MONITORING CONCEPTS

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INTRODUCTION:

Major & medium irrigation sector has been at the core of many of the activities envisaged to provide a sustainable solution for food security and agricultural growth. The created irrigation potential in respect of major and medium projects increased from 9.72 mha in preplan period to 46.24 mha (tentative) including 4.60 MHa anticipated to be created in XI Plan. In the corresponding period the potential utilization has increased from 9.70 mha during pre plan period to 35.10 mha (including 1.36 Mha anticipated during XI plan). Although plan expenditure on irrigation has increased from Rs. 441.8 crore in the Ist Plan to Rs. 100106 crore in the X Plan, the share in total plan expenditure has decreased from 23% in the Ist Plan to 6 % in the X Plan. Time and cost overruns have been a major cause for worry with MMI projects. Overall, the escalation is influenced strongly by local conditions and cost overruns occur due to time overruns and consequent price escalation over time. This indicates that implementation strategies adopted by the individual project authorities need detailed study and specific solutions for prevention of further escalation in the costs. Provision of financial resources in a timely fashion with adequate capacity to manage them by the implementing departments is the need of the hour.

The number of projects likely to be spilled over into the XII Plan works out to 337 including 155 major, 147 medium and 35 ERM projects.

NEED FOR MONITORING:

The major causes for not achieving the targeted potential are identified as: delay in initial start of the projects, frequent changes in scope of the projects, shortage of essential construction materials, inadequate funding, land acquisition, non-transfer of forest land, delay in decision making on contracts, delay in procurement of construction equipment and above all poor coordination amongst various implementation agencies. To keep close watch on project implementation to complete them in a time bound manner and to achieve targets of creation of irrigation potential, need for monitoring was realized. While reviewing the status of irrigation projects during the first and second state irrigation ministers' conference held in 1975 and 1976, the continuous slippage in the completion targets of the projects were noted. Therefore, a need to exercise more control over the implementation of the irrigation projects was felt and a 3 tier system of monitoring of major and medium irrigation projects at project, state and central levels was recommended. At central level, this work was entrusted to Central

Water Commission. Accordingly, CWC started with the monitoring of 25 projects on a selective basis in 1976.

In order to undertake the huge task of monitoring of major and medium projects in the country, project monitoring by CWC was made a plan activity in VIII Plan w.e.f.1995-96.

MONITORING OBJECTIVES:

The main objective of monitoring is to ensure the achievements of set targets of schedule for completion of the irrigation projects, identification of the inputs required, analysis of the reasons for shortfalls, if any, and suggest remedial measures. Briefly, the monitoring covers.

- Ensuring detailed and integrated construction planning of the project task to be accomplished.
- Collection of information regarding progress of execution.
- Comparison of past and anticipated future progress with targets and plans both on physical and financial side.
- Identification of deviations, shortfalls, lagging areas etc. occurred so far and those anticipated, analyzing causes, their effects on targets of the given projects as well as other inter-related projects/activities.
- Initiating corrective actions for overcoming the difficulties and problem areas so as to achieve targets; modifying targets where necessary so as to be realistic.
- Ensuring that corrective action is taken; reviewing its effect, carrying out any modifications in the action which may be needed.
- Building a progress data bank for future use.
- Sending necessary monitoring information to the concerned authorities and inter-related projects.

USEFULNESS OF PROJECT MONITORING BY CWC:

Monitoring has been recognized as a useful management tool for ensuring timely completion of irrigation projects in the country for creation and utilization of desired potential. Monitoring at central level by CWC is effective in achieving physical and financial targets of the monitored projects. This is feasible because of timely identification of bottlenecks, shortfalls impeding the progress and imparting suggestions on various critical issues ranging from construction planning, project staffing, land acquisition problems, contractual problems, rehabilitation and resettlement plans to quality control aspects etc. During the monitoring visits, the issues affecting the progress of works are discussed threadbare with the project authorities and action points are identified. Follow-up action on these points by the concerned agencies is also monitored continuously for speedy implementation.

Realizing the importance of monitoring and its positive impact on monitored projects, Planning Commission had suggested that the major projects should be monitored right from the investment stage up to the operation stage by CWC and Planning Commission. While this is the basis for overall monitoring of projects, the minimum need of the construction monitoring for speedy completion of the projects is being taken care of by the monitoring units set up in CWC. For this purpose, the monitoring units should be strengthened in CWC to cover all irrigation projects which would yield more benefits during the future plan periods. The effective monitoring of all the major ongoing projects by the strengthened monitoring units would be instrumental in timely completion of projects, ensuring creation of targeted irrigation potential and early returns from the projects.

Ministry of Water Resources and its apex technical body, Central Water Commission which are responsible for planned development of the irrigation sector in the country do have with them the first hand information about the status of all the projects and overall picture of the sector.

Monitoring activity covering all ongoing major projects of the country at a time has enabled Ministry of Water Resources/Central Water Commission to have better control to deal with any situation arising in the irrigation sector at any point of time like that of inter-state projects.

The Government of India and Planning Commission are in a better position to appreciate the utilization of huge investments being made on irrigation projects which are costly in nature and consume a big chunk of the national resources.

The water sector as a whole has benefited with large monitoring network at the central level.

Monitoring of "Accelerated Irrigation Benefits Programme(AIBP)" for providing central loan assistance to needy projects as announced in 96-97 has been possible through the network of CWC monitoring units created at state level and closer to the project sites.

4.1 FUNCTIONS OF HQ MONITORING DIRECTORATE OF CWC:

Each Monitoring Directorate is responsible for monitoring of projects in a specified region of the country. The basic functions of each Directorate are as under:

i) Monitoring visits to the projects at regular intervals for on-the-spot study of progress of works. Identification of bottlenecks, shortfalls in progress with suggestions for remedial measures and bringing them to the notice of project managers and State Governments through issue of Status Reports for taking necessary action. The Status Reports are also sent to the Ministry of Water Resources and Planning Commission for information, ii) Critical monitoring of potential targets and utilization during the construction period iii) Monitoring of activities related to rehabilitation and resettlement programme and progress and that of environmental safeguards, iv) Construction programme for total implementation of the projects with network techniques, v) Based on the total implementation programme, annual construction programme of projects is prepared by the project authorities in consultation with the Monitoring Units, vi) Feed-back information on Annual Construction Programme in the form of QPRs which are studied in depth, slippages and reasons for shortfalls identified and remedial measures suggested to accelerate the progress, vii) Data bank on management, information on overall development of water resources in a State through major and medium projects and preparing a Status Report on this aspect for each State once in every year, viii) Review of Annual Plan and Five Year Plan proposals for major and medium sector of the State and participation in Annual Plan discussions in the Ministry of Water Resources and Planning Commission. Also processing of additional plan assistance for projects for expediting progress. Furnishing materials for Working Group Report on five Year Plan of major and medium irrigation after interaction with the State Governments, ix) Furnishing material for Parliament Questions and VIP references etc. to the Ministry of Water Resources in respect of major and medium irrigation projects in the States.

4.2 FUNCTIONS OF FIELD MONITORING DIRECTORATES OF CWC:

Each Monitoring Directorate is responsible for monitoring of projects in a specified region of the country. The basic functions of each Directorate are as under:

i) Monitoring visits to the projects at regular intervals for on-the-spot study of progress of works. Identification of bottlenecks, shortfalls in progress with suggestions for remedial measures and bringing them to the notice of project managers and State Governments through issue of Status Reports for taking necessary action. The Status Reports are also sent to the Ministry of Water Resources and Planning Commission for information, ii) Critical monitoring of potential targets and utilization during the construction period, iii) Monitoring of activities related to rehabilitation and resettlement programme and progress and that of environmental safeguards, iv) Construction programme for total implementation of the projects with network techniques, v) Based on the total implementation programme, actual construction programme of projects is prepared by the project authorities in consultation with the Monitoring Units, vi) Feed-back information on Annual Construction Programme in the form of QPRs which are studied in depth, slippages and reasons for shortfalls identified and remedial measures suggested to accelerate the progress, vii) Feed-back to monitoring unit at HQs about the Status of the projects, irrigation development in the State as a whole for coordination at HQs, viii) Monitoring of AIBP Projects and preparation of AIBP Status Reports, obtaining proposals for Central Assistance from States under AIBP, pursuing submission of monthly and quarterly physical and financial progress of AIBP works.

VARIOUS SCHEMES OF MOWR, GOI for IRRIGATION

ACCELERATED IRRIGATION BENEFIT PROGRAMME (AIBP):

BACKGROUND:

A large number of river valley projects, both multipurpose and irrigation have spilled over from Plan to Plan mainly because of financial constraints being faced by the State Governments. As a result of this, despite a huge investment having already been made on these projects, the country is not able to derive the desired benefits. There were 171 Major, 259 Medium and 72 ERM on-going Irrigation projects in the country at various stages of construction at the end of VIII Plan(i.e. end of March,1997) with spillover cost of Rs. 75690 crore. This was a matter of grave concern for the Union Government and remedial measures for expeditious completion of some of the projects which were in advanced stage of completion became necessary.

The AIBP was conceived in the year 1996 by the Government of India in order to provide financial assistance to States to complete various ongoing projects in the country so that envisaged irrigation potential of the project could be created and thereby extend irrigation to more areas. Since its formulation, the terms of the programme have been widened and liberalized over the time.

Central Government, during 1996-97, launched the Accelerated Irrigation Benefit Programme (AIBP) to provide Central Loan Assistance (CLA) to approve major/medium irrigation projects in the country with the objective to accelerate the implementation of those projects which were beyond resource capability of the States or were in advance stage of completion. Subsequently the programme was also extended to minor surface irrigation projects and ERM Projects satisfying some specified conditions.

The Accelerated Irrigation Benefits Programme (AIBP) extends financial assistance to the States for creation of irrigation potential by completion of identified ongoing irrigation projects. As per the present pattern of assistance under the AIBP, the Centre is providing grant to the irrigation projects as an incentive to the States for creating irrigation infrastructure in the country.

With effect from October'2013, following are terms of funding under AIBP:

1 **Major/Medium and ERM irrigation projects**: The cost at the time of inclusion of any new project in the scheme of AIBP will be frozen for the purpose of working out the quantum of central assistance, with the States being at liberty to fund the project from their own resources after the stipulated date of completion. The stipulated date of completion will be four years starting from the financial year of first release of Central Assistance and excluding year of inclusion. The projects which are not going as per schedule, time extension of maximum two years and escalation of cost by maximum 20% may be allowed based on justifications provided by the State with the approval of Secretary, Ministry of Water Resources. The central assistance (CA) will be in the form of central grant.

