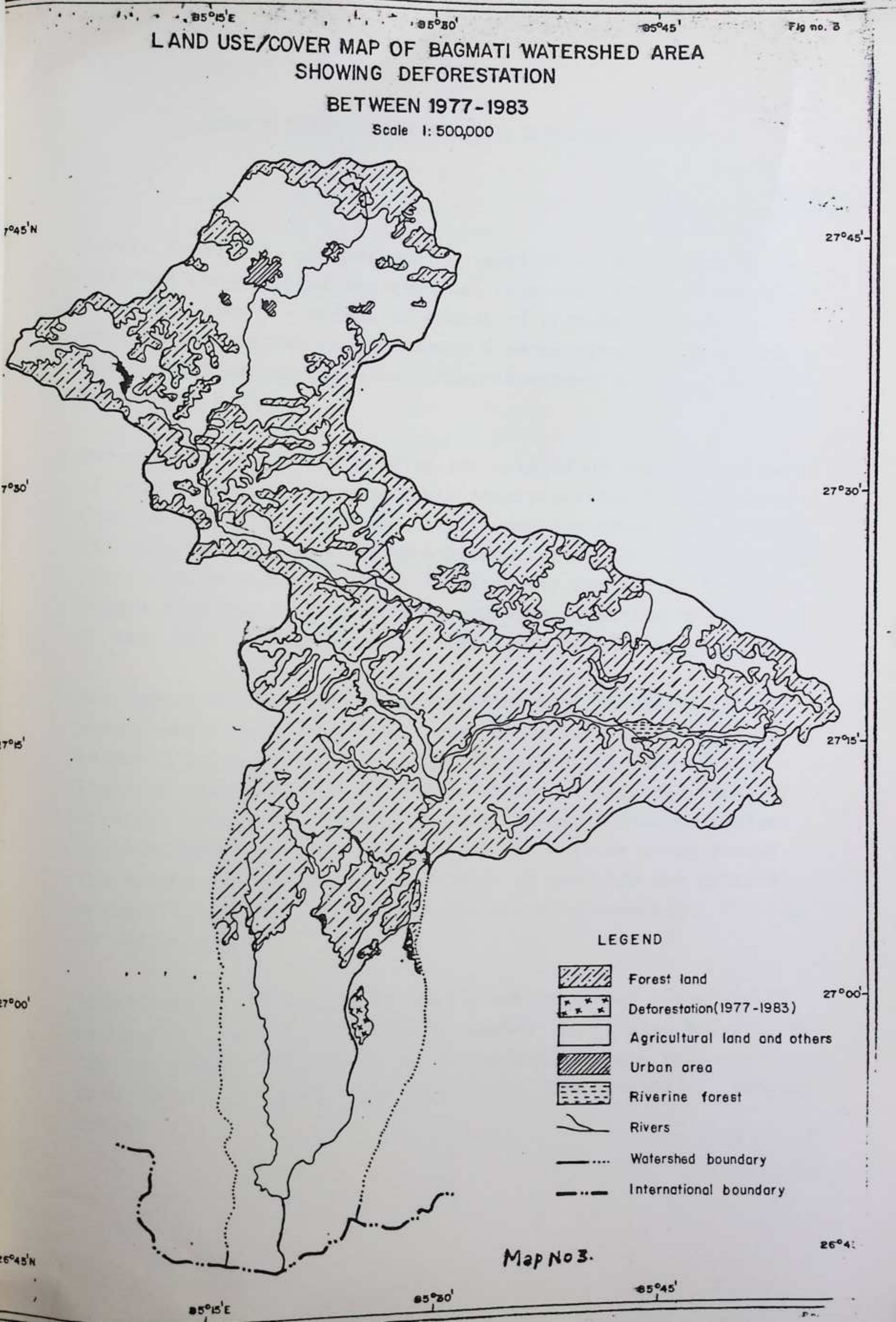
4. Protection and Development of Terai/Bhabar Forest by T.N. Bhattarai.

5. Remote Sensing :the Quantitative Approach by Swain.

6. Forest of Nepal by J.D.A. Stainton.


85°15'E
85°30'
85°45'
Fig no
ECOLOGICAL MAP OF
BAGMATI WATERSHED AREA
Scale 1:500,000
27°45'N
27°45'
MID LAND VALLEYS
Kulekhani
Kathmandu
27°30'
27°30'
MAHABHARAT LEKH
27°15'
27°15'
River valley within Siwalik
SIWALIK
TARAI
27°00'
27°00'
Map No.3


FOREST MAP OF
BAGMATI WATERSHED AREA
Scale 1:500,000
85°15'E
85°30'
Fig no
27°45'N
27°45'
27°30'
27°30'
27°15'
27°15'
27°00'
27°00'
26°45'N
26°45'
85°15'E
85°30'
85°45'
Changu
Nagarkot
LEGEND:
Pinus ruxburghi
Q. Semicarpifolia, Q.Lantana, Pinus excelsa, Rhododendron
Sal, Terminalia spp., Bombax malabaricum, Andina cordifolia
Dalberjia sisoo, Acacia catechu
Sal dominant, Lager stromia parviflora, Acacia spp.
Agricultural land and others
Pinus ruxburghic, Rhododendron
Pinus ruxburghi, Sal, T.T., Michelia kisopa, Trewia nudiflora.
Map No. 2


85°15'E
85°30'
85°45'
Fig no. 8
LAND USE/COVER MAP OF BAGMATI WATERSHED AREA
SHOWING DEFORESTATION
BETWEEN 1977-1983
Scale 1: 500,000
27°45'
27°30'
27°15'
27°00'
26°45'N
LEGEND
Forest land
Deforestation(1977-1983)
Agricultural land and others
Urban area
Riverine forest
Rivers
Watershed boundary
International boundary
Map No 3.

REMOTE SENSING FOR NATURAL RESOURCES SURVEY

Mr. B. N. Acharya
Survey Department/
Nepal

Remote Sensing is any methodology applied to study from a distance the physical and chemical characteristics of objects. It is not simply a modest extension of conventional aerial photography, rather it represents a revolution in the way we think about and approach resources inventory analysis and management problems.

Human sight, smell and hearing are example of rudimentary forms of remote sensing. Photographic interpretation is considered a form of remote sensing since it is used for identifying objects and judging their significance without physically touching them. Photo interpretation however is generally limited to the study of images recorded on photographic emulsion sensitive to energy in or near the visible portion of the electromagnetic spectrum.

The Camera was the only remote sensing tool (Sensor) till the second world war, when RADAR began to be used which employed scanners instead of camera. The images in the form of scan lines of reflected signals can be stored on magnetic tapes or directly on films. Thermal scanning (passive sensing system) records signal of emitted heat from the objects being sensed. The amount of heat given off depends on the size and emision characteristics of the objects and varies according to the time of day or night.

Side-looking airborne radar (SLAR) has the great advantage of being able to penetrate through clouds. It is also known as an 'active system' because it emits signals that are reflected back from the earth surfaces are recorded by the original sensing device.

With low and middle altitude aircraft aerial Camera, multi-spectral Camera systems, thermal scanners and SLAR are used. But with high altitude aircraft wide angle cameras, multispectral camera systems and thermal scanners are used. This gives spectral resolution in visible, near infra red and thermal infra red range.

Because of the relatively small area coverage obtained from air craft, the data availability is some what restricted as repetitive regional monitoring of natural resourcesis cost-prohibitive. The most promising of the new developments in remote sensing is 'sensing by satellite'.

In July 1972 ERTS-1, later renamed LANDSAT-1 with a resolution of 79 m four channel multispectrul scanner (MSS) and three channel Return Beam vidicon (RBV) was launched by NASA under the earth resources technology programme of U.S.A. Similarly LANDSAT-2, 3, and 4 were launched on 1975, 1978 and 1982 respectively.

The sensors used in LANDSAT series are MSS, RBV, and TM (thematic mapper). The sensor used in LANDSAT-1, 2, 3 were MSS and RBV but in LANDSAT-4, MSS and TM.

The electromagnetic spectrum wavelength commonly used are:

Multispectral Seanner (MSS)
Band 4-0.5 -0.6μ (green)
5-0.6 - 0.7μ (red)
6-0.7 - 0.8μ (Near IR)
7-0.8 - 1.1μ (Near IR)
8-10.4 - 12.6μ (Thermal IR)
(Landsat - 3 only)

Return Beam Vidicon (RBV)
Band 1-0.48 - 0.57μ (green)
2-0.58 - 0.68μ (red)
3-0.69 - 0.83μ (IR)
(RBV on Landsat 3- 0.50 - 0.75μ

Thematic Mapper (TM) (only Landsat 4)

Band 1	- 0.45 - 0.52 μ	
2	- 0.52 - 0.60 μ	Visible
3	- 0.63 - 0.69 μ	
4	- 0.79 - 0.90 μ	NIR
Band 5	- 1.55 - 1.75 μ	Middle I.R
" 6	- 2.08 - 2.35 μ	
" 7	- 10.4 - 12.50	Thermal I R

The size of satellites is 3 x 1.5 m and 4 m array, and weighing 959 kg. These satellites are at a altitude 917 km (900 - 950km). The orbit is near polar. They appear at horizon at 9.42 AM local sideral time. The sun synchronous time of Landsat D is modified to 9.45 AM LST. The speed of satellite is 6.47 km/sec.

According to the position of sensor the remote sensing systems can be classified as:

i) Terresterial Remote Sensing: - In this system the sensors are kept near the ground surface and the object of far distance are sensed.

ii) Airborne Remote Sensing: In this system the sensors are kept on air and the objects on ground surface are sensed.

iii) <u>Space craft or satellite Remote Sensing</u>: In this system sensors (plate form) are kept in the space. It does not require medium for observation. Electromagnetic radiation is the means or (medium) to sense the objects or to gather the informations. Now-a-days this is a very common system and is the only system which is widely known as remote sensing.

The principal functioning of satellite remote sensing are summarised as:

a) The objects on the ground surface get light from sun after its modification from passage through the atmosphere.

b) Radiate electromagnetic spectrum according to their physical and chemical characteristics.

c) This radiated energy again modified by atmospheric absorption and scattering reaches the sensor in the space craft.

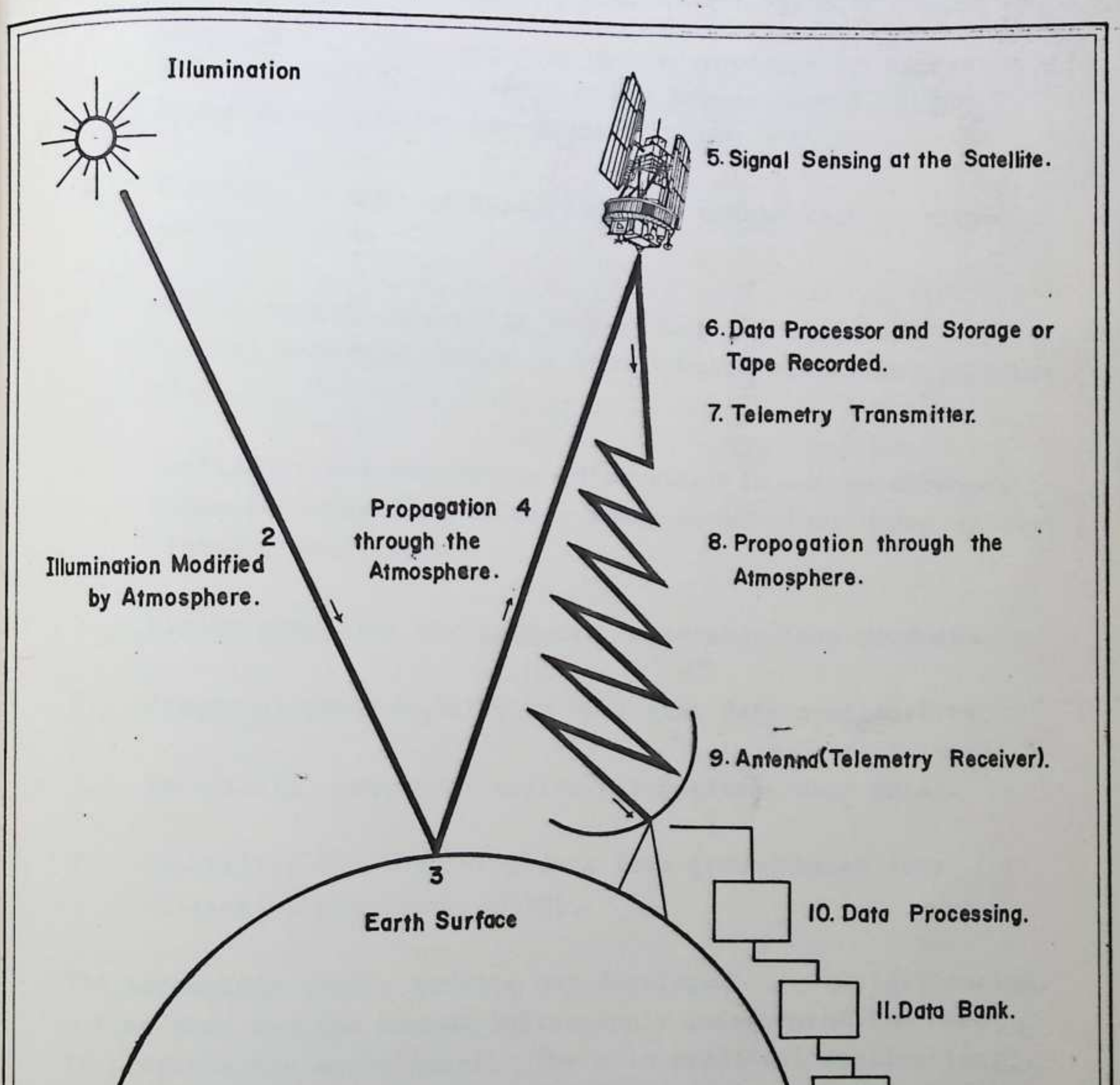
d) The power for the altitude and maintaining orbit and telementry of the signals is provided by the solar cell linked to Nicd batteries.

e) The signals sensed are processed and telemetered to the ground antenna.

f) The telemetered signals are again propagated through the atmosphere and received by a ground antenna.

g) The signals are processed in variety of ways for the calibration of different errors.

h) Then the signals are stored at data bank and made available for all users in form of computer compatable tape (CCT) or image from (this flow chart is illustrated by the fig.)


Illumination
5. Signal Sensing at the Satellite.
6. Data Processor and Storage or Tape Recorded.
7. Telemetry Transmitter.
Propagation 4 through the Atmosphere.
2
Illumination Modified by Atmosphere.
8. Propogation through the Atmosphere.
9. Antenna(Telemetry Receiver).
3
Earth Surface
10. Data Processing.
11. Data Bank.
12. Distribution.
13. Analysis by the users.
Drawn By:- S. Bhattarai.

The advantage of satellite remote sensing over other systems are:-

1. Large aeria coverage: The aeria coverage by Landsat frame is very large, small scale images such 1:500,000 broad area coverage per frame.

2. Provide higher spectral fidelity within each of those spectral bands.

3. Multitemporal capability for providing 'Multi look' to monitor seasonal change in snow cover, vegetation, land use, etc.

4. Continuous and repetitive observation in sun synchronous modes for obtaining uniform image tone values under similar lighting conditions.

5. Direct provision for computer compatable tape products.

6. Potential minimum delay on real time data availability.

7. Systematic coverage of entire earth, except near poles.

8. Capability for receiving data from ground based data collection platforms (DCPS).

The technology remote sensing has developed rapidly during a time when man has become increasingly conscious of the need to preserve his environment. The main practical applications of remote sensing in inventory and management of natural resources are as follows:

1. <u>Agriculture, Forestry and Range Resources</u>:

   Discrimation of vegetative types, crop types timber types, range vegetation, measurement of crop. average by species, measurement of timber acerage and volume by species, determination of range readiness and biomass, determination of vegetation vigor, determination of vegetation stress, determination of soil conditions, determination of soil associations, assessment of grass and forest fire damage.

2. Land Use and Mapping

Classification of land use, cartographic mapping and map updating, categorization of land capability, separation of urban and rural categories, regional mapping, mapping of transportation networks, mapping of landwater boundaries, mapping of fractures.

3. Geology

Recognition of rock types, mapping of major geological units, revising geological maps, delineation of unconsolidated rock and soils, mapping ingneous intrusions, mapping recent volcanic surface deposits, mapping land forms, search for surface guides to mineralization, determination of regional structures, etc.

4. Water Resources

Determination of water boundaries and surface water areas, and volume, mapping of floods and flood plains, determination of arieal extent of snow and snow boundaries, measurement of glacial features, measurement of sediment and turbidity patterns, determination of water depth, deliniation of irrigated fields, inventory of lakes.

5. Oceanography and Marine Resources

detection of living marine organisms
determination of turbidity patterns and circulation
mapping shoreline changes,
mapping of shoals and shallow areas,
mapping of ice for shipping and
study of eddies and waves

6. Environment

Monitoring surface mining and reclamation,
mapping and monitoring of water pollution,
detection of air pollution and its effects,
determination of effects of natural disasters and
monitoring invironmental effects of man's activities.

Landsat Identification of Land Cover classes

Categories

Category	Best Band	Salient Characteristics B/W - color
a. Clear water	7	Black tone in B/W and color
b. Silty water	4,7	Dark in 7; bluish in color
c. Non forested coastal wet Land	7	Dark gray tone between black water and light gray land, blocky pinks, reds, blues, blacks
d. Decidious forests	5,7	Very dark tone in 5, light in 7, dark-red.
e. Coniferous forests	5,7	Mottled medium to dark gray in 7, very dark in 5, brownish-red and subdued tone in color.
f. Defoliated Forest	5,7	Lighter tone in 5, darker in 7 and grayish to brownish red in color relative to normal vegetation.
g. Mixed forest	4,7	Combination of blotchy gray tones, mottled pinks, reds and brownish-red.
h. Grassland (in growth)	5,7	Light tone in B.w, pinkish red in color.
i. Croplands and pasture	5,7	Medium gray in 5, lint in 7, pinkish to moderate red in color depending on growth stage.
j. Moist Ground	7	Irregular dark gray tones (broad.), darker colors.

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REMOTE SENSING APPLICATIONS TO LAND MANAGEMENT

BY

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The importance of land management is generally accepted, but what do we really mean by the term. Specifically, what constitutes 'land' and 'management' and for what objective is the land to be managed ?

'Land' I will define as including all the components of the terrestrial surface - landform, substrate, soil, land cover - and their various attributes. There is also a significant interrelationship between water and land management. 'Land management' may be defined as the policies and practices of land utilization. These policies and practices should directly reflect the objectives of land management.

There may be many different objectives of land management. In Nepal, top priority might be given to land conservation and to maximizing and sustaining the yield of agriculture and the forests. However, the management plan must look beyond the immediate objective to the environmental impact of that plan.

The process of land management, regardless of scale of interest, generally involves:

- o an inventory of what is there -- the AMOUNT, NATURE, and DISTRIBUTION (location) of resources to be managed, and of parameters affecting, or affected by that management. Together these define land capability and land suitability.

- understanding of the environmental interrelationships such that the possibilities for, and impact of, specific management procedures might be predicted.

- definition of land management objectives, which will take account of land capability and suitability, socio-economic projections, and political will.

- implementation

- monitoring and evaluation of the implementation process and effects.

Remote sensing refers to all techniques of 'remote' data collection, but especially aerial photography and satellite imagery. Remote sensing may make a significant contribution to the land management process, especially those aspects of inventory and monitoring. Aerial photography has long been standard in resource inventorieis while satellite imagery is now seeing increasing use for reconnaissance and semi-detailed studies of large areas in poorly mapped regions of the world.

Image tones and patterns may be related to specific land characteristics. In this way the images provide a framework for organizing field work and extrapolating point field observations. Finally, by analyzing two or more dates of imagery, changes in land resource characteristics may be evaluated and monitored. This may help the implementation, regulation, and evaluation of land management decisions. Finally, many different resources are represented in a remotely sensed image which enhances the potential for an integrated management approach. Given the interrelationships in the natural environment, this is perhaps the most exciting potential of remotely sensed data in land management.

To summarize, remote sensing will not replace traditional field techniques aimed at describing and understanding the environment. Remote sensing is merely another tool at the disposition of the land manager. Applied properly, it may be a very powerful tool, both in increasing the efficiency of many field operations, and in opening new potentials to the land manager, such as repetitive monitoring at relatively low cost.

INVENTORY AND ANALYSIS

- AMOUNT, NATURE AND DISTRIBUTION OF RESOURCES

  - SOILS
  - LAND USE/LAND COVER
  - CROP TYPE
  - SURFACE GEOLOGY
  - HARD ROCK GEOLOGY
  - LAND FORMS
  - CLIMATE
  - WATER PARAMETERS

  LAND CAPABILITY

  ↓

  - INFRASTRUCTURE
  - EXISTING LAND USE SYSTEMS
  - SOCIOLOGICAL ASPECTS
  - REQUIRED INPUTS
  - PROJECTED DEMAND

  LAND SUITABILITY

LAND MANAGEMENT

OBJECTIVES

- ECONOMIC PRODUCTION (MAXIMUM YIELD)
- SUSTAINABLE YIELD
- LAND CONSERVATION
- RECREATION/TOURISM
- URBAN/INDUSTRIAL DEVELOPMENT
- WATER SUPPLY (DRINKING; IRRIGATION, ETC.)
- PRESERVATION (E.G., NATIONAL PARKS)
- IMPACT MINIMIZATION

TIME FRAME

- LONG TERM E.G., SUSTAINED YIELD
- SHORT TERM E.G., MINERAL EXTRACTION

SCALE

·Kinds of soil surveys and their uses.

Kinds of soil survey	Examples of use	Type of planning
1st Order	Experimental plots, sites for houses	Detailed—very intesive planning
2nd Order	Farming, ranching, woodland management, urban development	Detailed planning
3rd Order	Extensive ranching or woodland management, watershed management	General—specialized planning
4th Order	Large watersheds Large resource conservation and development areas Large regional Council of Governments areas County or multicounty planning districts State planning districts	General planning
5th Order	Multistate or nations	General—very broad planning

Table 1—Examples of database systems for land use and land cover, geographic resolution and representation, and suggested applications.

Source	Descriptor	Geographic resolution	Geographic representation	Applications	Reference
California	Land Use Mapping Programs (LUMP)	Variable	Grid cell, polygon	Land capability and land habitability rating; inventory & evaluation maps	Johnston et al., 1975
Canada	Geographic Information System (CGIS)	1:250,000, variable	Polygon, UTM	Express land capability in seven categories	McCormack, 1971
Illinois	Natural Resource Information System	Variable	Polygon, grid	Land capability	Tschanz & Kennedy, 1975
Iowa	Land Classification Method for Land Use Planning	Variable	Grid cell	Alternative land use decisions	Land Use Analysis Lab., 1973
Maryland	Automated Geographic Information System (MAGI)	1:63,360	Grid cell	Natural soil groupings; cropland, urban, recreational, wildlife & woodland displays	Shields, 1976
Minnesota	Land Management Information System (MLMIS)	1:500,000, qvariable	Grid cell	Depict level I land use; alternate land use decisions	Hsu et al., 1973
New Jersey	Land Oriented Information System (LOIS)	Variable	Grid cell, STC	Depict land use	New Jersey Dep. Community Affiars, 1973
New York	Land Use and Natural Resource Inventory (LUNR)	1:24,000, variable	Grid cell, polygon, UTM	Categories (51) of land use	Office of Planning Services, 1974
N. Carolina	Planning and Land Use Management Information System (PLUM)	Variable	Grid cell, UTM	Identification of critical areas	Skinner, 1974
Oklahoma	Land Use Information System	1:24,000 (level II) 1:250,000 (level I) 1:1,000,000	Grid cell, UTM	Alternative decisions in land use	Watson et al., 1973
Ohio	Statewide Land Use Inventory	1:62,500	Grid cell	Factors influencing water quality; level I land use categories	Baldridge et al., 1975
Tennessee	Natural Resource Planning Aid System (NRPAS)	1:24,000 1:250,000	Grid cell, UTM	Categories (6) of land use	Stevens, 1973
Wisconsin	Land Resource Analysis Program (LRAP)	1:250,000	Grid cell, UTM	Define critical resources; soil suitability for	Kiefer et al., 1975
USDA	Map Information Assembly and Display System (MIADS)	Variable	Grid cell	Display soil attributes	Nichols, 1975
USGS	Land Use and Data Analysis Program (LUDA)	1:250,000	Grid cell, UTM	Depict land use and land cover	Fegeas, 1975
USDI	Resource and Lands Investigations Program (RALI)	1:100,000–1:250,000		Wetlands evaluation, wild & scenic rivers, coastal zone management, critical areas.	

Table 1—Criteria for identifying kinds of soil surveys.†

Kinds of soils survey	Kinds of‡ map units	Kinds of components	Field procedures§	Appropriate scales for field mapping and published maps	Minimum size delineation¶
1st Order	Mainly consociations and some complexes	Phases of soil series	The soils in each delineation are identified by transecting and traversing. Soil boundaries are observed throughout their length. Air photo used to aid boundary delineation.	<1:12,000#	<0.6 ha (<1.5 acres)
2nd Order	Consociations, associations and complexes	Phases of soil series	The soils in each delineation are identified by transecting and traversing. Soil boundaries are plotted by observation and interpretation of remotely sensed data. Boundaries are verified at closely spaced intervals.	1:12,000 to 1:31,680	0.6–4 ha (1.5 acres to 10 acres)
3rd Order	Associations and some consociations and complexes	Phases of soil series and soil families	The soils in each delineation are identified by transecting, traversing and some observations. Boundaries are plotted by observation and interpretation by remotely sensed data and verified with some observations.	1:24,000 to 1:250,000	2.3–252 ha (6 acres to 640 acres)
4th Order	Associations with some consociations	Phases of soil families and subgroups	The soils of delineations representative of each map unit are identified and their patterns and composition determined by transecting. Subsequent delineations are mapped by some traversing, by some observation, and by interpretation of remotely sensed data verified by occasional observations. Boundaries are plotted by air photo interpretations.	1:100,000 to 1:300,000	40–370 ha (100 acres to 1,000 acres)
5th Order	Associations	Phases of subgroups, great groups, suborders and orders	The soils, their patterns, and their compositions for each map unit are identified through mapping selected areas (39 to 65 km^2; 15 to 25 sq. miles) with 1st or 2nd order surveys, or alternatively, by transecting. Subsequently, mapping is by spaced observations, or by interpretation of remotely sensed data with occasional verification by observation or traversing.	1:250,000 to 1:1,000,000	252–4,000 ha (640 acres to 10,000 acres)

† Soil surveys of all Orders require maintenance of a soil handbook (legend, mapping unit descriptions, taxonomic unit descriptions, field notes, interpretations) and review by correlation procedures of the National Cooperative Soil Survey. Work plans for many survey areas list more than 1 order; the part to which each is applicable is delineated on a small scale map of the survey area.

‡ Undifferentiated groups may be used in any order with possible exception of 1st Order.

§ Field procedures used with meanings defined in preceding text.

¶ This is about the minimum size delineation for readable soil maps (i.e., 6 mm^2 or ¼ by ¼ inch area). In practice the minimum size delineations are generally larger than the minimum shown.

1st Order soil surveys are made for purposes that require appraisal of the soil resources of areas as small as experimental plots and building sites. Mapping scale could conceivably be as large as 1:1.

PROCESS OF LAND MANAGEMENT

FORMULATION OF GOALS AND OBJECTIVES

↓

INVENTORY AND ANALYSIS

- INVENTORY OF RESOURCES
- UNDERSTANDING OF ENVIRONMENTAL INTERRELATIONSHIPS

↓

DEVELOPMENT OF ALTERNATIVES

↓

STUDY/EVALUATION OF ALTERNATIVES

↓

SELECTION OF PLAN/ACTION

↓

IMPLEMENTATION

↓

MONITORING AND EVALUATION

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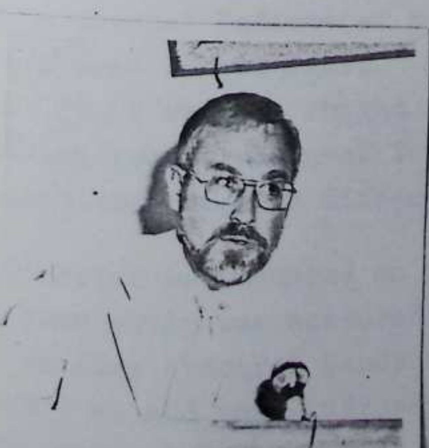

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SPECTRAL RESPONSE STUDIES OF VARIOUS LAND COVER TYPES USING HAND-HELD FOUR CHANNEL RADIOMETER MODEL 100 AX

BY

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Introduction

Spectral response is the ratio of reflected energy to incident energy as a function of wavelength. Different objects of the earth reflect different amounts of energy in the different bands of the electromagnetic spectrum. Average spectral reflectance values of an object over different bands or wavelengths comprise the spectral signature of the object. So, the study of the spectral behaviour of objects helps to identify and discriminate objects or land cover types. This difference can be seen clearly through the plot or the curve drawn from the spectral response of the object.

Objective

The main objective of this study is to measure the spectral reflectance of land cover types of using a hand-held four channel Radiometer.

Materials and Methodology

To study the spectral response of different land cover the hand-held four channel Radiometer Model 100 AX (Fig. 1) with tripod stand was used in the field. The Model 100 AX Radiometer is a compact, light weight, rugged and entire in self contained, four channel instrument designed for use in the field environment. The observationwere made in different places of the Kathmandu Valley.

The Radiometer was mounted on the tripod. The spectral response of the land cover was measured pointing the Radiometer to the object in four spectral bands within the visible (0.5 to 0.6, 0.6 to 0.7 m) and near infrared (0.7 to 0.8, 0.8 to 1.1 m) wavelengths, compareable to those of the MSS abroad Landsat with a field of view of 15^{o}.

Fig. 1 Four Channel Radiometer
160 AX

The spectral response of a reference white paper was also measured in every observation, to stimulate the total incident radiation.

By multiplying the observed values by appropriate instrument constants, percentage reflectance of different objects were obtained.

Result and Discussions

After the compilation of the observations of the different objects, the percentage reflectance were calculated and the results are given in table 1.

Table 1. Percentage Reflectance of the Different Objects in Four Spectral Bands

Objects	Band 4 0.5 to 0.6	Band 5 0.6 to 0.7	Band 6 0.7 to 0.8	Band 7 0.8 to 1.1
1. Wheat				
a.	18	20	40	40
b.	12	5	53	54
2. Garlic				
a.	24	14	49	71
b.	17	13	41	74
3. Broad bean	10	5	56	61
4. Mustard	18	19	48	60
5. Potato	6	12	35	65
6. Green grass	6	6	32	42
7. Fallow with rice stubble	20	20	31	46
8. Bare soil	14	7	25	31
9. Wet soil	9	11	15	21
10. Sand	17	73	53	80
11. Wet sand	13	13	54	15
12. Flowing water	6	10	5	8
13. Water with moss plants	7	4	1	3

A set of curves representing the spectral response of the different objects are presented in figures 2, 3, and 4.

Fig. 2A shows the spectral response of the various agricultural crops in different spectral bands. The general pattern of the crops is low spectral responses in band 4 and 5 and high responses in bands 6 and 7. But the wheat crop has a low spectral response in all bands in comparison to the other crops, and 1a has a higher response in bands 4 and 5, low in bands 6 and 7 than 1b. This is because wheat (1a) is more healthy and green in color. But in the case of the Garlic (2a, 2b), the spectral responses in all bands are similar.

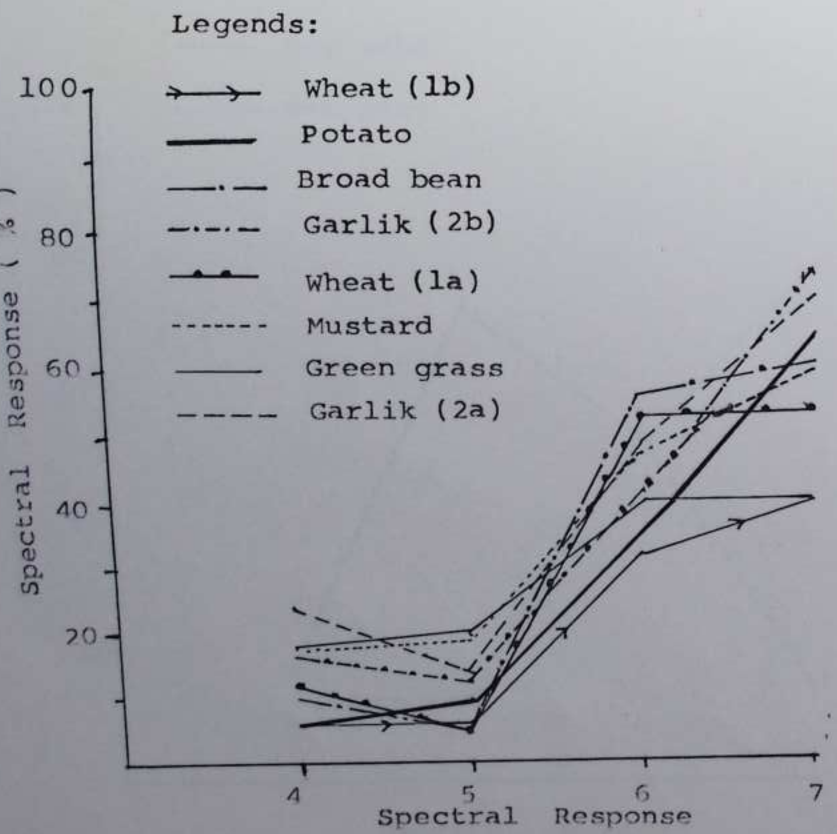
Fig. 2B shows the spectral responses of fallow lands. Fallow land with rice stubble has higher spectral responses than soils in all bands. However, there is a lower response in bands 4 and 5 and higher values in bands 6 and 7. But in the case of bare soil, there is a very low spectral response in band 5 and very high in bands 6 and 7.

Fig. 3A and Fig 3B show the spectral responses of sand and water in different conditions. Dry sand has a very high response in bands 5 and 7 and very low in band 4. But wet sand shows high spectral responses in band 6 and very low in the other three bands.

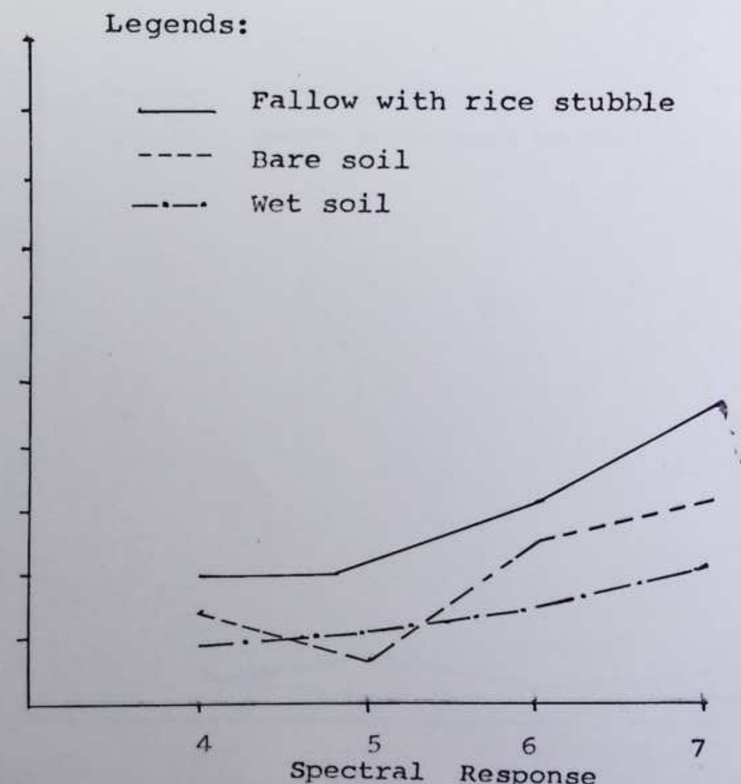
The water categories are unique in having uniformly lower response in bands 6 and 7. Flowing water has high responses in bands 4 and 7, and low in the others bands. But water with moss plants has a very low spectral response in band 7.