2 **<u>MONITORING OF PROJECTS UNDER AIBP:</u> As per latest AIBP guidelines Major/Medium projects** are to be monitored as per following procedure:

2.1 By State Governments:

The quarterly monitoring report on Physical and financial component wise (including CAD component) progress should reach to Chief Engineer (PMO) and Chief Engineer (CE) of the concerned field office of CWC. At the end of each year and on completion of the project, paper print of Satellite imagery clearly indicating the project components should reach to Chief Engineer (PMO), CWC and to concerned regional CWC Chief Engineer's office. Project level and State level Monitoring committee for environment safe guard implementation to be activated immediately for the project under AIBP.

State Governments is to submit a Quality Assurance report certifying that "All mandatory quality checks prescribed for construction material, construction procedure both in number and frequency has been carried out and all the results are within prescribed limits. The quality of works constructed and under construction is of good quality. Payments to contractors have been released based on Quality work. The mandatory inspections required by supervisory staff of all quality control labs is being carried out."

For monitoring of the distribution network related works, a list of all the major structures, outlets to be covered in the year concerned and rail/ road crossings/ utility crossings should be defined as targets and monitored for their achievement.

2.2 At central Level

All major and medium projects where funds have been released in the previous year are to be monitored once in a year by concerned field office of CWC. The CWC (HQ) will monitor inter-state projects.

A checklist for status of outlets after each visit will be required to be attached with the monitoring report. CWC may check at least 10% of the total outlets completed. Targets of monitoring by field offices of CWC will be fixed with the approval of MoWR.

3. The surface Minor irrigation projects are to be monitored as per following procedure:

3.1 Monitoring of the minor irrigation schemes has to be done by the State Government based on Geographic Information System (GIS) maps and each Minor Irrigation Schemes to be given a unique Identification Code (U.I.C) Monitoring will be done through agencies independent of construction agencies.

3.2 These schemes would also be monitored periodically on sample basis (at least 5% of MI Schemes) by the concerned regional Offices of Central Water Commission and will be assessed against predetermined targets set by the Ministry of Water Resources.

3.3 Evaluation will be carried out for completed MI schemes by the State Government through independent agency.

3.4 Monitoring of CAD works will be carried out by monitoring visit of CAD group of MoWR at least once a year wherever CADWM funding is going on.

* The Special Category States covers the North Eastern States, Sikkim, Himachal Pradesh, Jammu & Kashmir, and Uttaranchal. The projects in the undivided Koraput, Bolangir andKalahandi (KBK) districts of Orissa will also be treated at par with Special Category States.

** All other states not covered in special category shall be
Non-Special Category States

NATIONAL PROJECT FOR REPAIR, RENOVATION AND RESTORATION OF WATER BODIES DIRECTLY LINKED TO AGRICULTURE:

BACKGROUND: Union Finance Minister announced in his Budget Speech 2004-05 about launching of a massive scheme to repair, renovate and restore all the water bodies directly linked to agriculture. Under the scheme, it is proposed to restore water bodies throughout India to their original glory which is likely to upgrade the storage capacity significantly. the Ministry of Water Resources had launched a State Sector Scheme for Repair, Renovation & Restoration (RRR) of water bodies with two components (i) one with external assistance and (ii) another with domestic support for implementation during XIth Plan.

To increase the participation of all the States it is felt to frame a new scheme for Repair, Renovation and Restoration (RRR) of Water Bodies during the XII Plan as a State Sector Scheme with domestic budgetary support.

The objectives of the scheme are: (a) to restore and augment storage capacities of water bodies, and (b) to recover and extend their lost irrigation potential. Once the pilot scheme is completed and validated, it will form the basis for launching of the "National Water Resources Development Project" at much larger scale and spread to be completed in 7 to 10 years.

Monitoring and Evaluation:

(i) Regular monitoring of the project is to be carried out at each stage. Monitoring would include maintaining of both physical and financial Progress and the outcome. Monitoring would be done with the association of the Coordination Cell of the State Govt. and standing committee of the Panchayat at the appropriate level.

(ii) The water bodies under RRR would also be monitored periodically on sample basis by Field Office of Central Water Commission.

(iii) Baseline survey would be conducted before the commencement of the project execution. Evaluation and impact assessment of the scheme will be done by independent agencies to be identified by the Ministry of Water Resources. Necessary reports and field visits are to be made on regular basis for the purpose.

(iv) The State Government shall monitor the quality of works as per the relevant BIS codes through the agency independent of the executing agency.

(v) Concurrent evaluation is to be done by the State Government themselves by involving independent agencies which may include IIMs and IITs.

(v) Impact assessment can be done after completion of the scheme from the funds of CWC / MoWR.

COMMAND AREA DEVELOPMENT AND WATER MANAGEMENT PROGRAMME(CADWM)

BACKGROUND: During the post independence era, a large number of irrigation projects were constructed for increasing agricultural production in the country. However, during early seventies analysis of irrigation potential created and utilised revealed that there was a substantial gap between them. The Irrigation Commission made specific recommendations in its report in 1972 that systematic development of commands of irrigation projects should be taken up in order to fully utilise the irrigation potential created. Subsequently a Committee of Ministers set up by the Ministry of Irrigation and Power analysed the issue and suggested in 1973 that a broad based Area Development Authority should be set up for every major irrigation project to undertake the work of comprehensive area development. Based on this recommendation, the Government of India initiated a Centrally Sponsored Command Area Development Programme (CADP) in December 1974 to improve irrigation potential utilisation and optimise agricultural production from irrigated land through integrated and coordinated approach of efficient water management.

Beginning with 60 major and medium irrigation projects in 1974-75, 314 projects (with total CCA of about 28.95 Mha) have so far been included under the Centrally Sponsored Command Area Development Programme. The restructured CADWM programme thus, was being implemented in 144 projects.

Funding Pattern

The following components under CAD&WM Programme may be undertaken by the states:

Sl. No.	Components	Cost sharing between Centre and
a.	Survey Planning and Design	50 : 50
b.	On-Farm-Development (OFD) works	50 : 50
c.	Construction of Field, Intermediate and Link Drains	50 : 50
d.	Correction of system deficiencies	50 : 50
e.	Reclamation of Waterlogged Areas	50 : 50
f.	(i) Functional grant to registered WUAs (ii) Infrastructure grant to registered WUAs	45 : 45 75 : 25
g.	Software components such as demonstrations including on micro-irrigation, training, monitoring & evaluation, adaptive trials	75 : 25
h.	One time Grant to WALMIs/ IMTIs for strengthening of infrastructure (13 Nos.)	75 : 25
i.	CAD&WM Establishment (limited to 10% of b,c,d & e)	50 :

Central assistance will be limited to ceiling of cost norms. Excess expenditure, if any, will be borne by the States.

Monitoring and Evaluation

i. Monitoring of the projects under CAD&WM Programme is primarily the responsibility of the State Governments. However, MoWR and CWC will also monitor through quarterly progress reports, field visits, meetings etc. Remote sensing and GIS techniques can also be employed to monitor the progress on coverage of outlets having Unique Identification Number (UIN) and assess impact of the programme. State Governments are to use online web-based monitoring of CAD&WM Project for sending status of progress.

ii. Concurrent evaluation including quality control aspects by an independent agency must be done by the States.

iii. States to constitute a multidisciplinary Committee including representative of Panchayati Raj Institutions at State level (Wherever CADA Boards exist, the same can discharge the functions of State Level Monitoring Committee) with following indicative Terms of Reference:

a) To decide the annual work programme in such a way that pari- passu implementation takes place in the implementation in an integrated and holistic manner and to advise suitably.

b) To review the progress of program and make suggestions for improving its performance at all levels to achieve the target.

c) To decide upon the evaluation studies to be taken up at the State level.

d) To review and recommend project proposals to be sent to the Ministry of Water Resources for inclusion of project under the scheme.

e) The committee shall include representatives from MoWR, Central Water Commission (CWC), Central Ground Water Board (CGWB), Panchayati Raj Institutions (PRIs) and other members as per composition already circulated.

f) State Level Monitoring Committee (SLMC)/ State Government is to ensure quality control in the execution of the works and a report on the progress of works during preceding financial year to be submitted to MoWR in the Month of July-August of every financial year.

g) The procedure for quality control mechanism should be in place with responsibility on correctness of data & quality of works fixed for the officers at the level of JE/AE/EE/SE/CE. Details of quality control mechanism, frequency of such reports to be submitted to SLMC/State Govt., quality assessment parameters etc. are to be formulated.

NATIONAL PROJECTS

GUIDELINES FOR IMPLEMENTATION OF NATIONAL PROJECTS

Government of India has approved a scheme of National Projects to be implemented during XI Plan with a view to expedite completion of identified National Projects for the benefit of the people. Such projects will be provided financial assistance by the Government of India in the form of Central grant which will be 90% of the estimated cost of such projects for their completion in a time bound manner. Based on the criteria, the Government of India has already identified 14 projects as National Projects

MONITORING OF NATIONAL PROJECTS

(a) The progress of work in respect of National Projects shall be closely monitored by the Central Water Commission/Ministry of Water Resources. The monitoring of National Projects will be field based with GIS based project implementation units linked with management information systems.

(b) The State Government will keep close coordination with agricultural departments for the advanced crop planning and extension inputs to farmers of the command.

(c) Achievement of targets of the potential creation from the project may also be got assessed by the Ministry of Water Resources through independent agencies and other means such as remote sensing technique.

(d) The State Government shall send quarterly physical and financial progress reports in the proforma to the CWC/Ministry of Water Resources.

(e) The State Government shall establish independent quality control organization and adequate number of quality control laboratories in the project areas to maintain quality of works. The sampling and testing will be required to be carried out in accordance with relevant BIS Codes.

REVIEW BY STEERING COMMITTEE

The implementation of National Projects will be reviewed from time to time by the High Powered Steering Committee constituted under chairpersonship of the Secretary (Water Resources).

EVALUATION AND IMPACT ASSESSMENT

A concurrent evaluation of the Project and impact assessment of the project on its completion will be conducted by the State Government through a reputed independent organization to find out whether the envisaged objectives, outcomes and targets of the project have been achieved. The Ministry of Water Resources may also get the evaluation and impact assessment done separately. Funding for the evaluation and impact assessment will be provided by the Ministry of Water Resources through its ongoing Plan scheme “Research & Development Programme for Water Sector”.

6. Role of Satellite Remote Sensing data in Monitoring of Irrigation Projects

Satellite remote sensing is an ideal tool for mapping, inventorying and monitoring purposes. High resolution satellite data provides excellent opportunities to capture the existing irrigation infrastructure and for monitoring the project implementation progress. It supplements the existing monitoring mechanism by providing authentic and objective data base on existing irrigation infrastructure which is spatial in nature with a viable cost. The availability of high resolution satellite data from Cartosat missions has enhanced the scope of infrastructure mapping and monitoring.

High resolution satellite data acquisition can be planned to match the field reporting for effective monitoring of the project. Monitoring visit can be effectively planned and carried out with the help of critical gap areas identified in irrigation infrastructure creation using satellite data and thus minimizing the time required for each visit. Thus, satellite based monitoring addresses both inadequacy in number of monitoring visits and total area monitoring rather than random checks carried out presently.