Fig. 4 shows the spectral response of all the land cover types measured in all the spectral bands. The interesting thing in this curve is that the spectral response of all the objects are high in bands 6 and 7 and low in bands 4 and 5. The remarkable feature in this curve is that the sand has high response in band 5, 6, and 7 and very low in band 4.

Fig. 2 Spectral Response Curves for Agricultural Crops and Fallow Land

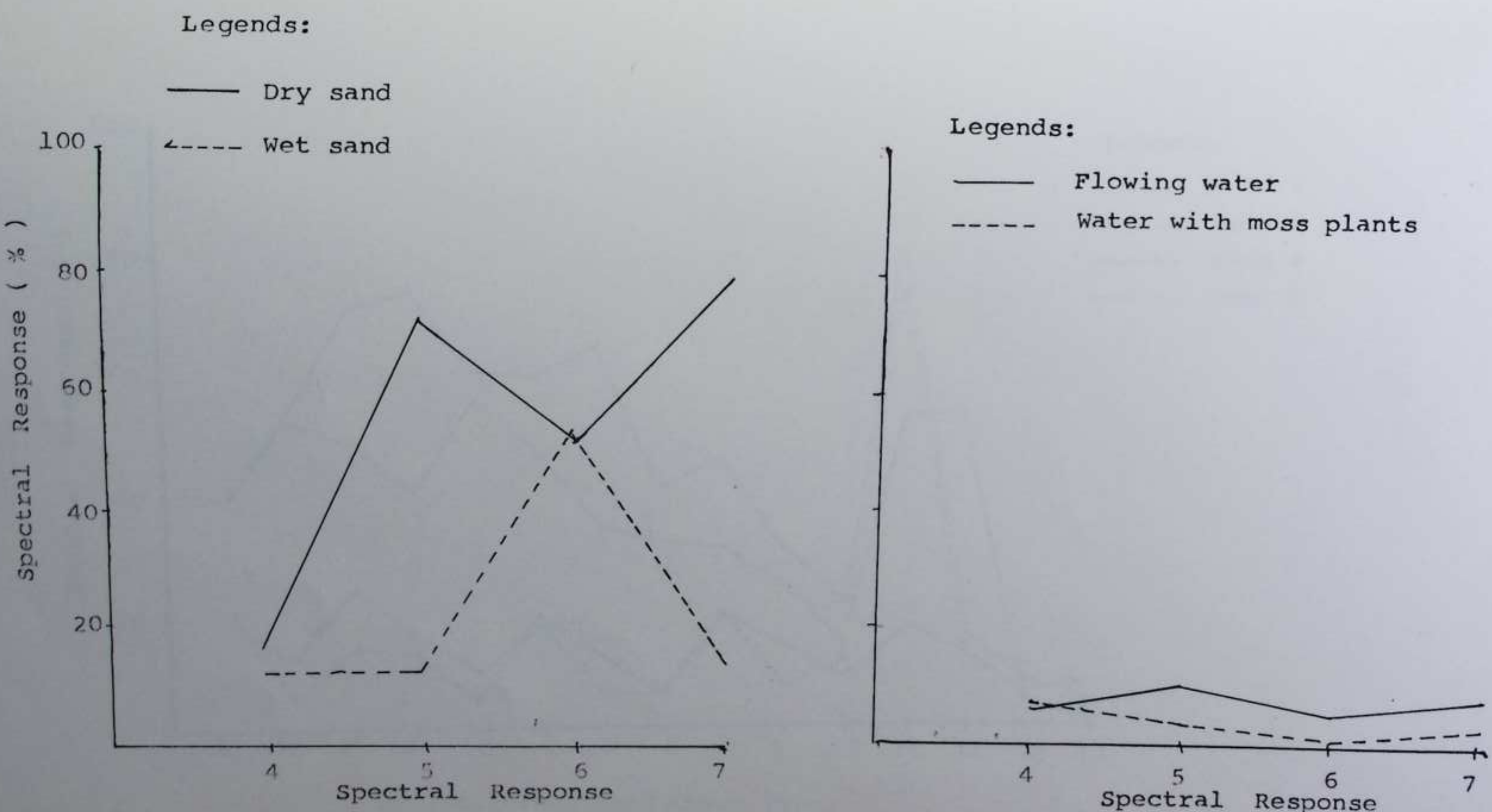


A. Agricultural Crops



B. Fallow Land

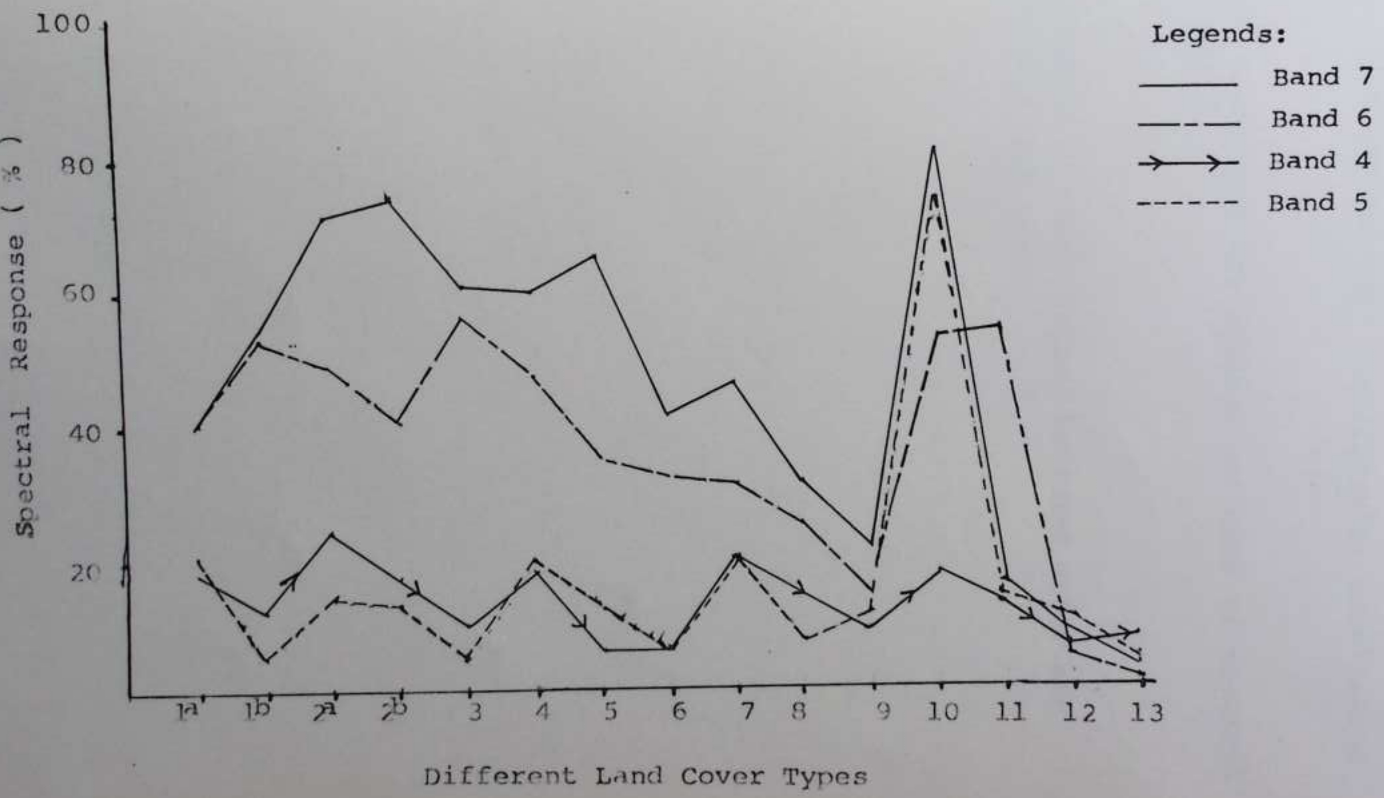
Fig. 3 - Spectral Response Curves for Sand and Water.



A. Sand

B. Water

Fig. 4 - Differences of Spectral Response of Various Land Cover Types on Bands 4, 5, 6, and 7.



Conclusions

On the basis of the study carried out, the following conclusions can be made:

1. The agricultural crops have the similar patterns of spectral response (Fig. 2A).

2. The spectral response of sand, fallow land and water are quite different from each other.

WATER RESOURCES APPLICATION OF SATELLITE DATA

BY

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The application of satellite data from a wide variety of satellites and sensors to the study of water resources is becoming common in many nations, both large and small. The early use of meteorological satellite data by meteorologists has inspired hydrometeorologists and hydrologists to evaluate their programs as satellite data becomes more timely and more detailed. Recent climatic variations of global proportions has caused reconsideration of available water resources in many droughtstricken countries, including Nepal.

High resolution Landsat imagery has proved very effective for a variety of water resource problems:

1. For improving the mapping of drainage and drainage basins.

2. For mapping variations in surface extent of lakes.

3. For inventories of lakes and dams.

4. For wetland mapping.

5. For mapping geologic structures that control ground-water movement.

6. For monitoring phreatophyte distribution.

7. For locating springs, seeps and swamps.

8. For dam-site location studies.

9. For monitoring water loss by seepage around dams.

10. For mapping snow lines.

11. For measuring snow extent in river basins.

12. For making seasonal forecasts of runoff from mountain snow packs.

13. For drainage basin land-use maps.

14. For determining flood extent.

The major advantage of satellite remote sensing of water resources are synoptic viewing, repetive data collection, low cost, timeliness of data, and the integrated nature of the sampling process.

The major disadvantages of satellite data are the inability to secure data during cloudy periods, the inability to collect data from subsurface, and resolution problems of the metsat data.

Intelligent use of remote sensing can provide valuable benefits in the surveying and monitoring of water resources, especially in the more dynamic aspects of hydrology such as transient snow cover, playa lakes, and precipitation estimates.

Remote Sensing Technique for Geology (In Nepal) A Brief Discussion

BY

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Introduction

Remote Sensing technique which covers wide range of sphere is not a new technique. As we can define it in a simple way"data collection from a distance". Ever since man inhabited the earth he must have felt the need for surveying his surroundings. Our ancient ancestor, the caveman must have looked down from the entrance of his cave, halfway up the cliffs, over the broad valleys below him to survey the area for animals which would provide his food. With his natural sensing instrument, eye, ear, nose, he must have scanned the area as repeatedly as the sat ellite scans the earth now a days. Listining to far off sounds and sniffing the scent of approaching danger, his mind and brain must have selectively assessed the usefullness of the data evaluating them for final action, climbing higher up the slopes, he must have increased his field of view, in one hand and in other, the scale of the gmage formed in his mind msut have become smaller and smaller until it was difficult to separate one animal from other; in modern words the spatial resolution of the image formed became less.

However as the science and technology advanced this technique (Remote Sensing) also grew faster and faster. The distance from which the surface may be surveyed has been increased from cliff height to normal flying height of aircraft-1000s of meter and further to the heights of the orbiting satellites- 100s of km. The sensor from eyes, nose, ears,have developed to a range of sophisticated sensors not only covering the range of visible light, but the entire range of the electro-magnetic spectrum and the force field. Further, as it covers the wide spectrum and properties like electromagnetic it is used in many field, to be precise, it will be difficult to suggest any such branch of human need which is out side the scope of Remote Sensing. Thus it is the needsof users and agency who could decide how far the techniques are applicable to them in any particular subject or topic. In my opinion it is that part of the understanding perception which is vitally important especially for a country like Nepal, that is in other words to know precisely how much and for what purpose we should use the Remote Sensing Technique. We all know coal can be made out of diamond but none of us start dc that simply because it is not feasible or sensible. In the same way to use of Remote Sensing technique, either simply because it is developing fast, or the technique being used by all the advanced countries, and acquisation of costly and sophisticated equipment will be as unjustifiable as making coal out of diamond. The possibility of optimum utilization of the equipment and its through evaluation should always proceed before any decision is made on the untilization of the technique.

With this background in our mind; Department of Mines and Geology have cautiously and meticulosuly used the Remote Sensing techniques to a limited extent. We may be slow in the acquisation of costly equipment as we do not have any yet, but we are not slow to use the imagery for visual interpretation. After long use of the iamgery visually and analysing the interpretation I have come to conclusion that I mentioned in my last paper presented in COSPAR symposium held in Ottawa 1982, that "....... this technique which has slowly taken root in developed countries, should not be left only for developed countries. Indeed the complex interpretation by sophisticated equipment and computer is beyond thelimit of present available technology in many places, but there are many studies which can be done quickly with the aid of simple instruments and this interpretation will certainly aid the government's aim of geological mapping and mineral exploration.

Remote Sensing Work for Geology

With this introduction I will explain in brief the various work done by Department of Mines and Geology for geological mapping and mineral exploration. The work as a whole can be grouped into three categories:

1) Works that are completed,
2) Works that are going on,
3) Works that are planned.

1. Completed Work

a) Lineament Map

The main purpose of this work was to plot all the linear features/lineaments, noticiable the country, and to utilise the information for various structural and other interpretation. Further, to analyse the lineament by various means and to correlate them with features like river system, land slide, structure, mineralization etc. Lineament which refers to natural lines as dark or light tones or bands visible on the Landsat Imagery or airphotographs. The Lineament could be fracture, fault, joint, or linear expression of a fracture system. They include many structural expressions that could initially be seen as lineaments, such as rift and graben troughs, fold axes, strategraphic ridges, and surface expressions of deep-seated major structures, other definable phenomena include changes in structural or stratigraphic orientation and various circular structures, possibly related to mineralization.

The Lineament map was prepared by plotting all lineaments lying within the country. The plotting was done by placing transparent mylar over the black and white Mosaic of Nepal. The prepared lineament map was compared with operational navigation charts, U.S. Army toposheets scale 1:250,000 and other available data to eliminate non geologic features such as fence lines telephone wires, ropeways, etc.

No detailed field check of the lineaments has been done to date when compared with field checked photogeological maps, and other available geological maps, however, most of them show good coincidence, and approximately 25 to 30 percent of the linear features, hitherto unnoted in the maps, are also seen. This suggests that 25 to 30 percent more linear features could be noted from Landsat.

b) <u>Fracture Density Contour Map</u>

The main purpose of this work was to find out the density of Lineaments, and then to interpret it along with other factors to delineate possible sites of mineralization. This fracture density contour map was prepared by measuring the traced lineaments for total within a centimeter grid area. The total length of lineaments in "miles per square mile" was tabulated with resultant grouping in length classes with values in miles. The fracture density contour map was prepared in which contour lines at one miles intervals connect areas of equal numbers of line miles of fracture per square mile. The maximum value seen was 16 miles which lies in the eastern part. There are considerable areas over the value of 9 miles and the sites over 10 miles were included in the map showing possible sites of mineralization.

More "high value points" were seen in the eastern part, than in the western and central parts. A few higher values are clustered together, thus making it possible to separate zones of high potential for mineralization.

c) Possible Sites Mineralization

The main purpose to do this work was to delineate, areas which look promising, as we know Remote Sensing technique can not detect minerals. Thus on the basis of lineament map and fracture density contour map, a map showing possible sites of mineralization was prepared. This was entirely based on the complex lineament intersections and the density values. More than 150 sites were deduced by this method-scattered all over the country. Some of the points however are clustered together at places which made it possible to divide the country into five potential zones-zones where five to eight sites are clustered together. They are (1) Terathum-Chainpur (II) Bhojpur-Dingla (III) Ramechhap-Majung, (IV) Murlingkot, and (V) Lungei Khola zone.

d) Photogeological Map

The importance of lithological association to mineral exploration, presence of altered rocks, and etc. is widely recognized. An area of 3500 Km^2 was studied with extensive field work, and a photogeological map was prepared. During the work photographs of 1:25,000 scale were used as the base map. The air photos were extensively used for selection of important areas for detailed geological field work. The photogeological map was the first of its kind in Nepal and shows more detail than the conventional geological maps- and undoubtedly shows the usefulness of airphotos.

Many faults, and fold structures were identified with the aid of airphotographs the map provided some important conclusions including, for example, the Kunchha formation being bassen of anomalies Pb-Zn anomalies in the mapped area can be grouped into strata-bound deposits or fault-controlled. Many such conclusions based on the photo-geological map re-oriented the types of detailed work to be done in this country for exploration of minerals.

e) Lineaments and their Relationship with Minerals

A map showing the relationship of lineaments with metallic minerals was prepared by comparing prospective sites for metallic minerals and the lineament map. All points showing possible prospective sites for metallic minerals were plotted on the map and only the lineaments which seemed to show adjacent relationship with the prospective sites were drawn. The map, in general, shows quite impressively a close relationship between lineaments and mineralization because there are only a few sites which do not show any lineaments around them. In most of the sites, lineaments in two directions at places even more than two are seen which are roughly perpendicular to each other. The Cross-cut relationship of two or more sets of lineaments and their intersection points in many of the sites are close enough to suggest a possible role of lineaments in mineralization (if any).

Even though many of the sites indicated as "prospective" may or may not be mineralized, the mere fact that Remote Sensing allows us to delineate some potential sites for possible mineralization - cheaply and quickly- is important, especially for a country like Nepal, where to delineate any area for detailed work by any other conventional method is expensive, difficult, and time consuming.

e) Lineaments and their Relationship with River Systems

The main purpose of this work was to study the relationship of lineaments with river system of Nepal. A drainage order map of Nepal was prepared at 1:506,880 scale based on the topo map printed by ordinance survey U.K. and was modified as far as practicable from LANDSAT Imagery.