Conceptualisation and Methodology Development

At the instance of Planning Commission, NRSC, ISRO proposed the concept on “Satellite Technology Applications in Irrigation Infrastructure Mapping” including the scope of monitoring the progress made and potential created through AIBP.

Subsequently, NRSC, ISRO has developed the methodology for assessment of irrigation potential created through inventory and mapping of irrigation infrastructure using high resolution satellite data through a pilot study carried out in two selected irrigation projects (Upper Krishna Project in Karnataka and Teesta Project in West Bengal during 2004-05.

Basic approach (Fig.1) consists of inventory and mapping of existing irrigation infrastructure (such as canal network, irrigation and other related structures) from high resolution satellite data in an on-going irrigation project and comparing the physical progress & status to the design with proposed irrigation infrastructure. Based on the completion status of irrigation infrastructure derived from the satellite data and considering the hydraulic connectivity from source to the outlet, the irrigation potential created in the project is assessed.

The pilot study had captured the ground reality of the irrigation infrastructure and its status in spatial domain. Based on the satellite derived information, percentage progress of AIBP works along with critical gap areaswere identified and an assessment of irrigation potential created in the project was carried out.

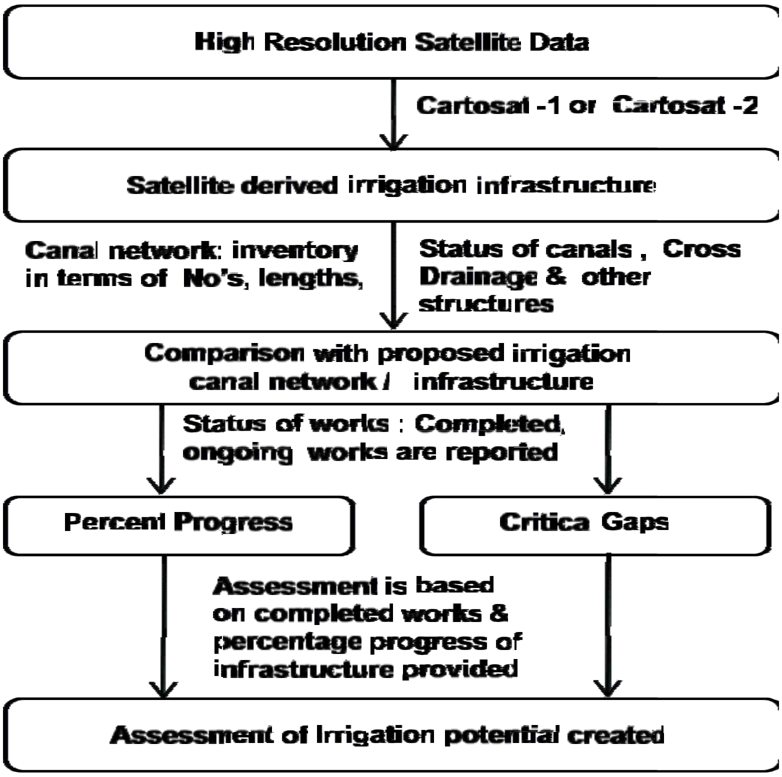


Fig. 1 : Methodology for monitoring satellite based irrigation projects

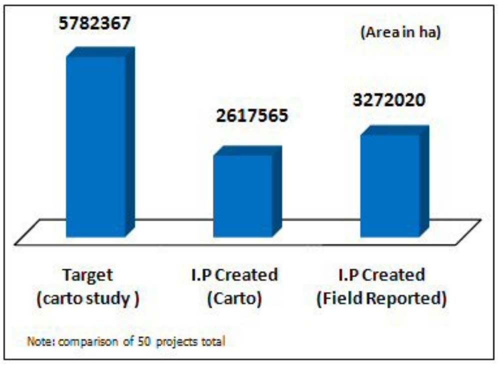
Thus, the satellite data captures the existing irrigation infrastructure and its physical status for time stamping its completion status. It also provides possibility to monitor the entire irrigation project yet with limited field checks overcoming the limitation of physical visits to entire project area.

The encouraging and satisfactory results of the pilot study(in terms of progress sstatus of infrastructure and associated irrigation potential created) were objective in nature and compared well with ground realities which were verified and reported by CWC field offices and State Government departments .

AIBP Phase-I and Phase-II Studies using Cartosat-1 data by NRSC

The availability of Indian Cartosat-1 (2.5 m resolution) data from 2005-06 provided a cost effective solution for upscaling the study. In view of the importance and utility of results arising out of satellite data based pilotstudy, Planning Commission in consultation with NRSC and MoWR decided to upscale the study to national scale covering all AIBP Projects with an estimated irrigation potential of 10 M.ha spread across different States in India in a phased manner.NRSC had carried out the study on "Assessment of Irrigation Potential Createdin 53 AIBP funded Irrigation Projects in India using Cartosat-1 Satellite data" with an I.P target area of 5.45 M.ha spread across 18 States in India during 2007-09.

Satellite data based I.P created was compared with field reported in 50 projects (*Summary Report, February 2010)*. The field reported I.P created is about 25% more than the satellite data based study. Assessment also indicated large deviation (>25%) in field reporting in 15 projects out of 50 projects studied (Fig. 2).



% deviation	No. of projects
No deviation	15
< 10%	15
10 – 25 %	5
25 – 50 %	6
50-100 %	1
> 100%	8

Project	Deviation
Saryu	2.70 L.ha
W.Kosi	1.44 L.ha
Teesta	1.01 L.ha
Sarda	0.54 L.ha
Bansagar	0.25 L.ha
Sindh-II	0.17 L.ha
Dhansiri	0.12 L.ha

Fig.2: Satellite derived study result in Phase-I projects

CWC and MoWR utilized the study result for reconciliation of figures on I.P creation through verifications and clarifications from respective State departments. The spatial irrigation infrastructure information generated in the study is utilized for further monitoring by CWC.

To create awareness among planners, managers, engineers and other stake holders, NRSC has conducted a two day workshop during May 2011 on the use of high resolution Cartosat data for monitoring irrigation infrastructure and potential creation. The workshop recommended for adoption of technology among Central and State Govt. departments after detailed deliberation on conventional monitoring mechanism and results of the operational phase study by NRSC.

To further the capacity building process, NRSC has executed additional 50 irrigation projects across 14 States essentially to transfer technology in the domain of satellite based monitoring of AIBP funded irrigation projects during 2011-12. This study was carried out with 14 Partner Institutions (P.Is) consisting of State Remote Sensing Centres (SRSCs) and academic institutions located across different states.

During this phase, NRSC provided training and guidance to all teams from Partner Institutes and the technology was transferred to CWC by providing intensive on the job training during execution of two projects.

Online monitoring through ISRO-BHUVAN

There are about 148 irrigation projects currently ongoing under AIBP in India. CWC does monitoring of these projects twice a year and needs two time period Cartosat data (pre and post monsoon) in near real time for use by their monitoring offices located across the country.

In this regard, ISRO-BHUVAN platform meant for Earth Observation visualisation provided an excellent opportunity for online monitoring of irrigation projects. It facilitates hosting of satellite data with user access control and provides multiple access facility from various locations.

A team headed by Chief Engineer, Project Monitoring Organisation, CWC had thoroughly evaluated the ISRO-BHUVAN services for online monitoring of AIBP projects and recommended for its implementation. Accordingly, CWC (MoWR) had prepared a road map for implementation of satellite data based online monitoring of AIBP projects through ISRO BHUVAN platform. NRSC has provided on the job training to 30 CWC officers through two training programs during December 2012 and February 2013 for implementation of online monitoring of AIBP projects.

Currently, CWC is monitoring 14 projects across 14 monitoring directorates using the Bhuvan platform. NRSC is providing the necessary help and guidance to CWC.

Conclusion

Satellite based monitoring provides an excellent opportunity to monitor the entire irrigation project yet with limited field checks overcoming the limitation of physical visits to entire project area. ISRO-BHUVAN platform is an excellent facility for online monitoring of AIBP implementation by CWC. The adoption of this new application and using ISRO-BHUVAN platform for online monitoring by CWC and other line departments would go a long way in institutionalization of technology.

PRINCIPLES OF REMOTE SENSING

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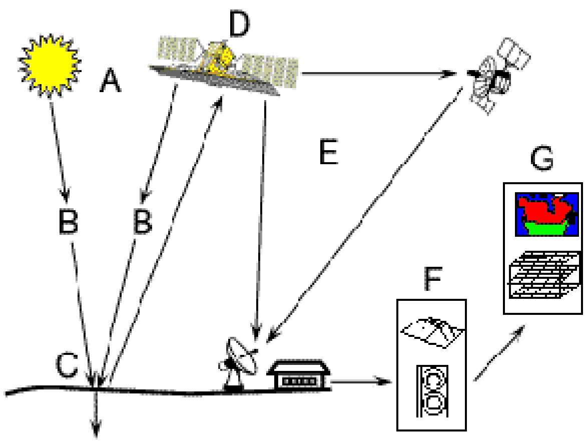
PRINCIPLES OF REMOTE SENSING

"Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information."

Detection and discrimination of objects or surface features means detecting and recording of radiant energy reflected or emitted by objects or surface material (Fig. 1). Different objects return different amount of energy in different bands of the electromagnetic spectrum, incident upon it. This depends on the property of material (structural, chemical, and physical), surface roughness, angle of incidence, intensity, and wavelength of radiant energy. The Remote Sensing is basically a multi-disciplinary science which includes a combination of various disciplines such as optics, spectroscopy, photography, computer, electronics and telecommunication, satellite launching etc. All these technologies are integrated to act as one complete system in itself, known as Remote Sensing System. There are a number of stages in a Remote Sensing process, and each of them is important for successful operation. The process involves an interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging systems where the following seven elements are involved. Note, however that remote sensing also involves the sensing of emitted energy and the use of non-imaging sensors.



1. Energy Source or Illumination (A) - the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.

2. Radiation and the Atmosphere (B) - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

3. Interaction with the Target (C) - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

4. Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

5. Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

6. Interpretation and Analysis (F) - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

7. Application (G) - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

These seven elements comprise the remote sensing process from beginning to end. We will be covering all of these in sequential order throughout the five chapters of this tutorial, building upon the information learned as we go.

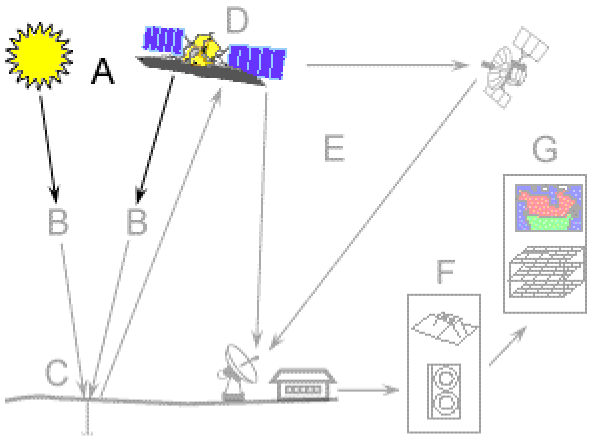
ELECTROMAGNETIC RADIATION

Experiments with electricity and magnetism in the 1800's developed a body of knowledge which led James Clerk Maxwell to predict in 1886 on purely theoretical grounds that it might be possible for electric and magnetic fields to combine, forming self-sustaining waves which could travel great distances. These waves would have many of the behavior characteristics of waves on water (reflection, refraction, defraction, etc.) and would travel at the speed of light.

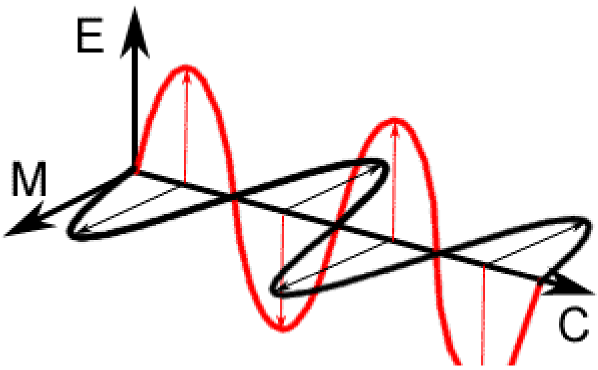
These properties gave rise to the possibility that light was an electromagnetic wave, but at that time, there was no proof that electromagnetic waves really existed. In 1888, Heinrich Hertz built an apparatus to send and receive Maxwell's waves. In this case the waves were around 5 meters long. The apparatus worked and, in addition, proved that the waves could be polarized which turns out to be an important property from a remote sensing point of view. After this, it was learned that light, x-rays, infrared, ultraviolet, radio, microwaves, and gamma rays were all electromagnetic waves. The only property dividing them was their wavelength ranges. The names for these divisions arise from the interaction properties each wavelength range exhibits. (For instance, we see light, radio waves are useful for communication, x-rays pass through objects, etc.)

EMR is a dynamic form of energy that propagates as wave motion at a velocity of $c = 3 \times 10^8$ m/sec. The parameters that characterize a wave motion are wavelength (λ), frequency (f) and velocity (c).

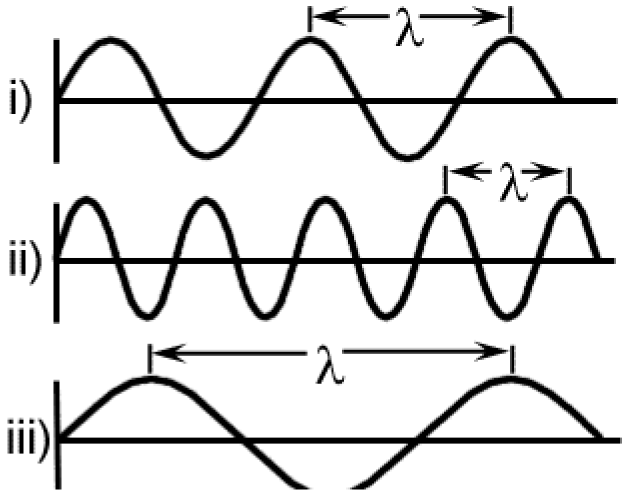
As was noted in the previous section, the first requirement for remote sensing is to have an **energy source to illuminate the target** (unless the sensed energy is being emitted by the target). This energy is in the form of electromagnetic radiation.



All electromagnetic radiation has fundamental properties and behaves in predictable ways according to the basics of wave theory. **Electromagnetic radiation** consists of an electrical field(E) which varies in magnitude in a direction perpendicular to the direction in which the radiation is traveling, and a magnetic field (M) oriented at right angles to the electrical field. Both these fields travel at the speed of light (c).



Two characteristics of electromagnetic radiation are particularly important for understanding remote sensing. These are the **wavelength and frequency.**



The wavelength is the length of one wave cycle, which can be measured as the distance between successive wave crests. Wavelength is usually represented by the Greek letter lambda (&lambda). Wavelength is measured in metres (m) or some factor of metres such as **nanometres** (nm, 10^{-9} metres), **micrometres** (µm, 10^{-6} metres) (µm, 10^{-6} metres) or centimetres (cm, 10^{-2} metres). Frequency refers to the number of cycles of a wave passing a fixed point per unit of time. Frequency is normally measured in **hertz** (Hz), equivalent to one cycle per second, and various multiples of hertz.

Wavelength and frequency are related by the following formula:

$$c=\lambda\nu$$

where:

λ = wavelength (m)
ν= frequency (cycles per second, Hz)
c =speed of light ($3x10^8$ m/s)

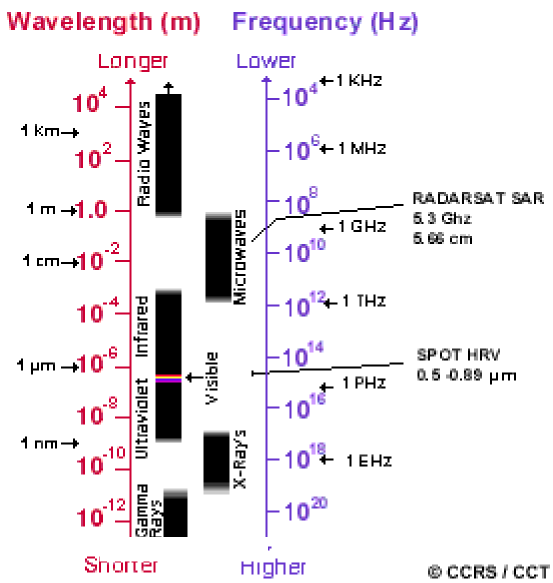
Therefore, the two are inversely related to each other. The shorter the wavelength, the higher the frequency. The longer the wavelength, the lower the frequency. Understanding the characteristics of electromagnetic radiation in terms of their wavelength and frequency is crucial to understanding the information to be extracted from remote sensing data. Next we will be examining the way in which we categorize electromagnetic radiation for just that purpose.

CHARACTERISTICS OF THE ELECTROMAGNETIC SPECTRUM

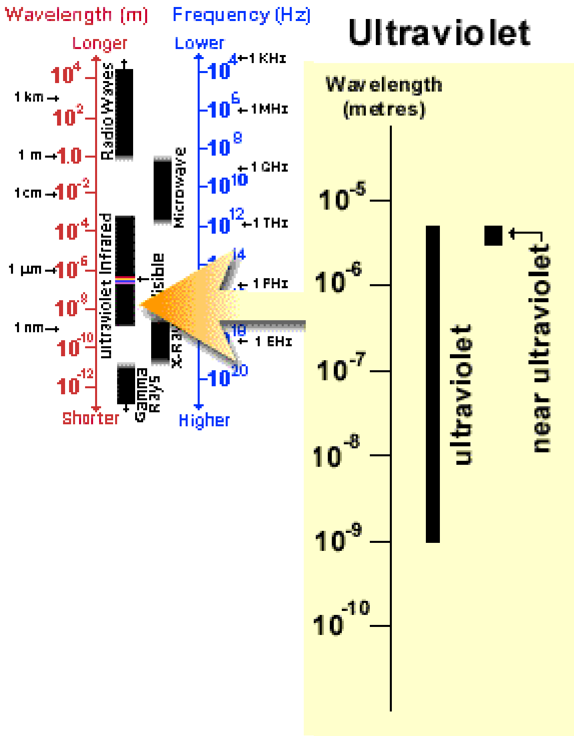
Photon Description. It is useful to think of radiation in terms of photons when considering concepts like detector efficiency, the number of photons required to produce a recognizable signal. Many modern radiation detectors actually count (at ultra high speed) photons as they arrive and send these counts back to earth in digital form. These counts are useful when determining quantities such as signal-to-noise ratios. They are used to answer the question "Is a useful signal even theoretically possible from that object using this system under these circumstances?"

THE ELECTROMAGNETIC SPECTRUM

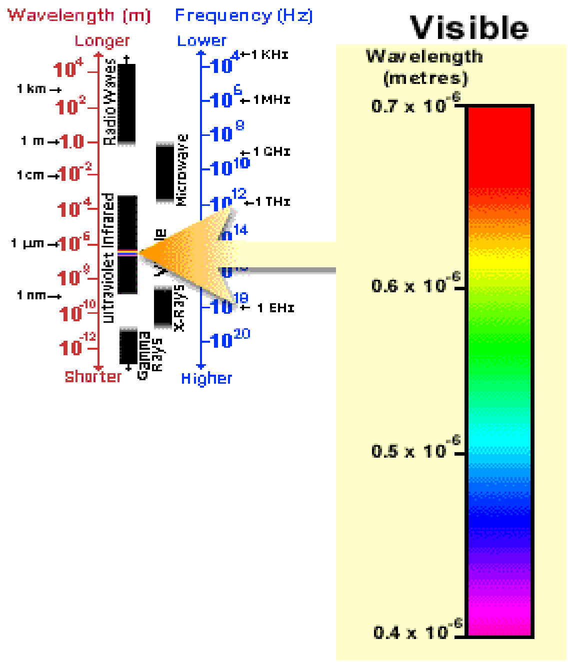
The **electromagnetic spectrum** ranges from the shorter wavelengths (including gamma and x-rays) to the longer wavelengths (including microwaves and broadcast radio waves). There are several regions of the electromagnetic spectrum which are useful for remote sensing.

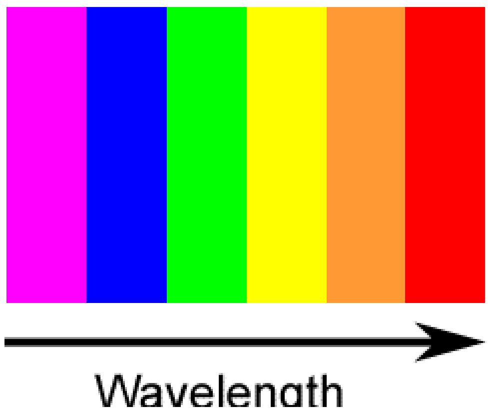


For most purposes, the **ultraviolet or UV** portion of the spectrum has the shortest wavelengths which are practical for remote sensing. This radiation is just beyond the violet portion of the visible wavelengths, hence its name. Some Earth surface materials, primarily rocks and minerals, fluoresce or emit visible light when illuminated by UV radiation.



The light which our eyes - our "remote sensors" - can detect is part of the **visible spectrum**. It is important to recognize how small the visible portion is relative to the rest of the spectrum. There is a lot of radiation around us which is "invisible" to our eyes, but can be detected by other remote sensing instruments and used to our advantage. The visible wavelengths cover a range from approximately 0.4 to 0.7 µm. The longest visible wavelength is red and the shortest is violet. Common wavelengths of what we perceive as particular colours from the visible portion of the spectrum are listed below. It is important to note that this is the only portion of the spectrum we can associate with the concept of **colours**.