The tributaries, according to its order were counted, for higher order the total distance was also measured. All this counting, and other calculation, and measurements were based on the newly prepared drainage order map.

Altogether, 20 rose diagrams 6 for showing the number of tributaries in different direction for the 6 different orders of river system in Nepal, and 14 rose diagrams for the individual rivers shwoing, their tributaries in different direction:

The correlation of the drainage data with lineament showed fairly good relationship. Further it was noticed that in Nepal even though the drainage is dense they attain only up to sixth order (in two river only), other interesting relationship of the small order drainage with the lineaments than the higher order, most probably are due to the fact that as most of the lineaments were originated during the Himalayan orogeny and thus it played important role in reshping the drainage pattern during orogeny and later on providing the weak zones for the river pattern.

At this stage, even though further work on the line to deduce its exact relationship is necessary, it can fair suggested that lineament in Nepal show a fairly good relationship with drainage patterns.

Present Work

1. Lineament Analysis

At present detail study of the lineaments of Nepal is going on. The lineament of Nepal which was prepared in 1977-78 are being digitizied in the Hewlett packard system 45 desk-top computer. The digitization was done twice, once dividing the country into east, central, and west Nepal sectors, and a second time according to the various geological units, of a newly compiled geological map based on Dr. A. Gansser's geology of Himalaya, and Dr. J. Stocklin and K.D. Bhattarai's geology of Kathmandu and adjoining areas.

The lineaments were further classified according to its length; to less than 10 km, 10-20 km, 20-30 km, and over 30 km. They are further grouped into different classes of preferred orientation. All these studies and interpretation will be correlated with the geological and structural data of the Nepal geology and different relationship with the lineaments will be deduced.

Future Work

In future department of Mines and Geology intends to use the Remote Sensing technique for the photogeological mapping of the country and second stage semidetailed study of the five prospective zone for delineation of mineralized areas. In additional to the conventional method of field study, extensive use of airphotos along with few imagery study will be done for completion of the photogeological mapping.

As regarding the second stage semidetailed study of the five prospective zones- along with field, and airphoto study; study of imageries in various forms will also be done in detail. The preparation of lineament map and fracture density contour maps in

1:250,000 scale will be completed for the 5 prospective zones. Further study in colour additive viewer of the area will also be our objective. In addition to this; other technique like, CCT interpretation along with band ratiowing and image enhancement will also be tried for some of the area of 5 prospective zones. However as these facilities are not available at present much depends upon the facility to be provided by the NRSC.

Conclusions

With this brief discussion of the various future, present, and past work related with the Remote Sensing technique for geology and mineral exploration; I as a users of the technique would like to stress to my past conclusion that ...... Landsat Imagery can not and will not replace the field geologist to look, detect, and search mineral locations. The assimilation of this technique with field work should be the primary orientation for developing nations like Nepal".

However, the two vital questions "How to look" and "where to look" that always confront us during our mineral exploration programme are to some extent, answered by the Remote Sensing technique by locating promising areas for detailed study. Let us hope in near future we will be successful enough to find some economic deposits in some of those five prospective zones.

Acknowledgements

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REMOTE SENSING AND ITS APPLICATION TO THE INTERPRETATION OF SOIL TYPES

BY

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Remote Sensing is the acquisation and interpretation of spectral measurements made at a distance location to obtain information about the land surface. One of the natural surfical resources of great concern is the soil. Soil is considered by most people, to be a non-reneweable resource: used primarily as a medium for the production of crops and vegetation.

Each landsat MSS (Multispectral scanner) detect spectral radiance in four bands (Table 1). Band 6 and 7 record reflection in the near infra-red.

Table 1.

Spectral Band	Type of radiation	Wavelength in micrometer
4	Visible green	0,5-0,6μ (micrometer)
5	Visible red	0,6-0,7μ
6	Invisible near infrared (IR)	0,7-0,8μ
7	Invisible near infrared (IR)	0,8-1,1μ

Band 4 is useful for studying water quality or siltation. Band 5 is helpful in separate different landuse pattern and vegetation. Band 6 shows the different landuse units and types of vegetation which can be related to certain type of soil. Band 7 has a most popular characteristic which is the sharp differentation between land and water.

Recent development in remote sensing techniques appear useful for Soil Scientist as a useful tool in soil surveying.

The fundamental method of Landsat interpretation for soil are as follows:

1. Physiogeographic analysis
2. Map analysis
3. Pattern analysis
4. Element analysis

Physiogeographic Analysis

It is based on geomorphological interpretation of a region, because all factors of soil formation, such as the land form material, hydrogeology and vegetation, are determined by the low of geomorphology and these geomorphological pattern are clearly recorded in the Landsat image, so it is the foundation of soil interpretation, and give slope and aspect information.

Map Analysis

In the interpretation of soil with contour maps of small scale, the map can only help us to locate the same place on the Landsat image.

Pattern Analysis

Patterns are "comprehensive information" formed by different colors and shapes. These patterns reflects both the soil properties and soil forming conditions, so can interpretate different soils by these patterns. But we must pay attentation to the geographical and the seasonal changes in patterns as well.

Soil Forming Elements

These elements consists of topography, parent materials drainage, vegetation and landuse. We delineate boundary of the mapping units and we should consider these element independently.

The Image Character for Soil Interpretation

A satellite image comprehensively reflects the spectral characteristics of soil and soil forming factors. Only a part of the tones, shapes, patterns and texture of image may directly reflect the spectral characters of soil and can be directly used to interpret soil type. For example image of gravelly sand, sand, and sandy soil distributed on plains developed from alluvial deposits lacustrine deposits or sea facies deposits are characterized by homogenous texture high reflectivity, clear edge and light gray or light tone. The image of soda saline soil or solonetz are gray white or light gray tone due to the change in salinity. The image of swampy soils and paddy soils are in dark blue green colour. Where as the image of loess and loess like material are gray white in colour. The image of red earth and red earth like material are bright yellow green, on a false colour composit.

Beach sand has the highest reflectance value in all the four LANDSAT bands (4,5,6,7) where as black soils has the lowest reflectance values. The reflectance value of water decrease in bands 5 and 6 band and is the lowest in 7 band of LANDSAT. This is because water absorbes more light in the infra-red region. Deep water gives lower reflectance value in all the four bands. Saline soils also have high reflectance values which may increase further with increase in salt contents on the soil surface and could be easily separated from sandy soil easily which have similar tone in a false colour image.

Soil mineralogy influences soil reflectance in various manner. Soils with gypsic mineralogy reflect high because of the inherent reflectance properties of gypsum. However montmorillinitic soils are often associated with high organic matter leves, shows low reflectance attributed to this high organic matter content Increased organic matter content has been seen to decrease soil reflectance in mineral soils. Less decomposed organic matter have higher reflectance in the near infra-red region because of the enhanced reflectance that is attributed to the remenant cell structures of well preserved fibres. In contrast very highly decomposed organic materials shows very low reflectance throughout the 0,5-2,3 wavelength region. Soil with low reflectance sand levels (10-30) had the lowest reflectance while pure sand had the highest reflectance. Surface roughness has substantial influence on the reflectance of soil. The rougher soil surface resulted in lower reflectance.

Some Characteristics of Soil Interpretation

	Properties of Soils	Characteristics of Soil Interpretation
1.	Sand and Sandy loam	White or Yellow pattern distributed in form of continuance in accordance with drainage.
2.	Clay loam and clay	Even dark colour attaches the pattern of crops. Degree of darkness of the basic colour are related with the soil moisture and the content of clay.
3.	Fine sand and Silt	It distributed in a form of vast area, when its moisture is low, the colour changes to white.
4.	Mountain brown earth	Usually it is bright red and brightness of red colour are related with the consists of forest and in different seasons.
5	Saline soil	Usually the basic colour is blue gray.
6.	Meadow soil	Usually blue, the blue will deepen as the ground water table will raise.
7	Skeleton soil	Basic colour is blue purple with an apparent dense texture of gully formation.

Conclusion

Landsat data have proven to be a very valuable tool for many areas of natural resources investation. Compared to aerial photography ,Landsat imagery has advantages in term of multi-spectral and multitempral viewing of the earth resources.

In addition Remote Sensing techniques should not only be applied to the investigation of quantity and quality of natural resources, but also to monitor the changes of environment and resources, to help in exploring and making full use of natural resources and to predict future situation of resources.

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Ground Truth Collection For Earth Resources Surveys

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Introduction

With few exceptions, remote sensors do not directly record parameters of interest to geologists, hydrologists and soil scientists. Aerial cameras and satellites scanners, at best, record and measure radiation attributes of a scene -- including variations in reflected or emitted radiation, spectral characteristics, and polarization properties. To obtain the ground or terrain information he needs, the earth scientist must be able to relate these remotely-sensed radiation attributes to the perameters of his particular interest. This is the purpose of ground truth.

Ground truth is the "bridge" between remotely-sensed data and the new information which is the objective of any study. Without appropriate ground truth, remotely-sensed data may turn out to be worthless for the purposes they were obtained. Without suitable ground truth, one can not say with confidence that remote sensing provides the necessary information or accuracy that is required for a particular application. This fact is especially true in the case of earth sciences where the information sought usually concerns subsurface properties or conditions.

Although it is not possible to describe all the possible types of ground truth data one could collect in support of earth resources investigations, one can say something about the nature of ground truth collection procedures, which provides a basis for planning. A clear understanding of the importance and uses of ground truth will allow investigators to properly identify the ground truth they do in support of his investigation. and equally important, eliminate from consideration data they do not need.

A Model

A user of remotely-sensed data should have in idea of now and why such data are expected to provide the information he needs. In other words, he needs a model of the relation between the data and the information sought. This model may be rudimentary and be only in the mind of the user or it may be explicite and rigorously mathematical. As a minimum the model must consider the radiation attributes that the sensor records in relation to the environment or the scene being sensed. To reliably interpret remote sensing data, he need know how radiation interacts with the surface or rear-surface of the ground, and if the parameter of interest is not at the surface, how that parameter is related to the surface.

Ground truth serves three principle functions:

1. Formulation: of the model or understanding of the relation of the remote sensing data to the parameter of interest.

2. Calibration: of the model (identifying scene conditions at the time and location of remote sensor data collection), and

3. Verification: of the results of a study or investigation.

The first function, formulation, is fundamental and should be accomplished prior to extensive fieldwork. Indeed, it requires that the objective of any study be clearly defined before the study is carried out.

The second function, calibration, often requires extensive ground observations and therefore, usually involves the developemnt of a field sampling strategy.

The third purpose, that of verifying the nature and accuracy of the results, also requires field observations and may involve sampling procedures somewhat different than those used in the model formulation or data calibration.

Ground Truth Types

In general, ground truth can be categorized in two general classes: (1) historical or archival information, such as existing maps, reports, surveys, and imagery, and (2) field observations and measurements.

In carrying-out any remote sensing investigation existing geographical and geophysical data should be consulted and studied in an effort to learn as much as possible about an area before actually conducting field work. (This is only natural and saves much time and trouble during the arduous task of collecting data in the field).

Field observations can be made before, during, or after the collection of remotely-sensed data -- depending on the nature of the information sought. For relatively static or unchanging resources, such as soils or rock types or structures, ground truth can be collected anytime; but for changing phenomena, such as crops, soil moisture, or flood-conditions, ground truth must be obtained at or near the time remote-sensor data collection.

Field Observations

An investigation should be concerned with at least three types of field observations:

(1) "housekeeping" or locational information,
(2) specific parameter information, and
(3) related surface and radiation information.

Housekeeping information is fairly straightforward; it identifies the location and time (if important) of the field observations. Location information is usually obtained from maps or existing aerial imagery. If the location of measurement sites are difficult to identify on the remote sensor data, their positions must be determined from easily indentifiable landmarks such as field boundaries, road intersections, or stream patterns, or even by latitude and longitude using a Geoceiver.

The user who wishes to relate remotely-sensed data to a specific environmental parameter (be it soil moisture, crop maturity, or rock type) must take a sufficient number of observations of the parameter to be assured that such an analysis can be done with confidence. The measured parameter need not be derectly visible at the surface but it must be relatable to an observable feature in the data. The parameter must be measured to at least the precision we expect from the remotely-sensed data and a sampling of the range of the parameter is desirable. The kinds of parameter recorded are as diverse as the application projects, and frequently include collection of samples for later measurement or laboratory analysis. Such samples, if properly labelled and preserved, can be referred to later when the remotely-sensed data is being analysed.

The third type of site observation concerns recording significant surface features and radiation information. Many site factors influence the radiation recorded by remote sensors, including for terrestrial sites such things as slope and aspect, type and density of vegetation cover, surface soil color, and the texture or roughness of the surface. A simple hand-held camera is one of the best tools for documenting surface features and conditions. The camera permanently records the same scene that the remote sensor sees but at a much closer distance and at different perspectives so that identification directly is certain.

Sometimes it is useful to measure on the ground the same radiation attributes that the remote sensor sees. Such measurements provide a basis for determining whether a parameter of interest gives rise to a detectable radiation difference at the surface and possibly whether atmosphere interfere significantly with the radiation received at the remote sensor. Since radiation and atmospheric conditions can change rapidly, ground measurements should be obtained, as nearly as possible, at the same time as the remotely-sensed data if they are to compared. For this purpose radiation measuring instruments, coupled with in-scene calibration references, are used to record incident, reflected, or emitted radiation. Various types of radiometers, spectral-radiometers, and pyranometers are often deployed for this purpose.

The same vertical perspective in site observations that the remote sensor has is often helpful. Such observations are more directly comparable to what the remote sensor sees and can provide a record of spatial variability that may not be noticed from oblique views. If the surface is relatively level vertical views can be obtained by climbing a tree, a ladder, or perhaps a specially constructed tower. For low surface features a large mirror held at an angle of 45 degrees to the ground can provide a limited vertical view.

Sampling Strategies

By its nature ground truth usually includes a set of observations or samples taken from an area of interest. The techniques used to obtain these observations (discussed in the previous section) are varied and depend on the information required and the environment being observed. However the quality and quantity of the ground truth is strongly dependent on the sampling effort. Properly designed sampling strategies permit valid uses of remotely-sensed data and generally will yield the information sought. Poorly designed programs may lead to some conclusions, but often not those intended as part of the original objectives.

Factors which affect data quality include: measurement of the correct variables, location and representativeness of the sample sites, proper calibration, storage, and reproduction of records and proper operation and maintenance of equipment. Factors which affect the quantity of the data include: the number of variables measured, the sampling method, frequency of sampling, and the resources available for sampling. Often the availability of personnel and equipment are key constraints to the amount of ground truth that can be collected. Obtaining only ground truth related to the project objectives and using the most efficient sampling methods are factors which conserve available resources.

In selecting sites for ground observations a number of strategies or combinations or strategies can be considered. One can use pre-existing sites, sites selected for special attributes, randomly selected sites, or sites located at systematic points along tranverses (or transects). Each strategy has certain advantages and limitations.

Examples for Earth Resources

In general, when using visual interpretation techniques in connection with remotely sensed data, we identify features by color or tone, pattern, texture, shape, size, height, shadowing, site, and associated features -- the so-called "elements" of image interpretation. Therefore, for earth resources studies ground truth related to these elements should be obtained. For example, soil and rock outcrop color and spatial patterns should be systematically recorded, and if possible, samples should be collected for later laboratory analysis or records. Their colors can be recorded by reference to standard soil or mineral color charts.

Frequently vegetation or topographic patterns are the key to identify subsurface phenomena and if so, these should be carefully recorded in the field from representative locations. For example, aquifers or hidden springs may be located, not through the observation of the water bodies directly, but by virtue of the association of green growing vegetation, especially during dry periods. Even for mineral exploration, it is the interpretation of surface structural, topographic, and landform features which provide the clues concerning the possibility sub-surface minerals or other economic features.

LANDSAT IMAGERY IN THE PRELIMINARY DATA PREPARATION OF BHERI WATERSHED

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Nepal is a mountanious country which has 75% covered by mountanious region and 25% consists of plain area. In the mountanious areas 25% is covered by snow and 25% is unaccessible. The remote sensing is used in the general investigation in which whole investigation area are searched. In the field of geology the remote sensing technique can be used to identify the major and minor structure like fault plane and structure anomalies and to interprete the lenear features for mineral potentiality. During the office work the preliminary maps of whole Karnali basin which combines the Karnali and Bheri watershed up to Chisapani were prepared. (No ground truth has been done. The watershed area lies in the far western part of the kingdom. The Bheri watershed consists of Bheri (Jajarkot, Dailekha and Surkhet districts) and Rapti zones (Rukum and part of Sallyan districts) having longitudes 81° 10" to 83° 30" and latitudes 29° to 30°. Landsat imagery is a suitable system for interpretation that could be used for having a basic geological information for assessment purpose in the hilly country, like Nepal, whose communication system is poor.

The edge enhance false color composite imagery were overlaid with transparent paper. The mapping was done using a light table. In this visual method of interpretation a zoom transfer scope was used to transfer the watershed boundary to the base map.

Linear structures interpretation from satellite images have advantages of higher reliability and simplicity in the geological applications of satellite remote sensing information. So from the global view point of crustal deformation,interpretation of linear structures gives information about geological strucţure. Study of linear features gives a great help in the solving the problem of metologeny with the study of linear structure in the developed country are using the with certain structure gives the criteria for the search of deposits (uranium explanation with circular structures and Nu pattern for oil and gas exploration) the linear features are controlled by fault, joints forms of mountain ranges, narrow straight mountain, or lines of isolated hills, all of suden change in the river direction (e-e straight flowing or all of suden turning of the river). All the linements of the area are derived from the FCC. Due to lack of different bands and imageres of different dates a comparative study of different bands and dates was not done. The linements show the regional trend within the area. Total distance of lineaments is 2900 km. length and grouped in the four directions E-W,N-S, NE-SW, SE-NW.

Out of 386 total Linements.