Violet: 0.4 - 0.446 µm

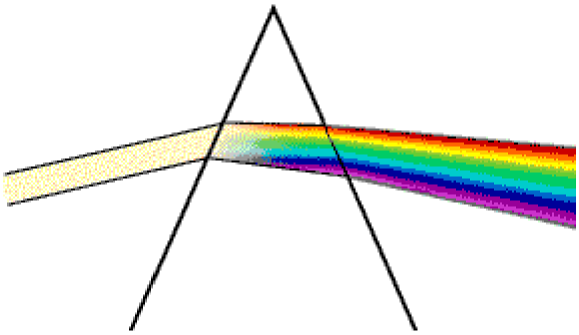
Blue: 0.446 - 0.500 µm

Green: 0.500 - 0.578 µm

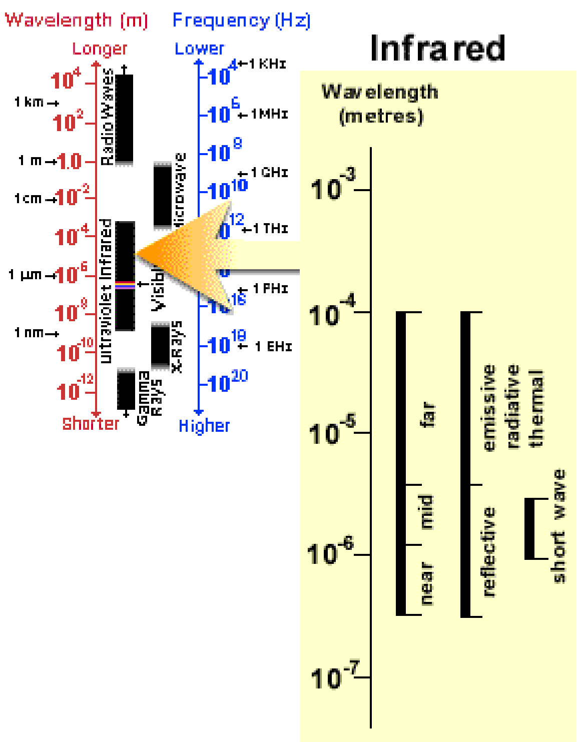
Yellow: 0.578 - 0.592 µm

Orange: 0.592 - 0.620 µm

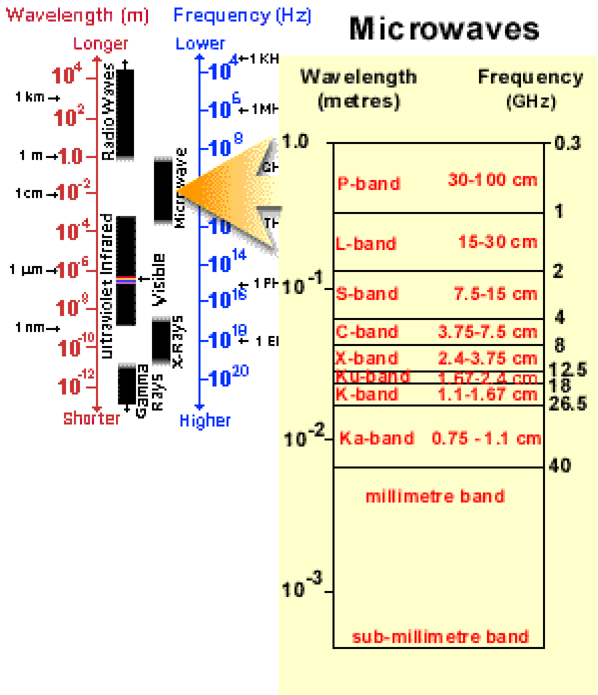
Red: 0.620 - 0.7 µm



Blue, **green**, and **red** are the **primary colours** or wavelengths of the visible spectrum. They are defined as such because no single primary colour can be created from the other two, but all other colours can be formed by combining blue, green, and red in various proportions. Although we see sunlight as a uniform or homogeneous colour, it is actually composed of various wavelengths of radiation in primarily the ultraviolet, visible and infrared portions of the spectrum. The visible portion of this radiation can be shown in its component colours when sunlight is passed through a **prism**, which bends the light in differing amounts according to wavelength.



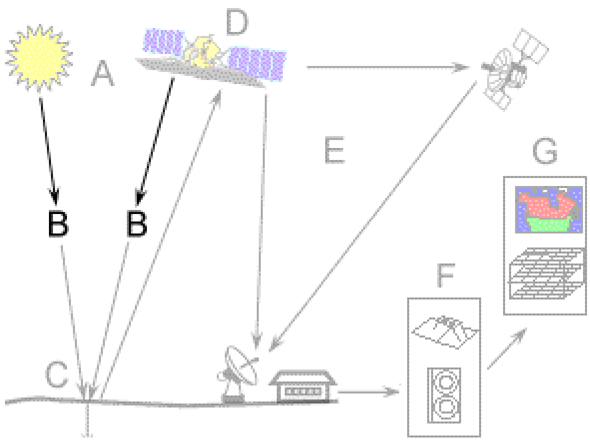
The next portion of the spectrum of interest is the infrared (IR) region which covers the wavelength range from approximately 0.7 µm to 100 µm - more than 100 times as wide as the visible portion! The infrared region can be divided into two categories based on their radiation properties - the **reflected IR**, and the emitted or **thermal IR**. Radiation in the reflected IR region is used for remote sensing purposes in ways very similar to radiation in the visible portion. The reflected IR covers wavelengths from approximately 0.7 μm to 3.0 μm. The thermal IR region is quite different than the visible and reflected IR portions, as this energy is essentially the radiation that is emitted from the Earth's surface in the form of heat. The thermal IR covers wavelengths from approximately 3.0 μm to 100 μm.



The portion of the spectrum of more recent interest to remote sensing is the **microwave region** from about 1 mm to 1 m. This covers the longest wavelengths used for remote sensing. The shorter wavelengths have properties similar to the thermal infrared region while the longer wavelengths approach the wavelengths used for radio broadcasts. Because of the special nature of this region and its importance to remote sensing in Canada, an entire chapter (Chapter 3) of the tutorial is dedicated to microwave sensing.

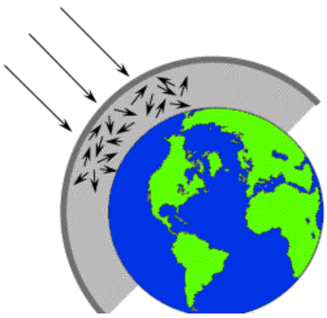
INTERACTIONS WITH THE ATMOSPHERE

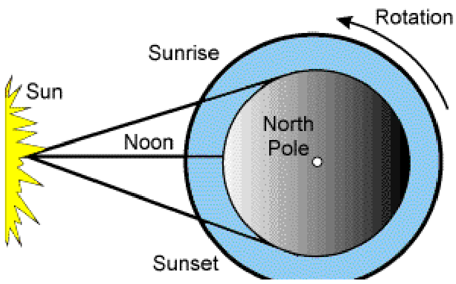
Before radiation used for remote sensing reaches the Earth's surface it has to travel through some distance of the Earth's atmosphere. Particles and gases in the atmosphere can affect the incoming light and radiation. These effects are caused by the mechanisms of **scattering** and **absorption**.



SCATTERING

This occurs when particles or large gas molecules present in the atmosphere interact with and cause the electromagnetic radiation to be redirected from its original path. How much scattering takes place depends on several factors including the wavelength of the radiation, the abundance of particles or gases, and the distance the radiation travels through the atmosphere. There are three (3) types of scattering which take place.

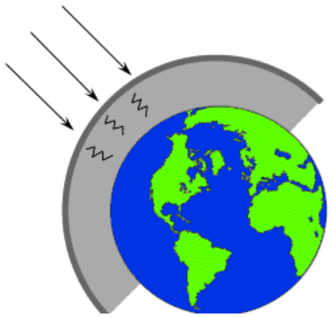




Rayleigh scattering occurs when particles are very small compared to the wavelength of the radiation. These could be particles such as small specks of dust or nitrogen and oxygen molecules. Rayleigh scattering causes shorter wavelengths of energy to be scattered much more than longer wavelengths. Rayleigh scattering is the dominant scattering mechanism in the upper atmosphere. The fact that the sky appears "blue" during the day is because of this phenomenon. As sunlight passes through the atmosphere, the shorter wavelengths (i.e. blue) of the visible spectrum are scattered more than the other (longer) visible wavelengths. At **sunrise and sunset** the light has to travel farther through the atmosphere than at midday and the scattering of the shorter wavelengths is more complete; this leaves a greater proportion of the longer wavelengths to penetrate the atmosphere.

Mie scattering occurs when the particles are just about the same size as the wavelength of the radiation. Dust, pollen, smoke and water vapour are common causes of Mie scattering which tends to affect longer wavelengths than those affected by Rayleigh scattering. Mie scattering occurs mostly in the lower portions of the atmosphere where larger particles are more abundant, and dominates when cloud conditions are overcast.

The final scattering mechanism of importance is called **nonselective scattering**. This occurs when the particles are much larger than the wavelength of the radiation. Water droplets and large dust particles can cause this type of scattering. Nonselective scattering gets its name from the fact that all wavelengths are scattered about equally. This type of scattering causes fog and clouds to appear white to our eyes because blue, green, and red light are all scattered in approximately equal quantities (blue+green+red light = white light).

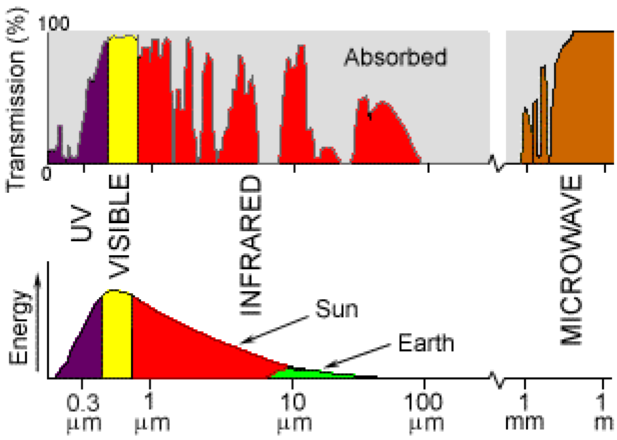


Absorption is the other main mechanism at work when electromagnetic radiation interacts with the atmosphere. In contrast to scattering, this phenomenon causes molecules in the atmosphere to absorb energy at various wavelengths.

Ozone, carbon dioxide, and water vapour are the three main atmospheric constituents which absorb radiation.

Ozone serves to absorb the harmful (to most living things) ultraviolet radiation from the sun. Without this protective layer in the atmosphere our skin would burn when exposed to sunlight.