130 - E-W
113 - N-S
118 - NE-SW
25 - SE-NW

The joint systems, as well as attitude of the bedrocks, control the drainage in the Bheri watershed. The general strike direction of bed rock in all lithologic units are E-W. The attitude of bed rocks have given the maximum number of linement in E-W direction. The study of Nu-Patters and circular structure of linear features reveals new prospects are in the search of minerals deposits. Surface and under ground satellite remote sensing information is the record of spectral characteristics of the crustal surface, but it has no significance at depth. However major structural movement causing deeper crustal deformation would inevetle result in surface deformation different from that caused by movements occuring at shallow depth and on a smaller scale, a greater number of major and minor lineaments can be observed on the landsat images than on geologic and tectonic maps compiled from aerial photographs which show major and minor faults.

And these new data can be used for improving the geologic and tectonic maps of the region.

During the interpretation of linear features the main Boundary fault easily fraceble where as main central thrust not well distinguished. All the drainages in the area are traced from FCC Landsat imageries. The river systems varries from 1st to 6th order length of lineaments varies from 4 km to 20 km.

Length of	1st	order:	1125 km.
"	2nd	"	288
"	3rd	"	87
"	4th	"	211
"	5th	"	3
"	6th	"	1

So, these linear feature techniques are most suitable techniques to solve the different geological problems.

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GEOGRAPHIC INFORMATION SYSTEMS
AN OVERVIEW

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Introduction

There is increasing attention to development needs in many areas of the world. Development in this context refers to improving each individual's quality of life at least to satisfy minimum human needs by better resource utilization. Resources are such naturally occuring features as forests, grasslands, soils, water, minerals and materials which can be utilized to provide employment and to increase the availability of food and other commodities.

Creating development policies is the function of decision makers. A problem common to many decision-makers, is the inadequacy of information on the available resource base. Without accurate information decision-makers often fail to make decisions or make incorrect decisions. Sound decisions depend on accurate information, yet every country faces severe competing demands for the financial and human commitments necessary to staff an information system equal to its decision-making requirements. The frequent inadequacy of resource base information may be due to difficulties in accessing some regions; lack of trained personnel, equipment, or funds to collect information properly; or rapid changes in the resource base not detectable by traditional data collection methods, such as the high rates of deforestation in many areas of the world caused by increasing population pressures. This workshop will examine one tool which is useful for providing resource information. That tool is remote sensing and particularly, satellite remote sensing systems such as Landsat.

A correlated problem to the lack of data upon which to make decisions is that available data may not satisfy the informational needs of the decision-makers. Existing data may not be in a usable format. Frequently, it is necessary to combine different types of data to make decisions. For example, it may be important to determine for different watersheds, the areas of agricultural land on slopes greater than six percent. To determine this would require the integration of watershed boundaries, land use maps, and slope information. Each of these data types may exist, but in different formats making it difficult to combine them.

The purpose of this manuscript is to describe a method by which a variety of data, including remotely sensed data, can be organized and utilized by decision-makers. This method is the creation of an information system and more specifically, because as resource analysts, we are concerned with spatially identifiable data, a geographic information system (GIS). The following sections will define geographic information systems; discuss considerations for their design and construction; review possible data inputs, manipulations and outputs; present several case studies; and make some summary comments.

GIS DESCRIPTION

An information system is a complex of people, equipment and procedures working together organizing data to provide needed information to a group of users. A simple example of an information system would be a telephone directory or an index to a series of books or journals. In a GIS, locational identifiers are attached to the data. In essence, a GIS integrates a selection of data types into a common spatial format so that the data can be easily referenced or compared in a variety of configurations. The methods of constructing and utilizing a GIS can be very simple and inexpensive or very complex and expensive.

A simple GIS might consist of taking existing thematic maps at different scales, such as soil, elevation, hydrology, and land cover, and creating new maps at a common scale on transparency material. Combinations of these individual transparencies could be overlaid to produce new maps integrating the various thematic data such as locating forest areas below 1200 m elevation within one kilometer of a permanent stream or river. This overlay technique requires a minimum of equipment, materials and infrastructure but can be a highly effective technique for integrating data (McHarg, 1969). A more complex GIS would incorporate a computer with associated periferals such as a digitizer and film output device to input, manipulate, and output data as requested. Such a system requires a significant financial investment and an elaborate support infrastructure. An expensive GIS is not always appropriate or necessary. Rather a system should be designed which can most easily meet current informational needs within available resources. A properly designed system should have the flexibility to incorporate new data and also new technology as resources permit and needs require.

There are five phases in the construction of a GIS. There phases are:

1. data specification
2. data acquisition
3. data input, storage, retrieval, processing and output
4. system utilization
5. system evaluation, expansion and update.

A brief discussion of each of these phases follows.

Data specification. It is important that a GIS incorporate as many potential individual or organizational users as possible during the system design and data specification phase. By having many people involved in the design phase, more system utilization will occur and more informational needs could eventually be satisfied. Planning and management decisions are increasingly becoming more interdisciplinary requiring data from many environmental, social and economic agencies or organizations. It is important for a successful GIS that as much data as possible for a given spatial area be incorporated. The more agencies involved in the design phase will increase the amount of data available to be included in the system. Data inclusion could, however, be a sequential process where a minimal data set is initially acquired and then expanded as necessary or appropriate.

Another design decision is the selection of a common map projection and coordinate system. The spatial resolution at which the data will be obtained must be determined. It is not necessary that all data be obtained at the same resolution and even the same data could be at different resolutions within the study area. For example, land cover data might be at a finer resolution for urban areas than rural areas. Some systems are also designed on a hierarchical basis where the data may be at fine resolution for small administrative districts but capable of being aggregated to coarser resolution for larger, such as national, analyses.

Data acquisition. A thorough inventory of all available data for the study area should be made and as much of the available data as desirable be obtained for the GIS. Table 1 is a list of some data types which are frequently incorporated into a GIS. This data may be maps, statistics, remotely sensed images or digital data, etc.

Table 1

Geographic Information System Possible Data Inputs

Soil type
Land cover/use
Political subdivisions
Population density
Railroads
Roads
Hydrology
Structures/cities
Geology
Elevation
Slope
Climatic data
Agricultural statistics

Generally an attempt should be made to minimize the collection of new data as a cost-reduction measure. A GIS design should, however, anticipate future data availability and be capable of incorporating such new data.

Data input, storage, retrieval, processing and output. The process of data input into a GIS is geocoding or digitizing. It is simply registering all data to the same coordinate system such that different data types for the same spatial location can be combined or compared. There are many geocoding techniques and the method used is a function of total system configuration. If the GIS is to be a series of map overlays, then the geocoding process would be placing all data into a map format with a common scale and coordinate system, generally as overlays. For a computer based system, the data is geocoded on a point, grid or polygon basis. There are advantages and disadvantages to all of these geocoding methods. A point system generally provides better co-occurrence statistics, a grid system is easiest for data collection and a polygon or natural boundary system utilizes less computer storage space.

Once the data is geocoded it must be logically and efficiently stored within the GIS so it can be retrieved for processing in response to user requests. Simple processing techniques would include data overlays to determine, for example, combinations of land cover and soil type or percipitation, slope and soil type. Other data manipulations include weighting different factors such as percent slope or population density and combining these weightings to determine suitability or capabilities for agriculture, new housing or industrial locations. This type of processing often has a search function to determine the distance away from a transportation route, city or water source. Modeling can also be accomplished within a GIS such as predicting soil loss by watersheds. Output products from a GIS can be in map format or more frequently, as statistics.

System utilization. An effective GIS must be utilized. The involvement of many parties in system design will influence utilization. However, utilization will only occur if the system can effectively respond to user needs.

System evaluation, expansion and update. The GIS should be constantly evaluated to identify improvements which might be made. The GIS should also be sufficiently flexible to obtain new data and update existing data when possible. Repetitive remote sensing devices, such as the Landsat series of satellites, can be particularly effective in providing data updates.

CASE STUDIES

There have been a variety of GIS created over approximately the past decade. These systems have varied in the number and type of data they contain, the complexity of data minipulations possible and the extent of geographic coverage. Some systems have been created for very localized analyses, 100 s of sq. km., while at the other extreme the United Nations Global Environmental Monitoring System has been contemplating a global GIS. There are elements of a GIS for Africa already compiled as well as national and regional systems. Following are descriptions of three GIS, each of which is on a spatial scale similar to Nepal.

Lake Erie Watershed. A Land Resources Information System was constructed for the United States portion of the Lake Erie watershed. Lake Erie is one of the Great Lakes in North America and is between the United States and Canada. This GIS was created to examine sources of water pollution, particularly non-point sources such as soil erosion and agricultural runoff. The study area was approximately 60,000 square kilometers. Data was collected for about 500,000 cells of various sizes including 4, 9, 16 and 36 hectares. These cells were registered to an Universal Transverse Mercator coordinate system. The primary data collected were land use/land cover, soils, watersheds and administrative units. Data sources were aerial photography, soils and topographic maps. The GIS, in combination with water quality data, was very useful in examining sources of water pollution and modeling the effect of various control measures (Haack, 1977).

Bolivia. The Inter-American Development Bank has funded the initial stages in the construction of a GIS for Bolivia. A country-wide system has been conceptualized and data compiled for one political subdivision, Oruro Department. The national system was identified as a hierarchical cell system registered to an Alberts equal-area map projection. The Oruro Department system collected data in 500m cells for approximately 54,000 square kilometers. Fourteen data elements were included; Landsat data for each of the four MSS bands, political boundaries, elevation, soils, hydrology, land cover/land use, meteorology, geomorphology, slope, aspect and geology (Bartolucci, 1983).

Thailand. A GIS for Thailand has been constructed under World Bank funding. Thailand has an area of 198,455 square miles. The GIS was constructed as part of a land suitability study to assist in land management decisions and agricultural development. Data elements included in this GIS were land use, political boundaries, transportation networks, cities, soils, critical slopes, sugar processing mills and forest reserves. These data were obtained from existing maps, aerial photography and Landsat data (Wainger and Jones, 1984).

SUMMARY

Effective planning and administrative decisions require adequate information. Remote sensing systems are becoming an increasingly important tool in providing some resource data but this data source is best utilized in association with other data. Geographic Information Systems are a method to combine different spatially identifiable data. It is this combination of data which can best meet the informational needs of decision makers. I would urge that the various governmental organizations of Nepal seriously consider coordinating their resources to develop a national GIS.

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The Mali Land Use Study : A Case Study

BY

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Mali is a landlocked country located in west Africa. The country exhibits a wide diversity of ecological and climatic conditions ranging from humid tropical forests in the south to the desert of the Sahara in the north. Flowing across these ecological regions, and often in stark contrast to them, is the Niger River. Of particular significance is this river's inland delta which occupies much of central and southern Mali.

Mali is one of the poorest and least developed nations in the world. However, statistics hide the desperate condition of many of the rural residents, especially those occupying the climatically marginal northern lands which are subject to significant variation in annual precipatation, as well as to cyclical long droughts. In planning for development, the Maliean government has been hindered by an inadequate cartographic and statistical base. Thus the U.S. and French governments were asked to help fund a reconnaisance inventory of the natural resources of Mali, south of the Sahara -- this to provide preliminary planning for development. Specifically, the project was to produce maps and other information for soil and vegetation, soil capability, water resources, land use, and ecological aspects.

The project area covered some 576,000 square kilometers, and the time frame allocated for mapping and data synthesis was 2 1/2 years. The same time coverage of large areas, and availability at modest cost, suggested that Landsat imagery would provide the most practical mapping base for such a reconnainance project. 40 Landsat scenes were required to cover the project area. These were chosen on the basis of the date of data collection, data quality, and compatability with adjacent scenes. Subsequently these images were geometrically corrected to match the catographic projection of existing topographic maps. Adjacent scenes were radiomatrically balanced and rephotographed to match the area of the 1:200,000 scale topographic maps. Finally each image was contrast stretched to bring out the maximum range of detail. 66 image maps were thus produced, exactly matching existing topographic maps at 1:200,000. This coincidence was invaluable in that it provided for the direct transfer of information by simple outlay methods (e.g. roads, towns etc).

Two years were spent incountry to carry out field investigations. Firstly, the country was stratified into "natural regions" within which a certain consistancy may be expected in environmental and image-ground relationships. For the soil-vegetation mapping, field work as conducted on a 'natural region' basis. Prior to each field mission, the appropriate Landsat image-maps were analyzed and routes planned to cross the maximum variations apparent in the image. In the field, actual ecological variation was recognized by visual observation, and described. In this way a soil-vegetation taxonomic legend was developed which described the primary ecological variations within the prospect area. Rarely, however, did there ecological types occupy an area large enough to be defined at a 1:200,000 scale; thus mapping units generally consisted of land units within which there is a consistant relationship between defined taxonomic units. The mapping unit boundaries were largely defined by image interpretation, and the taxonomic unit contents by a combination of image interpretation and field experience.

The land use maps were produced by a similar combination of field experience and image interpretation. Development of a land use legend was strongly influenced by the possibilities for data extraction by image interpretation. The resource and socio-economic data was largely obtained from existing statistical base. Although the Landsat images did not contribute greately to the development of this data, they provided a catographic base for displaying the data and a framework by which to intergrate this data with the resource data being mapped in the project.

This project remains one of the best examples of intergrated resource mapping using Landsat data. The availability of Landsat data permitted the execution of the project within a short time-frame and at modest cast; the use of aerial photography or other traditional techniques would have magnified many times the time and cost requirements. The level of detail apparent on the imagery is also most appropriate to reconnainance and semi detailed mapping. The result will permit a more rational allocation of resources to the areas of nigner potential.

Hydrologic Applications of the Meteorological Satellites

BY

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Meteorological Satellites (or Metsats) have been in operational use since April 1960, and have contributed greatly not only to the science of meteorology, but also to the betterment of mankind, for they have enabled weather forecasters to track dangerous tropical and extratropical storms and provide ample warning, thus saving lives and property.

The two types of Metsat are 1.) polar orbiting, and 2.) geostationary. Because the geostationary satellites remain fixed with respect to earth, they can provide timely (near real time) and frequent (every 30 minutes) images. Geostationary satellites are also utilized as communications satellites for transmission of data from remote hydrologic sites, e.g., volcanoes or remote mountain areas. The US geostationary satellites are called GOES for Geostationary Operational Environmental Satellite. The European space Agency's satellites is called Meteosat, and the Japanese geostationary satellite is called "Sunflower" in Japan but also is called GMS Geostationary Meteorological Satellite.

The polar-orbiting satellites circle the globe about once every 90-100 minutes. The latest US version is called NOAA-7, and it has onboard the Advanced Very High Resolution Radiometer (AVHRR) sensor as well as other sonsor. The AVHRR has five channels:

The visible	0.55-0.75	micrometer
The near-infrared	0.7 -1.2	micrometer
The mid-infrared	3.7 -3.9	micrometer
Two thermal IR	10.0-11.0 and 11.0-12.0 micrometer	

The AVHRR has a resolution of 1 km. at nadir. At a given location it collects imagery twice daily. As there are normally two polar-orbiters operating, data can be collected at about 0230, 0730, 1530, and 1930 local solar time.

The multispectral channels of the AVHRR are important for applications to hydrology. An algorthm has been developed using the visible and near-infrared data to produce weekly vegetation index maps of the Northern and Southern hemispheres.

AVHRR data are also used in Northern Hemisphere snow cover mapping. Other products under development at NOAA/NESDIS include daily estimates of precipitation, insolation, and maximum/minimum temperature. Recently a new snowmelt/runoff model has been developed by Martinec and Rango using satellite snow-cover data as an input. The model is being tested by hydrologists in various countries.

METEOROLOGY AND HYDROLOGY SESSION

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REMOTE SENSING AND METEOROLOGY

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Introduction

It is often viewed that meteorology means weather forecasting only. But it must be clearly understood that,whereas meteorology is the science of the science of the atmosphere and deals with the complete understanding of almospheric phenomena, weather forcasting is only one aspect although, no doubts a major one of meteorology. It is also true that better understanding of the behaviour of the atmosphere helps us to prepare better weather forecasts. Our limitations in forecasting also come more from our limitations in the knowledge of the complex of atmospheric behaviour. Hence there has been a constant endeavour by meteorologist to use all the available knowledge and tools, including remote sensing for a complete understanding of the atmospheric phenomena.

Similarly the difference between weather and climate also must be clear. Whereas weather refers to atmospheric events at a particular instant of time at a particular locally or region,the climate of a place in weather averaged over a long period of time (days, months, years).

Remote Sensing has helped immensely to observe analyse comprehend and unfold the complex behaviour of the atmosphere in recent years and has consequently enabled us to come out with better forecast than what was possible before with the use of imagery by Automatic Picture transmission received from satellites through receive since last few years in forecasting we in Nepal have already started applying remote sensing in meteorology.

Needs of Meteorology

Meteorology differs from other science basically because the atmosphere can not be isolated and studied. Moreover any disturbance or physical happening in any part of the atmosphere affects it wholly. Even if some laboratory or mathematical use. It will not be possible to simulate or incorporate all that happens in the true atmosphere. The short comings are obvious.

W.K. Widger has quoted an excellent statement on the problem facing the meteorologist: "Take a large, almost round, rotating sphere 8000 miles in diameter. Surround it with a murky viscous atmosphere of gases mixed with water vapour. Titt it back and forth with a source of heat and light. Freeze it at the ends and toast it in the middle. Fill most of its surface with liquid that constantly feeds vapour into that "atmosphere as the sphere toses millions of gallons up and down to the rhythmic pulling of a captive satellite. Then try to predit the conditions of that atmosphere over one small area 50 miles square for a period of one to three days in advance."

The global nature of the atmosphere therefore, compels us to consider an entirely different strategy for its study, compared to other physical phenomena which can be studied in the laboratories.

There is yet another aspect to the problem. At any instant of time even if we limit our studies to a particular locality, there is a multitude of physical processes that are occurring in the atmosphere. Each process may have a profound effect on the other and the total effect of such processes appears almost impossible to predict. Moreover we start observing, recording and analysing and particular atmospheric condition at any moment, the next moment the situation could have changed dramatically. The dynamic nature of the atmosphere causes such changes continuously and there is no way to stop them. Thus we see that the only best way to comprehen the complexites of the atmosphere is to study it in situ and in toto, and if possible, at each passing second. The enormity of the data that would need to be handled in such operations can be very well imagined.

The Importance of Synoptic View

It is probably in the nature of the Man that he likes to enlarge his horizon. Those who first set foot on Swayanbhu hill might have had the first glimpse of panoramic view of the Kathmandu Valley below. As a matter of fact this fascination for overviews has also practical advantages. We see that in Nepal almost all the old district headquarters of the Hill districts were atop hills which gave . commanding view of the surroundings. The logistical advantages of such locations were fully utilized as are evidenced by large number of KOTS (torts) built on such vantage points.

Such vantage sites also allow us to observe weather conditions over a much larger surrounding area than is possible from lowlying points. Anyone who has been Kathmandu Valley from Kakani or Nagarkot or even from Swayambhu hill during early winter mornings would have noticed the fog enveloping the valley. Such synoptic view of the weather conditions are eventual for the understanding of the atmospheric phenomena. And what could provide us a better synoptic view of the atmosphere than a satellite ?

Tackling the Problem: The Limitations

Meteorologist try to understand the atmosphere and predict its behaviour by using his experience and judgement to analyse and interpret available data for weather prediction. Statistical methods, compiled with past experience of weather analysis, are invaluable but they do not necessarily answer all the questions. A better answer will be the use of physical laws and mathematical models. Newton's, Second law of motion, viz, force equals mass times acceleration(F=ma) and the principle of conservation of energy have been helpful in develop the equations that govern the motions of the atmosphere. According to W.K. Widger again, there are three important factors which limit the development of such equations which could solve our problem, viz,

1. Lack of adequate observations

2. Lack of knowledge of all the factors involved and how to express them in equations

3. Equations too complex to solve, even with the present high speed computers.

Hence numerical weather prediction is done by using approximate and simplified forms of the equations. The advancement in computer technology has made it increasingly possible to use more complex equations. But as yet, modelling of the atmosphere is still far from desirable perfection.

The Importance of Data and Observation

No matter how much sophistication can be achieved in mathematical modelling, we still need to observe weather and collect relevant data as accurately as possible. As has been emphasized earlier, for a better understanding and interpretation of weather the meteorologist needs to have data of the earth' surface as possible along with the data for the upper part of the atmosphere from as many places as possible.

Collection of data on the surface of the earth is done simultaneously all over the globe at fixed hours several times a day, and these data are collated and archived in the national, regional, and global centers. Global centers are located in Washington, and Moscow. Similarly, radiosonde measurements from pilot balloon observations are made from various ground stations in the same way, that is at fixed hours and simultaneously all over the world. If possible the observing stations should be located not very far from each other and the time interval between observations should not exceed twelve hours. A three hour interval is considered ideal. Hence at regular intervals the temperature, pressure, humidity, precipitation,wind speed and direction, radiation and sunshine duration, evaporation, etc. are measured and recorded by surface stations. Similarly radiosonde measurement of temperature, pressuse, humidity and wind are carried out.

This is a very big demand and often the need for such data is not appreciated by people from other walks of life. The need for global data comes from the fact that weather knows no boundary and the entire atmosphere is a single, closely interacting mass. The other need for global data comes because of the need for long-range forecasts, even for local regions.

The distribution of meteorological stations is not uniform over the globe. They are mostly located in the more developed countries of the northern hemisphere. There are very few stations covering the sea-surfaces and the southern hemisphere. According to one estimate an additional annual cost of $ 160 million would be required if the north pacific and southern hemisphere sea surfaces were to becovered by weather ships. In contrast coverage of the entire globe four times a day with a satellite will cost less than $ 100 million. Again, running a climatological station in a remote and inaccessible locality is very expensive if we use unmanned automatic stations and manning may not be feasible at all. Thus the alternative provided by remote sensing through satellites has special significance for a country like Nepal.

Meteorological stations were established in Nepal during the British Rule in India and they were managed by India meteorological Department (IMD) and not by Nepal's national meteorological service. Even now quite a few stations are managed and maintained by IMD. Nepal Meteorological service started functioning since 1965 only.

What Meteorological Satellites can and can not do

Meteorological Satellites can provide excellent photographs of cloud patterns associated with various weather conditions and systems.

We know that we derive all our energy from the sun. Energy from the sun operates the atmospheric engine. Hence proper understanding of radiation balance is essential for full understanding of the atmospheric behavior. It is possible to measure incoming radiation from the surface, but almost one-third of it is reflected back to space by the clouds and earth's surface. To measure this radiation which is not available to our atmosphere, we have to go above the atmosphere. Again there is emission of radiation in the I-R band by the earth's surface during both the day and night times as well as those emitted by clouds and atmospheric layers during night time. Part of there radiation is lost to space and which can not be measured from the surface. Both the reflected solar radiation and the I-R emission by the earth-atmosphere system can be ideally measured by satellites.

Meteorological satellites use electromagnetic radiation from various wavelengths (notably visible, I-R, microwaves, and UHF and VHF radio waves) to measure various meteorological parameters and to send such data and information to the earth. Depending upon the type of satellite, various kinds of cloud photographs and other data, covering various regions of the world can be received at the ground by suitably equipped stations when the station lies in line of sight of the satellite.

Meteorological satellites can measure winds and temperatures in the upper atmosphere as well as surface temperature and precipitable water present in the atmospheric layers. They also provide observations of snow cover, melting snow and glaciers, tropical disturbances and temeratures of sea surface and large sized lake surfaces. The importance of such data need not be over emphasized,not only for meteorological and hydrological purposes, but also for resource management.

Thus, although the remote sensing of earth and its atmosphere which began in early 1930's with radiosonde and later in 1940's with rockets,the spectacular break through came later in 1957 when the first man-made satellite, the Russian Sputnik was launched into orbit (October 1957). This gave tremendous impetus to the development of modern satellites and the series of meteorological satellites which started with vangard and TIROS projects of the USA, have ushered in an era of entirely new dimension in the field of meteorology opening up unlimited opportunities to explore and understand the complex behavior of the atmosphere.

It must, however be clearly emphasized that conventional meteorological measurements can never be dispensed with. Even with the most sophisticated satellites,accurate measurements of pressure, winds and detailed temperatures in the upper atmosphere may not be possible. Thus for both research and forecasting, satellite observation must be supplemented and calibrated with the actual measurements by . surface stations, radiosondes, aircraft, radar, ships and all other available or new methods.

Finally, it must be also emphasized that satellites do not forecast weather nor study them. They are just the tools for observing the atmosphere. Hence it must be remembered that it is only Man's continuous search for perfection and application of his judgement and faculty to explore the unknown including the complex atmosphere which will help us to understand the unknown and which is supreme. It is the Man who decides and must decide everything finally, and everything else is just his tools and subordinates.

Remote Sensing for Meteorology in Nepal

With the use of APT receivers for cloud photographs received from satellite during the late seventies, we have started using satellites for meteorological purposes. Radiosonde observations which were once started at Kathmandu are now suspended. Hence we don't have a direct means of observing upper air conditions in Nepal.

Considering the unique features of Nepal, the inaccessibility and remoteness for its northern region and lack of basic infrastructures of transport and communications in major part of the country, meteorological satellites can provide invaluable informations at a reasonable cheaper price. Such informations can help us to understand and our forecast climates and enlarge our activities in hydrology and agrometeorology. The importance of satellites for the study of the snow cover and snow melt need not be re-emphasized. Thus remote sensing has an unparallel potential to enhance our effectiveness in resource management (After all climate is also just another resource - albeit a basic resource). Hence our capability to use satellite data must be established and enhanced without any loss of time.

Acknowledgement

This paper has drawn a lot on material from W.K. Widger's "Meteorological Satellites" which the author of this paper considers an excellent introduction to this field.

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HYDROLOGY AND REMOTE SENSING IN NEPAL

BY

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Summary

The paper describes the recent history of hydrologic data collection in Nepal and the objectives of the present WMO/UNDP project.

Remote sensing must play an important role in future developments in hydrology simply because of the difficulty of surface access to many areas of Nepal.

Remote sensing, particularly from satellite, will be a major part of the expansion of hydrologic services to include more sediment data collection, snowpack estimation and flood forecasting.

Background

Very little had been done in the field of hydrology in Nepal prior to 1960. The Swiss Mission had obtained data in the Kosi Khola at Panauti, and the Government of India had collected some data at a proposed power site at the Trishuli River, work at three sites in the Kosi River basin was started in 1961 by the UN Special Fund for a feasibility study of a power project in this basin.

The Hydrological Investigations Project, a joint venture between HMG/Nepal and USAID-Mission to Nepal, began in 1961. This project was designed to establish a nation-wide hydrologic data collection network with a centralised agency to collect, compile and publish data produced by the network. The project was implemented in 1962 by the Hydrological Survey Section, initially under the Department of Electricity, later a component of the Department of Irrigation and Water Supply. After several reorganizations, Hydrology became a Section in the Department of Irrigation, Hydrology and Meteorology, under the Ministry of Water, Power and Irrigation in July 1979.

Within the Department of Irrigation, Hydrology and Meteorology, hydrological and meteorological services are divided into:

- Surface Water Section, including a Sediment Analysis Laboratory.

- Meteorological Services Section.

- Groundwater Section, including a water quality laboratory to furnish chemical analysis of water from ground water sources.

Surface water is perhaps the greatest potential resource in the economic development of Nepal. The development of the resources of Nepal's numerous river systems could provide low cost hydro-electric power, thus reducing dependence on fossil fuels; furnish water for irrigation, thus increasing production of food and agricultural commodities; and supply water for domestic and industrial uses. The development of water resources in Nepal is however not without difficulties; high floods during the monsoon season are followed by a dry season, and substantial regulation works, appropriately managed, are necessary for delivering water when and where required. Furthermore, frequent landslides disturb river flow and change channel shape, and heavy sediment transport is a threat to the life span of reservoirs.

Rational development of Nepal's water resources needs appropriate hydrological information based on long-term series of hydrological data. In addition to historical data required for the planning of water resources and for multifarious other design purposes in constructing roads, bridges, culverts etc., real-time data are needed for flood forecasting and warning and for rational management of reservoirs.

At present, the Surface Water Section is operating:-

(1) 45 regular stations out of which
44 are equipped with cable cars, and
22 with water level recorders. All hydrometric stations have staff gauges read daily by observers.

(2) 122 partial and miscellaneous stations,

and (3) 10 sediment sampling stations.

The regular stations are of two types: primary and secondary. Primary stations are long term installations, and operational for lengthy periods of time. Records from these stations are used to study trends and changes in flow patterns on a long range basis, and secondly to extend short term station records on basis of correlation studies.

Secondary, satellite or roving stations are short term installations of five to ten years duration, operated only long enough to obtain a record of sampling of the runoff characteristics of different areas and to make correlation studies with a nearby Primary station. If no correlation exists, they are up-graded to primary status.

Partial stations are installed to collect low flow data only, whereas miscellaneous sites are used to make discharge measurements according to the special needs for supplementing data from other types of stations.

The Hydrology Section has an active construction schedule. Each year about 8 cableways, 4 gauge houses and 18 staff gauges are installed. Not all these, however, are at new locations, some are replacements for installations destroyed by floods.

This last year, for example, the reinforced concrete gauge house on the Karnali River at Chisapani was destroyed by a flood reaching an elevation of 15 m. with a discharge estimated at 24,000 m^3/s.

Since the start of records at this site in 1962 the previous maximum gauge height was 12.98 m. in 1975 with an equivalent flow of 20,000 m^3/s.

Project NEP 78/020

This joint project between WMO/UNDP and HMG/N started in 1983 with the objective of developing and strengthening the national hydrological services. More specifically the objectives are to:

a) Expand the river gauging, rainfall recording and sediment sampling network of stations.

b) Strengthen and improve the reliability of the data collection, reporting and communication network.

c) Improve the quality of observational data through better observing procedure, the establishment of an inspection and supervision system and of regular equipment maintenance.

d) Develop computerized data-processing procedures for the analysis of data, establish a hydrological data bank with data recorded on magnetic tapes accessible for various statistical summaries and estimates.

e) Publish more detailed year-books, statistical summaries and results of studies and research works.

f) Initiate operational, real-time services by issuing current hydrological bulletins, hydrological analyses, forecasts and flood warnings.

g) Initiate the elaboration of hydrographic maps of Nepal.

h) Provide training of professional staff at all levels through on-the-job training, short-term in-service courses, university courses and post-graduate fellowships abroad.

i) Improve the organization and management of the national hydrological services.

Possible uses of remote sensing in hydrology

The routine business of the Hydrology Section is regular hydrometric data collection and processing. Remote sensings major importance here is in the increased reliability it could give for data from remote sites. At the present time, remote stations are visited only a few times per year and, if the water level recorder breaks down, many months data can be lost before a team visits the site and repairs the recorder.

If data collection platforms could be installed then with the very frequent transmissions of data from such equipment, a breakdown would be noticed almost immediately, repairs could be effected more rapidly and less data would be lost. Such equipment, being automatic, could also be installed in more remote sites where observers may be difficult to find.

However, in countries such as Nepal where labour costs are low and the availability of skilled technicians is limited it is not likely that the existing network will be changed to DCP's in the near future.

More likely is that remote sensing will be used for specialised activities such as forecasting. Two types of forecasting will likely be introduced to the Hydrology Section. First is the obvious flood forecasting. Floods cause damage and cost lives every year in Nepal and downstream in India. At the present time, with no real-time data transmission very little can be done in the way of warning people.

Within the WMO/UNDP project it is intended to provide SSB radio at about 20 sites so that routine hydrologic data can be transmitted quickly to Kathmandu. Here, it is intended to establish, for certain river basins, mathematical models to forecast downstream water levels and flows from the data provided by upstream stations. Flood warnings will then be disseminated to the affected areas by radio.

The warning time available could be greatly increased for many rivers if we could use satellite to collect and transmit data from further upstream, beyond the elevation of human habitation.

The second type of forecasting, often termed prediction, is longer term such as prediction of seasonal water availability for an irrigation project. For those rivers in which snowmelt is an important component of the total river flow then remote sensing could be used.

USAID officials visiting the Nepal Remote Sensing Center at Kathmandu have discussed with Hydrology Section the possible needs of the section and have concluded that use of data collection platforms (DCP's) measuring hydrologic data could be used to transmit these data to the U.S. polar orbitting weather satellites and thence to the Remote Sensing Centre. Coordinating the needs of Hydrology Section with those of meteorology, the experts concluded that a system of 10 data collection platforms, 2 computer systems and satellite data reception equipment together with necessary training and software could be provided at a cost of around $ 925,000.

Direct measurement of streamflow

Streamflow is presently derived indirectly. The most common method is to use a current meter, either a propellor type or a cup type of instrument (see Fig. 1), to measure velocity at different points in the river and then to multiply velocity by cross-sectional area to obtain flow. As mentioned earlier in the paper, an alternative method is to calculate flow from the change in water conductivity induced by adding a known volume of salt solution.

Both methods are complicated and time-consuming. Since we need flow measurements, at a minimum every day and, more often (particularly during high flows) every hour it is not possible to use current meters or salt dilution every time we need the flow. Other methods of measurement such as calibrated weirs and notches are usually unsuitable for rivers in Nepal because of the extremely high velocities and sediment loads encountered.

Recourse is then made to a relationship between flow and river level, the rating curve. Since river level can easily be measured directly (and recorded on paper chart, paper tape or magnetic tape) then, once a rating curve is established, flow can be computed directly from river level (see Fig. 2). The problem with this is that, in Nepal, the relationship between river level and river flow is not stable. Most rivers have sand beds and these beds erode or accrete with the seasons, complicating and making less accurate the process of calculating flow.

What is needed is some mthod of estimating flow directly without having to go through the intermediary step of measuring velocity or water level on the ground.

How can remote sensing help solve this problem for us ? What can we measure from satellite ? If the resolution of the satellite is good enough then we can certainly estimate the width of a river at a given point. Present resolution is 30m, too course for most of Nepal's rivers but this will decrease next year to 10 m with the French satellite SPOT and will certainly decrease further in the future. River depth can be estimated by remote sensing (although not, currently, from satellite) by measuring the light attenuation given the known reflectivity characteristics of the river bed.

River surface velocity may be estimated by a mathematical analysis of the surface wave pattern.

Once we have measurements of width, depth and surface velocity then we can calculate, with a feasonable accuracy, the streamflow.

This method of measuring streamflow is not currently possible but, with the present rate of advances in electronics and communications, it cannot be many more years before it could be tried.

Conclusions

A good hydrometric data network is of great importance for Nepal. Water is the key to development through its use for power generation, irrigation and, directly, for drinking or for industry. The effectiveness of water related projects is often less than good because of the poor data used in their design. If unaware of the quality of data a designer may undersign his project resulting in early failure. On the other hand, an awareness that data are inadequate may lead to overdesign and higher than necessary costs. The solution is to have plenty of good data.

Remote sensing is going to play a large part in ensuring that Nepal has an adequate supply of hydrometric data. Data collection platforms will be installed, as costs permit, firstly in remote, difficult to access, locations but later on at more and more regular stations, supplementing existing equipment. Parameters measured will certainly include snowpack and river level and may be expanded to include sediment data. Cooperation with the Meteorological Section will be essential to maximise benefits.

These data from the DCP's will be used first of all for urgent needs such as flood forec-sting but later will be used routinely in file updating.

These applications of remote sensing are possible right now, the technology and the equipment are matter-of-fact in many countries. Not yet possible, but perhaps not too far off, is the use of remote sensing to estimate streamflow from space. How much easier the life of a hydrologist in Nepal would be if that were possible!