You may have heard **carbon dioxide** referred to as a greenhouse gas. This is because it tends to absorb radiation strongly in the far infrared portion of the spectrum - that area associated with thermal heating - which serves to trap this heat inside the atmosphere. Water vapour in the atmosphere absorbs much of the incoming longwave infrared and shortwave microwave radiation (between 22µm and 1m). The presence of water vapour in the lower atmosphere varies greatly from location to location and at different times of the year. For example, the air mass above a desert would have very little water vapour to absorb energy, while the tropics would have high concentrations of water vapour (i.e. high humidity).

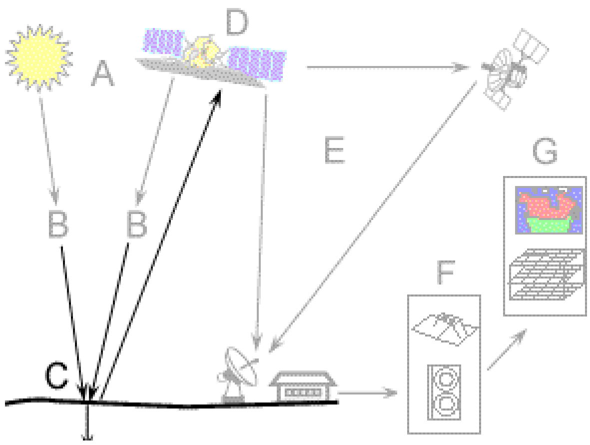


Wavelength

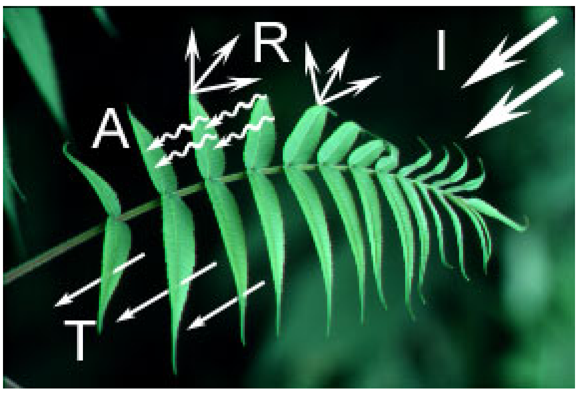
Because these gases absorb electromagnetic energy in very specific regions of the spectrum, they influence where (in the spectrum) we can "look" for remote sensing purposes. Those areas of the spectrum which are not severely influenced by atmospheric absorption and thus, are useful to remote sensors, are called **atmospheric windows**. By comparing the characteristics of the two most common energy/radiation sources (the sun and the earth) with the atmospheric windows available to us, we can define those wavelengths that we can use **most effectively** for remote sensing. The visible portion of the spectrum, to which our eyes are most sensitive, corresponds to both an atmospheric window and the peak energy level of the sun. Note also that heat energy emitted by the Earth corresponds to a window around 10 µm in the thermal IR portion of the spectrum, while the large window at wavelengths beyond 1 mm is associated with the microwave region.

Now that we understand how electromagnetic energy makes its journey from its source to the surface (and it is a difficult journey, as you can see) we will next examine what happens to that radiation when it does arrive at the Earth's surface.

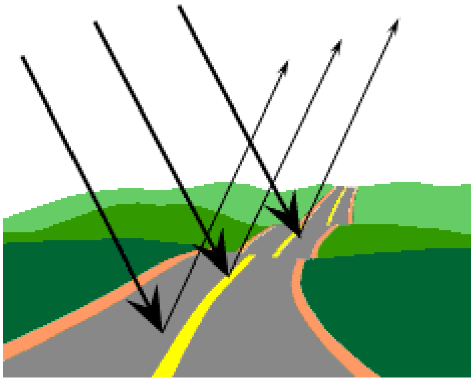
RADIATION - TARGET INTERACTIONS



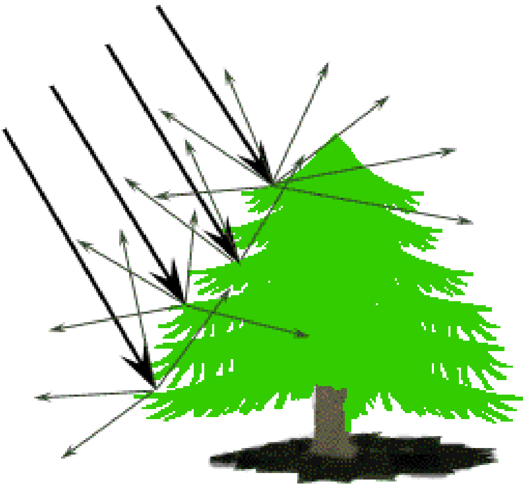
Radiation that is not absorbed or scattered in the atmosphere can reach and interact with the Earth's surface. There are three (3) forms of interaction that can take place when energy strikes, or is **incident (I)** upon the surface. These are: **absorption (A)**; **transmission (T)**; and **reflection (R)**. The total incident energy will interact with the surface in one or more of these three ways. The proportions of each will depend on the wavelength of the energy and the material and condition of the feature.



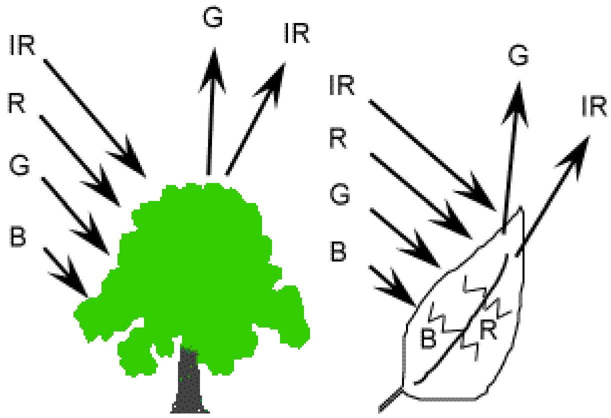
Absorption (A) occurs when radiation (energy) is absorbed into the target while transmission (T) occurs when radiation passes through a target. Reflection (R) occurs when radiation "bounces" off the target and is redirected. In remote sensing, we are most interested in measuring the radiation reflected from targets. We refer to two types of reflection, which represent the two extreme ends of the way in which energy is reflected from a target: **specular reflection** and **diffuse reflection**.



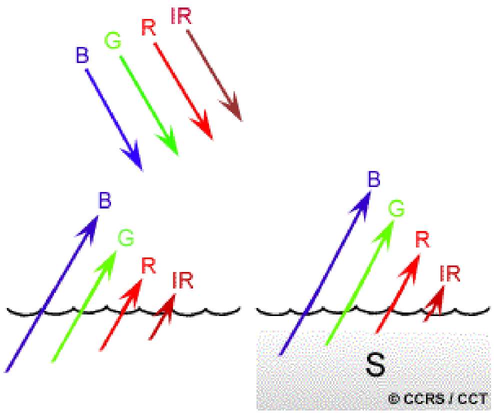
When a surface is smooth we get **specular** or mirror-like reflection where all (or almost all) of the energy is directed away from the surface in a single direction. **Diffuse** reflection occurs when the surface is rough and the energy is reflected almost uniformly in all directions. Most earth surface features lie somewhere between perfectly specular or perfectly diffuse reflectors. Whether a particular target reflects specularly or diffusely, or somewhere in between, depends on the surface roughness of the feature in comparison to the wavelength of the incoming radiation. If the wavelengths are much smaller than the surface variations or the particle sizes that make up the surface, diffuse reflection will dominate. For example, fine-grained sand would appear fairly smooth to long wavelength microwaves but would appear quite rough to the visible wavelengths.



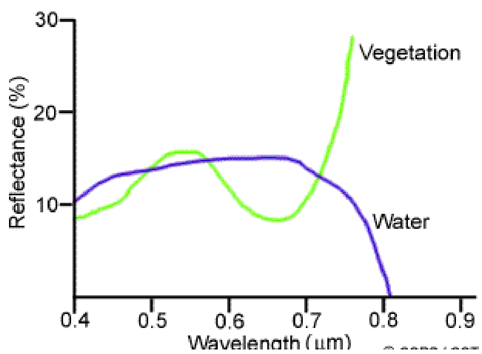
Let's take a look at a couple of examples of targets at the Earth's surface and how energy at the visible and infrared wavelengths interacts with them.



Leaves: A chemical compound in leaves called chlorophyll strongly absorbs radiation in the red and blue wavelengths but reflects green wavelengths. Leaves appear "greenest" to us in the summer, when chlorophyll content is at its maximum. In autumn, there is less chlorophyll in the leaves, so there is less absorption and proportionately more reflection of the red wavelengths, making the leaves appear red or yellow (yellow is a combination of red and green wavelengths). The internal structure of healthy leaves act as excellent diffuse reflectors of near-infrared wavelengths. If our eyes were sensitive to near-infrared, trees would appear extremely bright to us at these wavelengths. In fact, measuring and monitoring the near-IR reflectance is one way that scientists can determine how healthy (or unhealthy) vegetation may be.

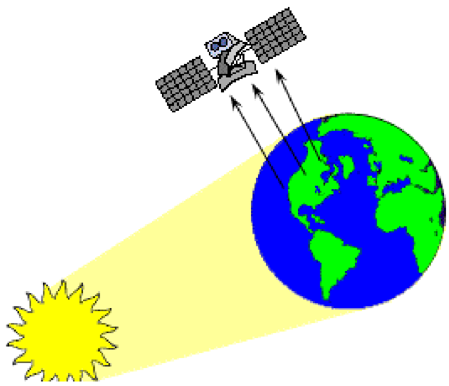


Water: Longer wavelength visible and near infrared radiation is absorbed more by water than shorter visible wavelengths. Thus water typically looks blue or blue-green due to stronger reflectance at these shorter wavelengths, and darker if viewed at red or near infrared wavelengths. If there is suspended sediment present in the upper layers of the water body, then this will allow better reflectivity and a brighter appearance of the water. The apparent colour of the water will show a slight shift to longer wavelengths. Suspended sediment (S) can be easily confused with shallow (but clear) water, since these two phenomena appear very similar. Chlorophyll in algae absorbs more of the blue wavelengths and reflects the green, making the water appear more green in colour when algae is present. The topography of the water surface (rough, smooth, floating materials, etc.) can also lead to complications for water-related interpretation due to potential problems of specular reflection and other influences on colour and brightness.

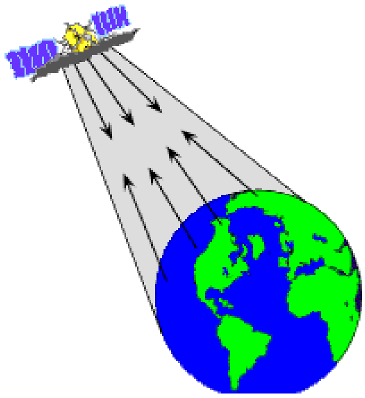


We can see from these examples that, depending on the complex make-up of the target that is being looked at, and the wavelengths of radiation involved, we can observe very different responses to the mechanisms of absorption, transmission, and reflection. By measuring the energy that is reflected (or emitted) by targets on the Earth's surface over a variety of different wavelengths, we can build up a **spectral response** for that object. By comparing the response patterns of different features we may be able to distinguish between them, where we might not be able to, if we only compared them at one wavelength. For example, water and vegetation may reflect somewhat similarly in the visible wavelengths but are almost always separable in the infrared. Spectral response can be quite variable, even for the same target type, and can also vary with time (e.g. "green-ness" of leaves) and location. Knowing where to "look" spectrally and understanding the factors which influence the spectral response of the features of interest are critical to correctly interpreting the interaction of electromagnetic radiation with the surface.

PASSIVE VS. ACTIVE SENSING



So far, throughout this chapter, we have made various references to the sun as a source of energy or radiation. The sun provides a very convenient source of energy for remote sensing. The sun's energy is either **reflected**, as it is for visible wavelengths, or absorbed and then **re-emitted**, as it is for thermal infrared wavelengths. Remote sensing systems which measure energy that is naturally available are called **passive sensors**. Passive sensors can only be used to detect energy when the naturally occurring energy is available. For all reflected energy, this can only take place during the time when the sun is illuminating the Earth. There is no reflected energy available from the sun at night. Energy that is naturally emitted (such as thermal infrared) can be detected day or night, as long as the amount of energy is large enough to be recorded.

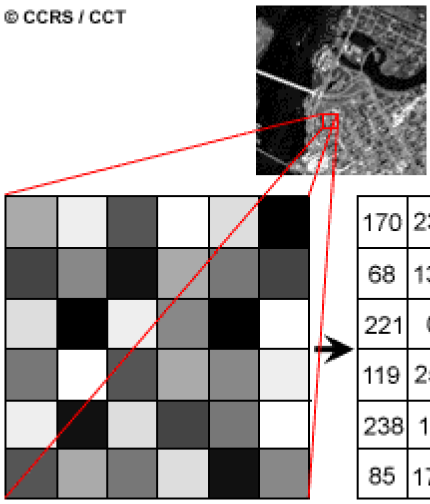


Active sensors, on the other hand, provide their own energy source for illumination. The sensor emits radiation which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor. Advantages for active sensors include the ability to obtain measurements anytime, regardless of the time of day or season. Active sensors can be used for examining wavelengths that are not sufficiently provided by the sun, such as microwaves, or to better control the way a target is illuminated. However, active systems require the generation of a fairly large amount of energy to adequately illuminate targets. Some examples of active sensors are a laser fluorosensor and synthetic aperture radar (SAR).

CHARACTERISTICS OF IMAGES

Before we go on to the next chapter, which looks in more detail at sensors and their characteristics, we need to define and understand a few fundamental terms and concepts associated with remote sensing images.

Electromagnetic energy may be detected either photographically or electronically. The photographic process uses chemical reactions on the surface of light-sensitive film to detect and record energy variations. It is important to distinguish between the terms **images** and **photographs** in remote sensing. An image refers to any pictorial representation, regardless of what wavelengths or remote sensing device has been used to detect and record the electromagnetic energy. A **photograph** refers specifically to images that have been detected as well as recorded on photographic film. The black and white photo to the left, of part of the city of Ottawa, Canada was taken in the visible part of the spectrum. Photos are normally recorded over the wavelength range from 0.3 µm to 0.9 µm - the visible and reflected infrared. Based on these definitions, we can say that all photographs are images, but not all images are photographs. Therefore, unless we are talking specifically about an image recorded photographically, we use the term image.



170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

A photograph could also be represented and displayed in a **digital** format by subdividing the image into small equal-sized and shaped areas, called picture elements or **pixels**, and representing the brightness of each area with a numeric value or **digital number**. Indeed, that is exactly what has been done to the photo to the left. In fact, using the definitions we have just discussed, this is actually a **digital image** of the original photograph! The photograph was scanned and subdivided into pixels with each pixel assigned a digital number representing its relative brightness. The computer displays each digital value as different brightness levels. Sensors that record electromagnetic energy, electronically record the energy as an array of numbers in digital format right from the start. These two different ways of representing and displaying remote sensing data, either pictorially or digitally, are interchangeable as they convey the same information (although some detail may be lost when converting back and forth).

In previous sections we described the visible portion of the spectrum and the concept of colours. We see colour because our eyes detect the entire visible range of wavelengths and our brains process the information into separate colours. Can you imagine what the world would look like if we could only see very narrow ranges of wavelengths or colours? That is how many sensors work. The information from a narrow wavelength range is gathered and stored in a **channel**, also sometimes referred to as a **band**. We can combine and display channels of information digitally using the three primary colours (blue, green, and red). The data from each channel is represented as one of the primary colours and, depending on the relative brightness (i.e. the digital value) of each pixel in each channel, the primary colours combine in different proportions to represent different colours.

When we use this method to display a single channel or range of wavelengths, we are actually displaying that channel through all three primary colours. Because the brightness level of each pixel is the same for each primary colour, they combine to form a **black and white image**, showing various shades of gray from black to white. When we display more than one channel each as a different primary colour, then the brightness levels may be different for each channel/primary colour combination and they will combine to form a **colour image**.

IMAGE PROCESSING OF CARTOSAT SATELLITE DATA

Dr R N Sankhua
Director,
NWA, CWC, Pune

1. Open ERDAS IMAGINE from your desktop by going to **Start --> Programs --> ERDAS IMAGINE.** When ERDAS opens, a Menu Bar running across the top of the screen and a Viewer window below the Menu Bar appear. All available functions for ERDAS can be activated from the Menu Bar; however, not all functions can be activated from the Viewer.

2. In the Viewer window go to **File --> Open --> Raster Layer.**..and find the **PM_NWA** folder. Open the "project.img" file from the folder. Make sure that the file type is ".img".

3. On the toolbar inside the Viewer window, click on the Zoom In button . Zoom in on the image a few times. Click on the image with the right mouse button and choose "**Fit Image to Window**" from the menu that appears. This command is analogous to the "Zoom to Theme Extent or Full Extent" buttons in Q-GIS. This part of the exercise is to illustrate the point that ******Clicking on the right mouse button*** gives you access to many of the functions QGIS. The separate lecture of Q-GIS has been provided to you for details. So.....if you cannot find a function in the menu or on the tool bar, try clicking once on the right mouse button.

Also, note that as you move the mouse over the icons of the view window you are told what each icon will do in the lower left of the View Window. Your Viewer window should look like **Figure 3**.

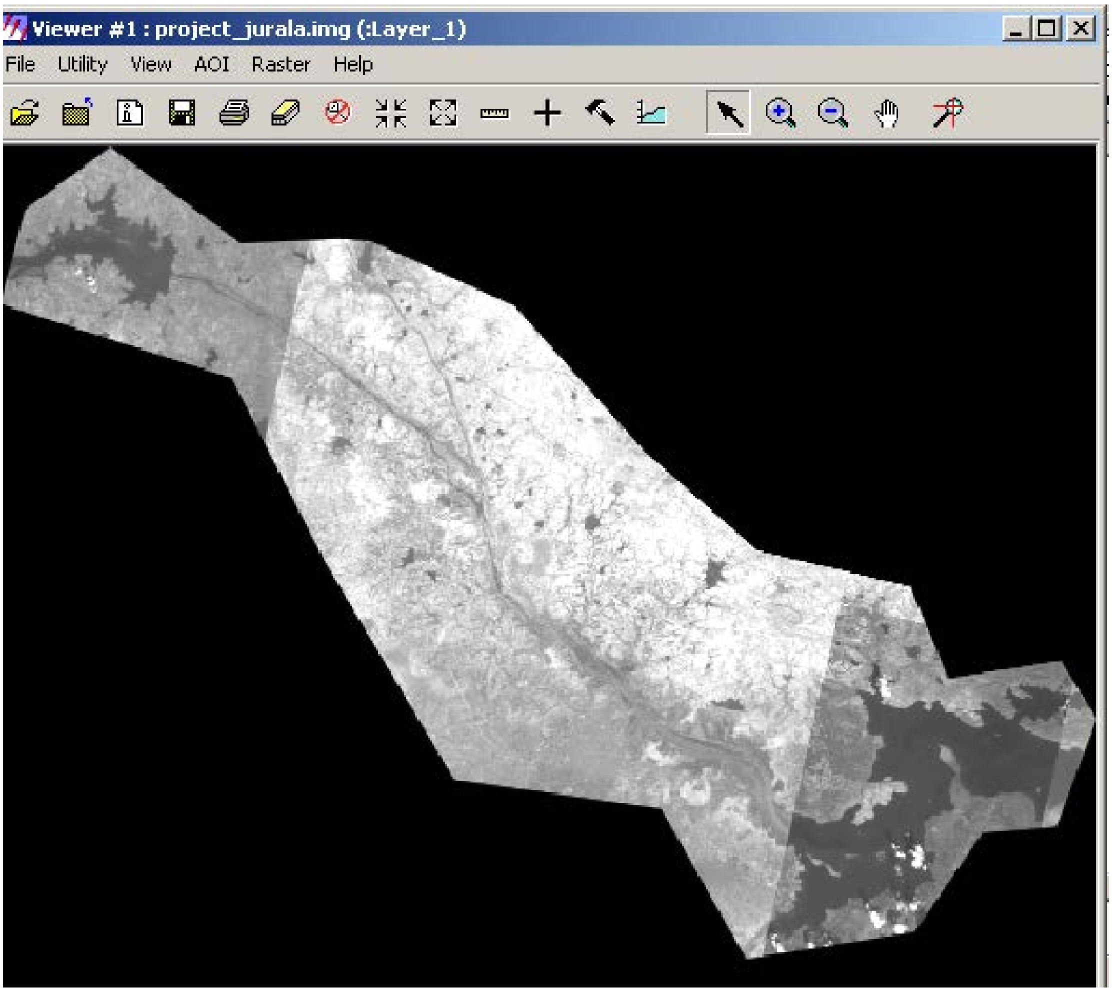
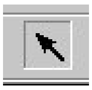
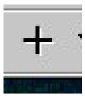


Figure 3 Display of CARTOSAT PAN image

4. Change back to the arrow button  and click on  . The following menu will appear and white cross-hairs will appear on the image. (**Figure 4**)