FIG 1

SCHEMATIC REPRESENTATION OF A TYPICAL HYDROMETRIC INSTALLATION

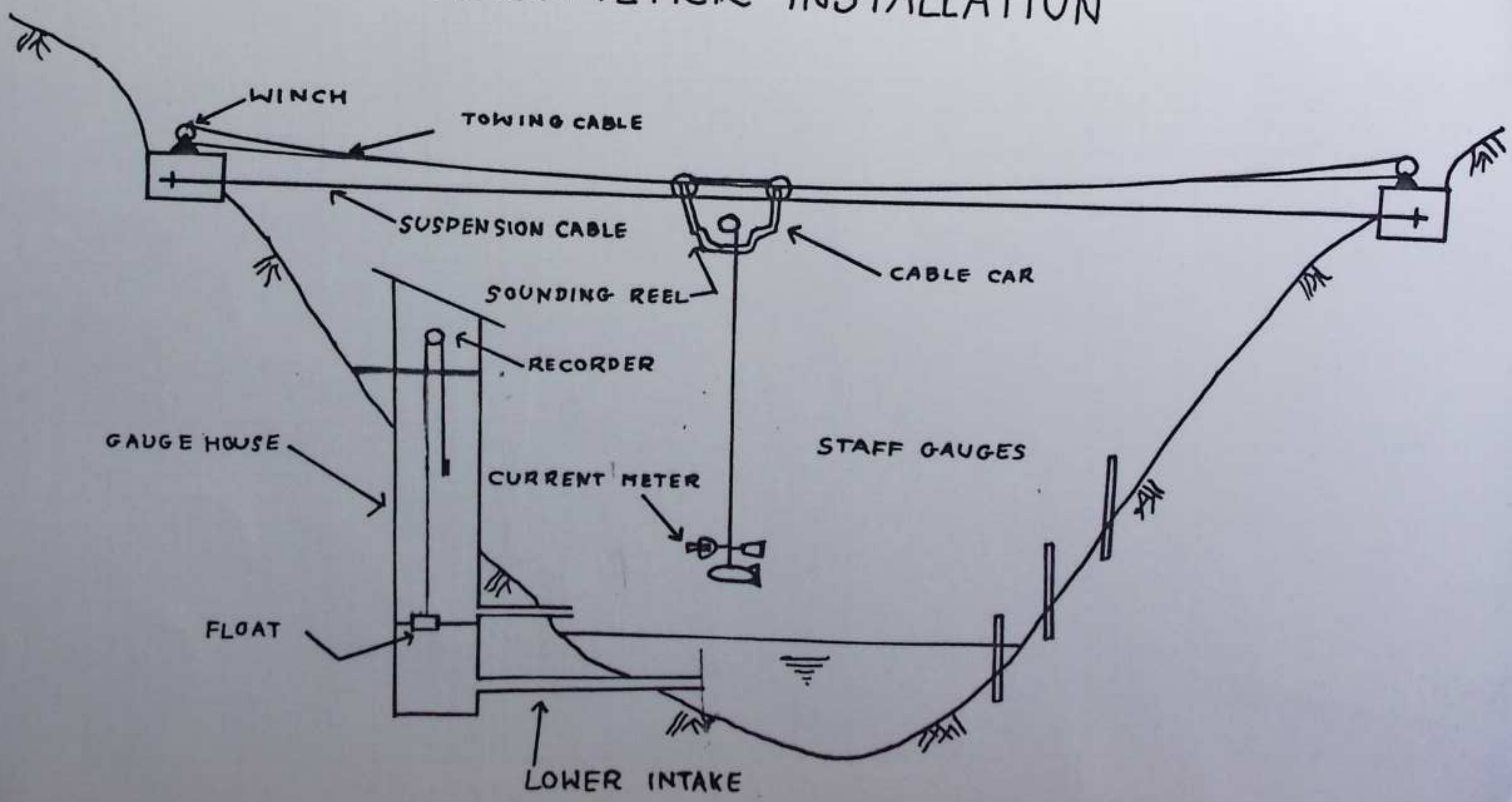
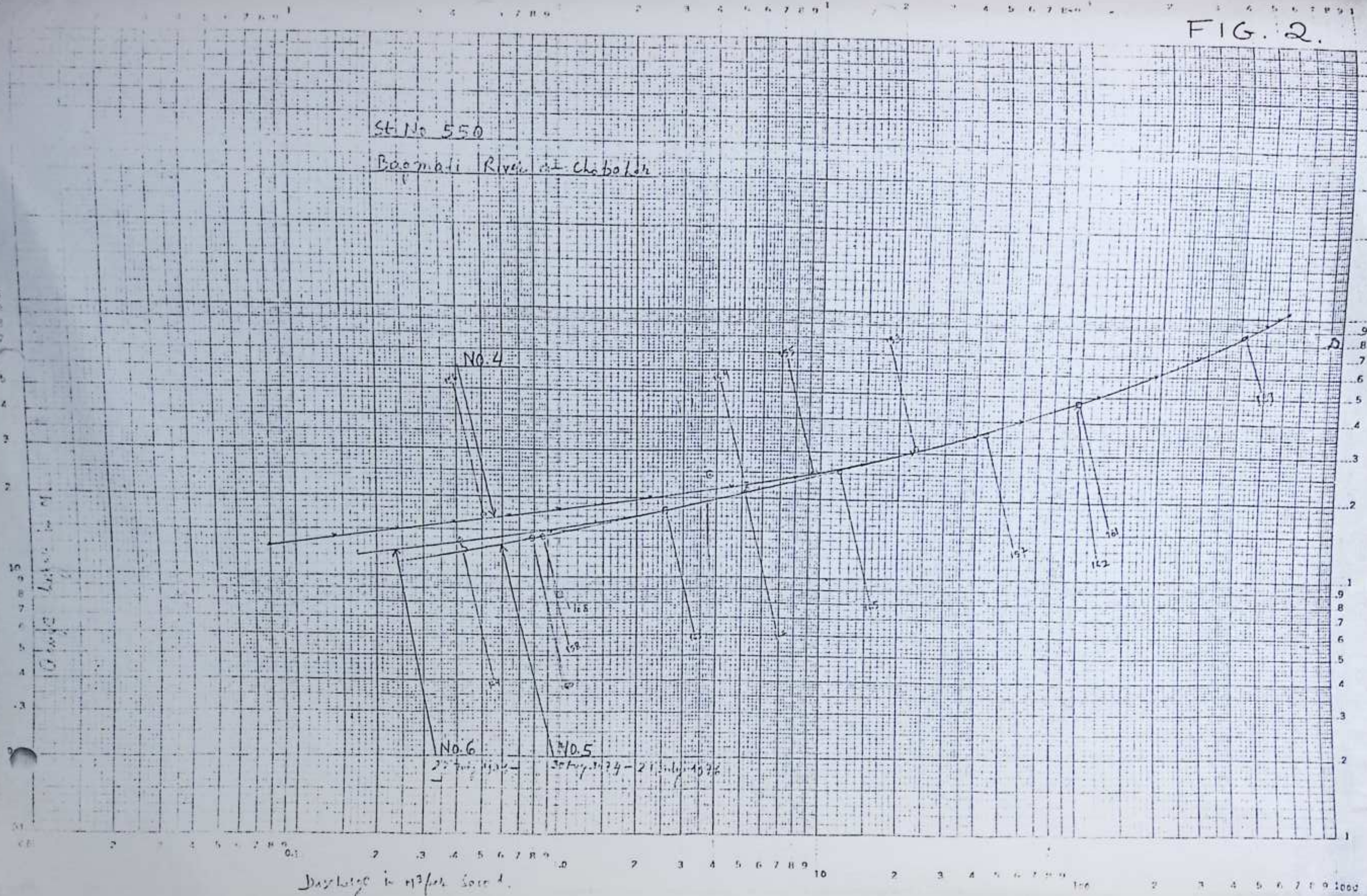
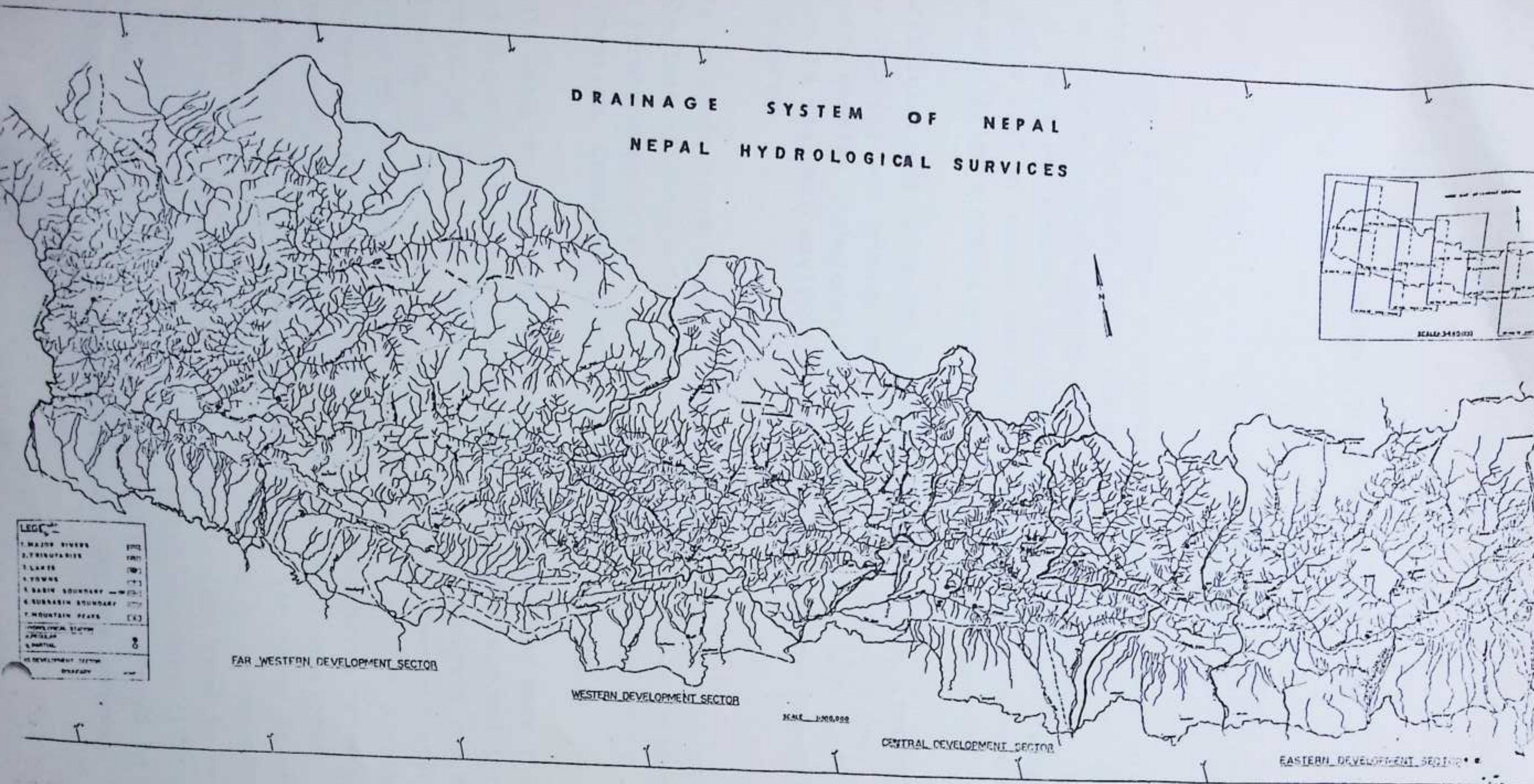


FIG. 2.


St No 550
NO.4
NO.6
NO.5
Gauge Level in M.
Discharge in m³/per Second.


DRAINAGE SYSTEM OF NEPAL
NEPAL HYDROLOGICAL SURVICES
LEGEND
FAR WESTERN DEVELOPMENT SECTOR
WESTERN DEVELOPMENT SECTOR
CENTRAL DEVELOPMENT SECTOR
EASTERN DEVELOPMENT SECTOR

REMOTE SENSING APPLICATION IN HYDROLOGY

BY
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Hydrology is a science of dynamic phenomena. It deals with the waters of the Earth, their occurrence, circulation and distribution, their chemical and physical properties, and their relation with their environment, including their relation to living beings. A major goal of remote sensing in hydrology is to observe and measure dynamic conditions of water quality and quantity.

Water interacts with the Earth's atmosphere, soil, vegetation, physiography and geology and it affects the works of man. Hence remote sensing techniques can be used to assess hydrologic conditions by indirect analysis of water along with environmental parameters.

Data collected from aircraft and satellite and the ever-growing technology of remote sensing provide powerful tools in preparing for future water stages and as a practical means of water exploration, development and management.

Fresh water in glaciers and ice caps accounts for more than 2% of the world's hydrological cycle. The glaciers and ice caps cover 10% of the total earth's surface. The analysis and careful monitoring of the world's glaciers is an important undertaking Supplies of fresh water are highly valued to support population increases and agricultural expansion. Inexpensive procedures for monitoring frozen water resources should be developed. Unfortunately the assessment of the world's ice cover is made difficult not only by sheer size of the features to be considered, but also because these areas supporting glaciers tend to be remote from population centers, mountains or polar and very difficult to assess. Furthermore glaciers can hardly be surveyed in morphology and structural characteristics for the general difficulties due to their dimensions, extension and severe environment. So usual measurements are made in critical conditions and referred to a pointwise analysis both in space and time. Nevertheless the knowledge of glacier dynamic has a great social impact for energy production, so that a continuous monitoring along the time is desirable. Thus, glacier-related analysis are most often characterized by a slow and somewhat piecemeal collection and compilation of data from local field-mapping programmes as well as some large scale nationally supported resource-assessment projects,usually based upon low-altitude conventional aereal photography.

Certainly considerable progress has been made, but their remains a clear-cut need for more rapid and less expensive methods of mapping the geographical distribution, measuring the aereal extent, monitoring the fluctuations, and identifying and classifying the features related to the world's ice masses.

The total length of the Himalayas from Kashmir to Assam is 2400KM, out of this length the middle strip of nearly 870KM belongs to Nepal. The only area in Nepal, covered by snow is the Himalayas where major big rivers of Nepal have their origin. During the summer months the discharge of big rivers critically depend on the snowmelt runoff for power generation, irrigation and drinking water supply. In the dry period a significant contribution to the river flow comes apparently from snowmelt. The quantity of runoff varies with the magnitude of the snowfall in the Himalayas. If the expected seasonal or fortnightly runoff could be forecast well in time before the onset of snowmelt season, it would be of immense value to water resources project managers to plan in advance the operation of reservoirs for achieving optimum utilization of the scarce summer flows. So knowledge of snow cover over the Himalayas is of great importance to hydrological interests. Any information that can be derived from satellite data regarding snowline, estimates of snow accumulation and snowmelt, the periods when they occur as well as the areas involved will be of great use to hydrologists.

At present Nepal does not have big artificial reservoirs Glacier ice and ground water are two big natural reservoirs retaining water. The summer monsoon usually lasts from June to September and brings precipitation to the Himalayan High lands above 5500 m. The amount of snow accumulates during the summer monsoon is about 10 times more than that of the remainder of the year. Precipitation during the monsoon is 80% of the annual amount in the most of the Nepal Himalayas. Precipitation at night is much more than that at the day time and this gives favourable condition for preservation and formation of the glaciers in the Nepal Himalayas.

The estimation of snow water equivalent and snowmelt volume in a basin is important for the water resources management. In order to attain the snow data, snow survey using snow samplers has been the most usual method for a long time. On the other hand a field survey using helicopter could also be applied. Another method namely "topographical factor method" was developed. Because of the danger and economic disadvantages, snow survey by snow sampler is losing its popularity everywhere. From this point of view a new method based on remote sensing technology is to be introduced here in Nepal also. The term 'remote sensing' did not appear in publications until 1959. It was only in the late 1960s that these techniques were sufficiently used in experimental and civil studies.

Many have used remote sensing to identify and measure glacial and erosional ice features. The varieties of topographic climatic conditions are thought to produce the aerial distributions and characteristics of glaciers such as physical properties of glacier ice, mass balance, glacier flow, debris contents of glaciers and other characteristics, which influence the characteristic distributions and shapes of glaciers in certain areas. To make an inventory of glaciers and to know the aerial characteristics of glacier distributions is fundamental, not only for the glaciology of the Great Himalayas, but also for the utilization of glaciers based on works of the glacier inventory in the Nepal Himalayas. However, it is not possible to observe the aerial characteristics of glacier distributions by ground surveys, since it is difficult to walk all over the Himalayas in a short time due to the mountainous topography. So air flights for photographing glaciers in the Nepal Himalayas were carried out by the Japanese Glaciological Expedition of Nepal to analyse the present state of glaciers, the characteristics of glacier types, the shape and length of glaciers and other glacial characteristics. The study focusses on one Nepalese glacier in the Mount Everest region, principally the Khumbu glacier. This area encomposses a portion of the high Himalayas that has commanded considerable attention from mountaineering expeditions and explorers since higher elevations are not to be found elsewhere in the world.

The glaciers of the Everest region are stagnating and thus possess tongues that are generally short. In fact 90% of the ice of masses of the Dudh Kosi region are found to be in retreat. Many smaller glaciers occupy larger valleys, indicating a much more extensive earlier glaciation.

Since satellite pictures (APT) are now being received in our country everyday, it is logical that we should look into the problem of utilization of satellite data for snow hydrology over the inaccessible areas of the Great Himalayas. APT pictures can be utilized on an operational basis for the delineation of snowcover over the Himalayan region and marking of the snowline. The superiority of the satellite method lies in the fact that the cost involved in this method are negligible when compared to other methods, such as aerial survey, spot observations, etc. Besides, the satellite gives a synoptic view over very large areas day by day. Another important factor is familiarization with the geographical background of the area as it appears in the satellite pictures on cloud-free days. This will facilitate easy recognition of landmarks and snow boundaries quickly on the picture and also avoid confusion with clouds or other spurious features.

DETERMINATION OF SNOW COVER FROM LANDSAT IMAGERY

BY
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Landsat satellites have been widely used for measurement of areal snow cover, snowline altitude and glacier mapping. It is cartographic format and its resolution (80 m) is suitable for snow cover and glacier measurement in large, medium and small basins. However one of the greatest drawbacks of landsat satellite is its infrequent coverage; once in eighteen days. We can not see the change in daily basis.

This paper presents a method of determining the change in snow cover from 1972 to 1975 and from 1975 to 1977. But how much water quantity has been contributed to respective streams have not been investigated. For this Tamor watershed has taken as a case study

Tamor Watershed

Tamor watershed, situated in the eastern Himalaya region was choosen for this purpose. This watershed area lies in inner Himalaya and Higher Himalaya to midland zones with relief ranging from 500 m above mean sea level of out let point of Tamor to 8585 m above mean sea level at Mt. Kanchanjunga, which extends north to south along the eastern Nepal border, which is the third Highest peak of the world, at 27^{o} 42'09" latitude most southerly of the major Himalayan peaks. The area of this watershed is 5974.1 sq.km. Here we have taken landsat imagery of three different years: November 1972, March 1975, and March 1977, and delineat the boundry of snow cover area as shown in maps No.1,2 and 3, then compare each other to see the changes. There are number of glaciers, the name of some glaciers are as follows:-

1) Kanchanjunga glacier

2) Ramthan glacier
3) Jannu glacier
4) Yamavari glacier
5) Yalung glacier

The total snow cover and its persentage in different years are as in follows:

SNOW COVER AREA OF TAMOR WATERSHED

Month/Year	Whole Area of watershed in sq. km	Snow cover in sq. Km.	Snow cover in %	Length of main river in km.
Nov. 1972	5974.1	1653	27.6	146.9
March 1975	-	1775	29.7	-
March 1977	-	1714	28.7	-

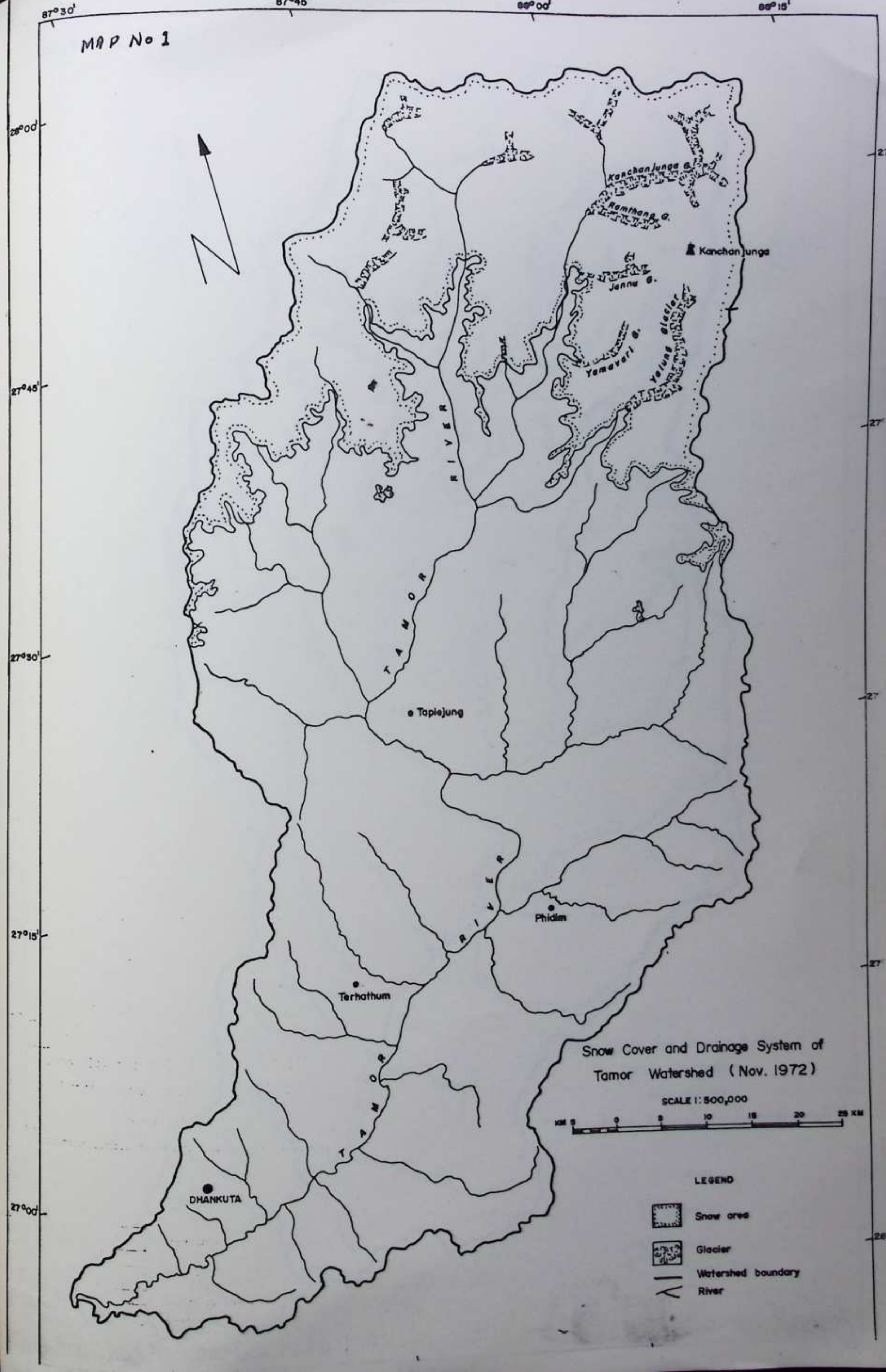
According to the above landsat data it is known that the change in area of snow cover from 1972 to 1975 is increased by 7.471%. From 1975 to 1977 snow cover area decrease by 3%. The change of snow cover from 1972 to 1977 increased by 3.7%.

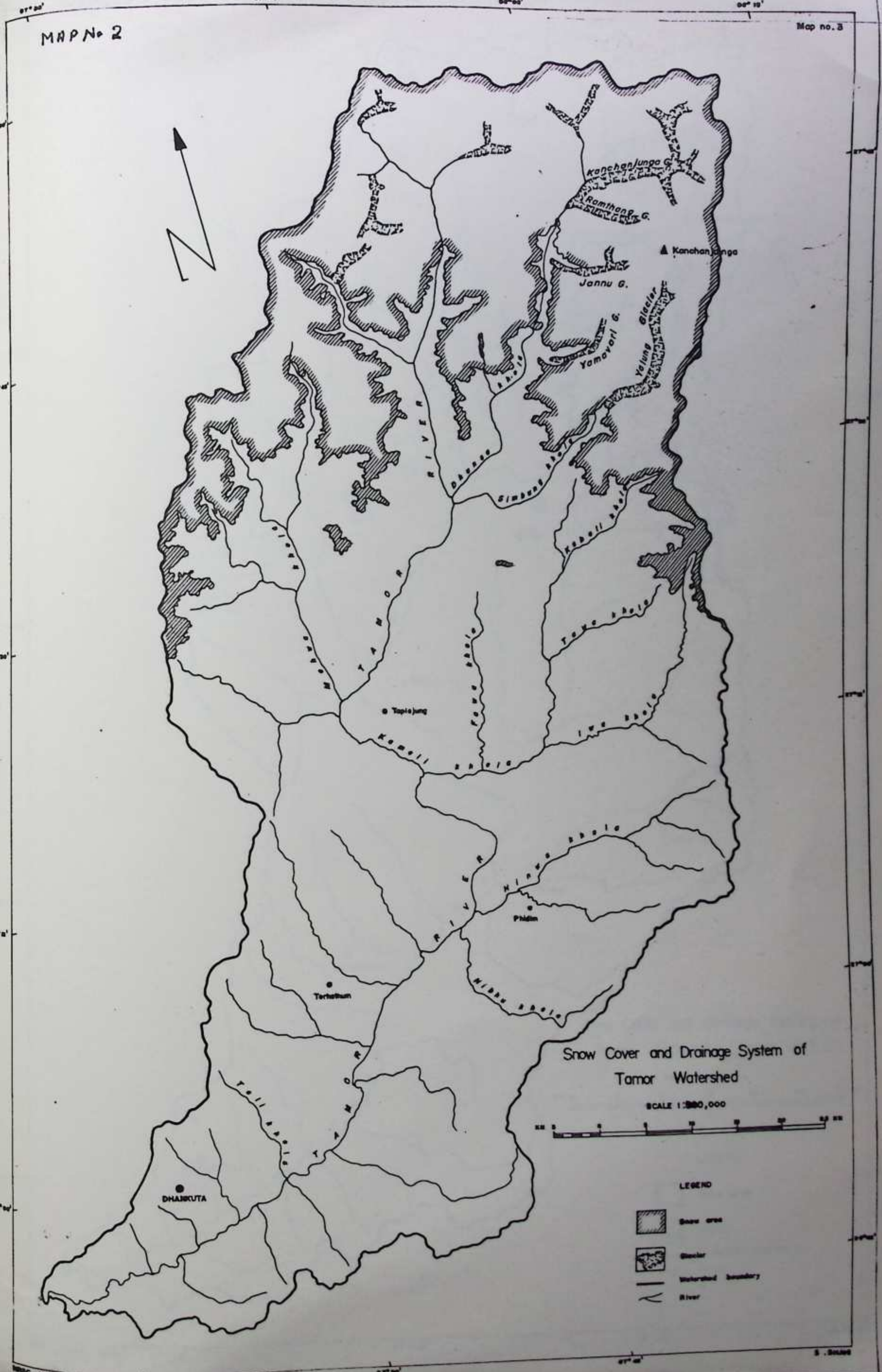
One of the major problem to map snow cover from satellite pictures it is necessary to distinguish snow from clouds. This can be best accomplished by comparing landsat imagery of the same area on successive 18 days before or after. If the imagery of these date is not available, it is necessary to bear in mind these things very carefully that clouds seldom retain the same shape or location more then few hours, non changing pattern is indicate of snow cover. Another main point is that snow cover plains usually have smooth texture while clouds are after rough or lumpy in apperance. Again the snow cover on the Himalaya follow the same geological pattern as the mountain range, which is different from the pattern of clouds views from space. Due to the low sun angles and on the northern slope mountain, there is shadowed area and seems to be dark in landsat imagery. The landsat imagery (November 1972, March 1975 and March 1977) of this upper watershed has not clouds and used for the purpose of mapping of snow and glaciers.

The precipitation generally increases with altitude, on the windward side of the mountain slopes. Quantitative estimate of this orographic increase (or decrease after a suitable altitude) at any particular altitude can be obtain by noting the period during which the mountain slope at that altitude remains under snow. Generally snow increases from the month of October and each to maximum in the middle of March. The precipitation in this watershed ranging from 1000 mm to 3000 mm per annum.

The major source of Tamor river and its main tributaries are snow and glaciers in the Himalaya region. However this does not seem to have a desired result in High Mountain basin of this watershed. The possible reason is that there is no quantitative estimation of long term data in the higher region to estimate the contribution of water from snow and glaciers.

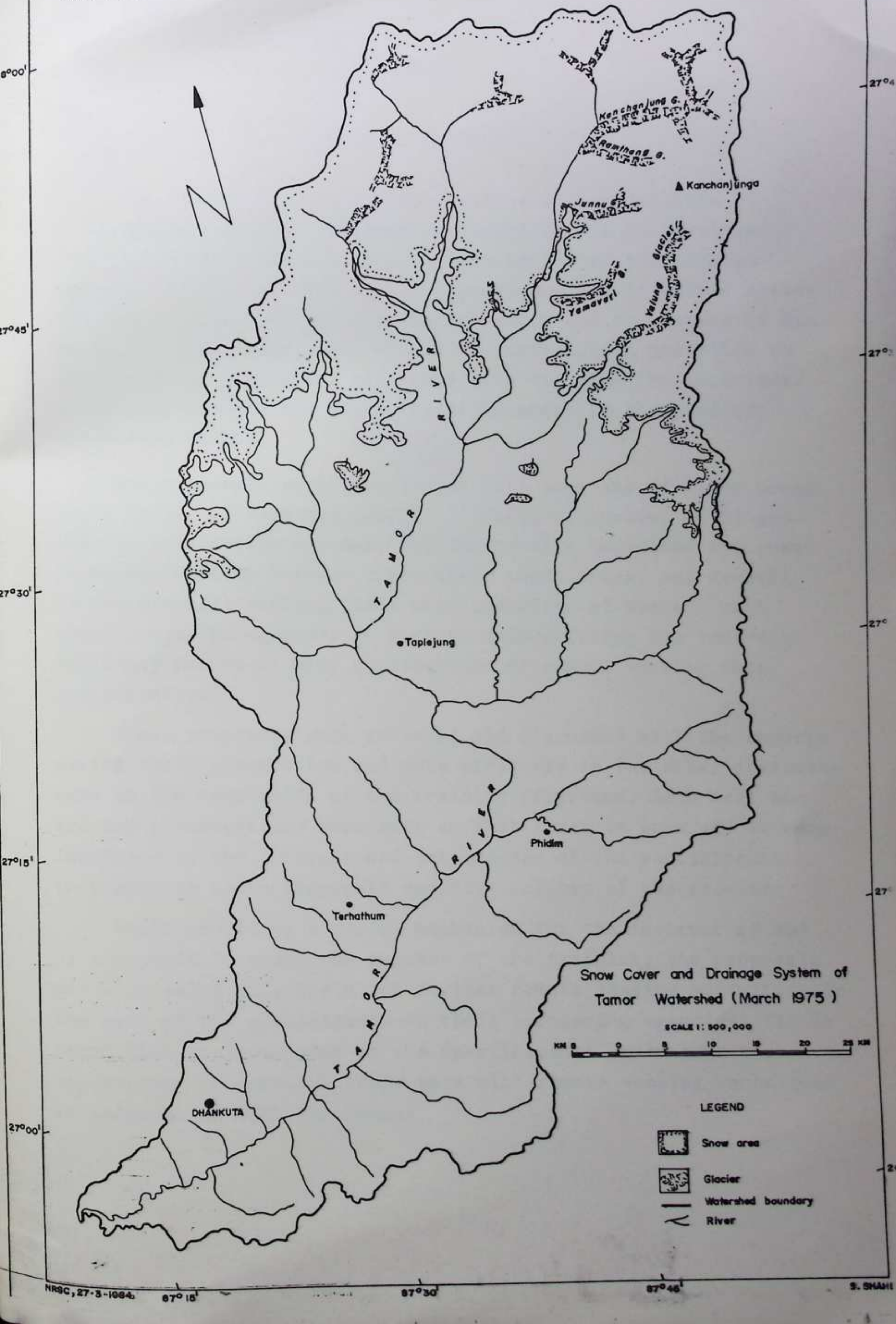
Utilizing the landsat image forming in different time to investigate the areal extent of snow and glacier change. We have got in a good result of applications. The mapping and monitoring of snow and glacier are very important in order to predict run-off from their melting. Remote Sensing provides data in successive days. The require information includes the extent of snow cover, snow land recession, ablation of snow in this watershed. The application of this technology in this descipline is more economical and can be done in short duration.


MAP No 1
87°30'
87°45'
88°00'
88°15'
28°00'
27°45'
27°30'
27°15'
27°00'
Kanchanjunga G.
Ramthang G.
Kanchanjunga
Jannu G.
Yalung Glacier
Yamavari G.
TAMOR RIVER
Taplejung
Phidim
Terhathum
TAMOR
DHANKUTA
Snow Cover and Drainage System of
Tamor Watershed (Nov. 1972)
SCALE 1: 500,000
KM 5 0 5 10 15 20 25 KM
LEGEND
Snow area
Glacier
Watershed boundary
River



MAP No 2
Map no. 3
Kanchanjunga G.
Ramthang G.
Kanchanjunga
Jannu G.
Yamavari G.
Yalung Glacier
Simbung khola
Kabeli khola
Tawa khola
Tamor River
Tapiejung
Kamali khola
Iwa khola
Phidim
Tamor River
Terhathum
Hinwa khola
Tali khola
Dhankuta
Snow Cover and Drainage System of
Tamor Watershed
LEGEND
Snow area
Glacier
Watershed boundary
River

MAP NO 3



Kanchanjung G.
Ramthang G.
Kanchanjunga
Junnu G.
Yamavari G.
Yalung Glacier
TAMOR RIVER
Taplejung
Phidim
Terhathum
DHANKUTA
Snow Cover and Drainage System of Tamor Watershed (March 1975)
SCALE 1: 500,000
KM 5 0 5 10 15 20 25 KM
LEGEND
Snow area
Glacier
Watershed boundary
River
28°00'
27°45'
27°30'
27°15'
27°00'
87°15'
87°30'
87°45'
NRSC, 27-3-1984
S. SHAHI

SUMMARY
OF
TRAINING PROGRAMME

The Project Proposals were prepared by participants of a one-month training programme conducted by the professional staff of Nepal's National Remote Sensing Center and foreign experts. As part of this training programme and to better assess its applicability to the information needs and programmes of His Majesty's Government, each of the 24 participants was asked to contribute to a proposal concerned with applying the techniques which they learned and which was of interest to them and/or sponsoring agency.

The proposals were expected to fall into one of three broad topic areas: 1) land management, 2) water resources, or 3) geographic information systems; but the results indicated the great interrelationship between these three topic areas, and several of the proposal writing teams were comprised of members with very diverse backgrounds -- perhaps demonstrating the interdisciplinary nature of many applications of remote sensing data and techniques.

These proposals were reviewed and discussed with the experts during their preparation and were presented to the other classmembers at the conclusion of the training programme. Both oral and written presentations were made at that time. In general, we were impressed by the interest and seriousness of the participants in preparing these proposals and high caliber of the results.

While providing a useful mechanism for the instructors and participants to guage the success of the training, the proposals may also serve as a basis for further remote sensing activities on the part of the participants on their sponsoring agencies. (It is hoped that at least some of the aparticipants would take the opportunity to continue their work with remote sensing techniques in cooperation with the NRSC.)