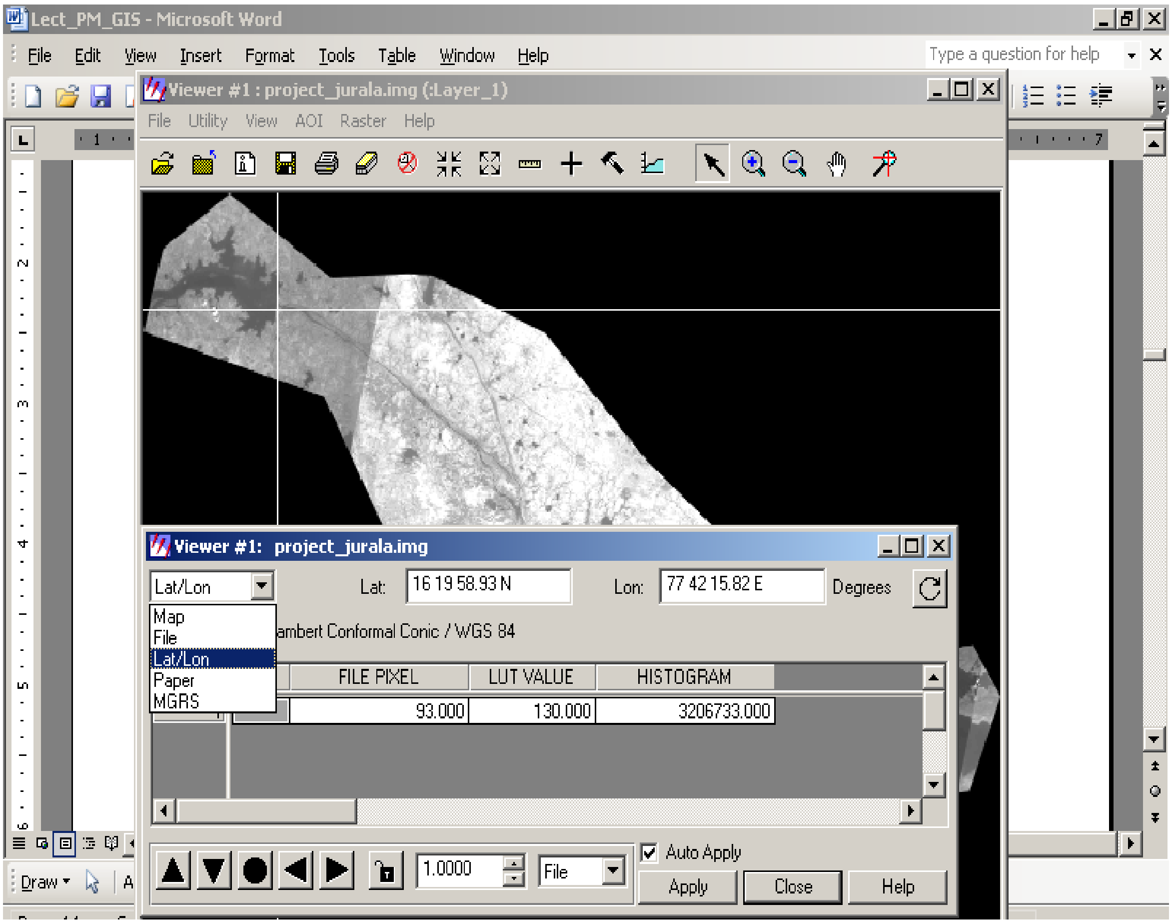


Figure 4 Displaying lat-long, point information

Use your pointer to move the cross-hairs by clicking once in the intersection of the two lines and dragging the center of the cross around. As you do this, notice that the X and Y values in the table change. Zoom in on the image a few times so that you can see each individual pixel.

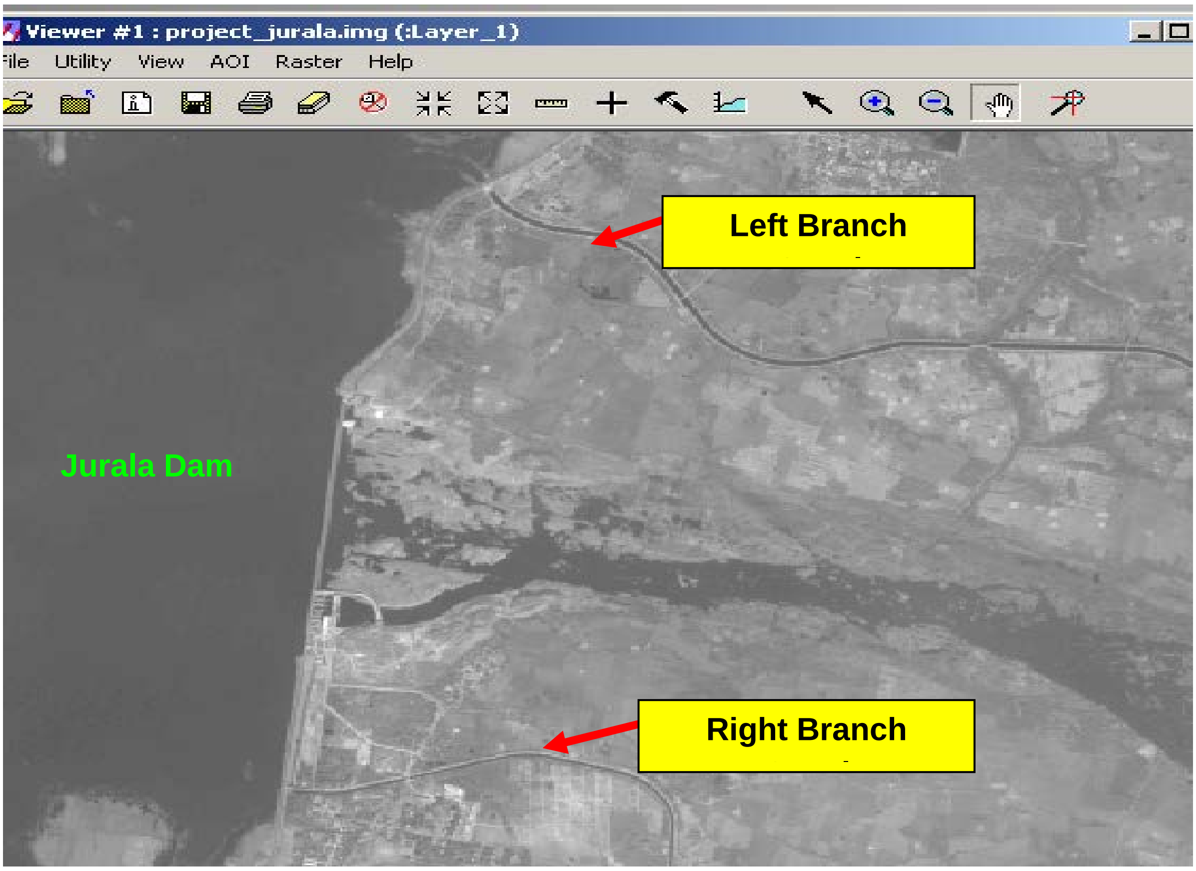


Figure 5 Zoomed view of Jurala Dam and LBC/RBC

Move the cross-hairs again, but this time stay within one pixel. Notice that the X and Y values in the table still change, but that the values in the File Pixel and LUT (Look Up Table) Value columns do not change. The columns assign to each pixel a value from 0 to 255 (DN value). The File Pixel columns are the actual pixel values of your data. The LUT Value column assigns a number to each pixel based on a combination of red, green, and blue used to make the colors on your screen.

5. Changing Band Combinations. Zoom back out to fit the image to the window and close the table that is now open to get rid of the cross-hairs. From the **Viewer menu** choose **Raster -->** Bands Combinations and a table will appear: As this is PAN data **only 1 band** will appear. Notice that the reservoir area looks bit dark gray and other areas now appear light gray. You can play around with this band combination to give the image some really funky colors, but this feature is also useful. For example, by knowing that soils shows up really well with a certain band combination you can use this combination to see them more clearly than you would with another combination of bands. In case of forests, it might show up more clearly in a different band combination than soils. Also you can see layer info from UTILITY> Layer info. (**Figure 6**)

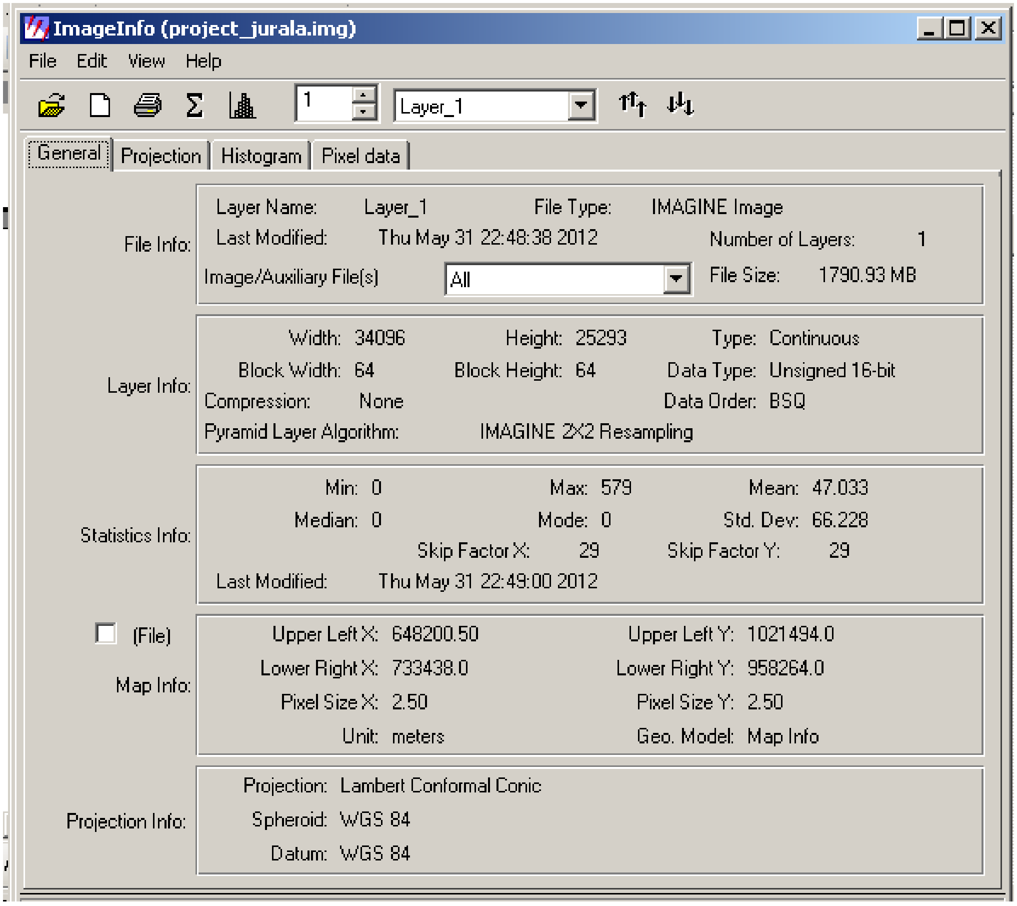


Figure 6 Layer information

6. The purpose of the next part of the exercise is for you to see how ERDAS can help you see that different features (i.e. water, urban areas, forested areas, etc.) reflect different wavelengths. Now click on the graph button in the toolbar  and a menu with appear:

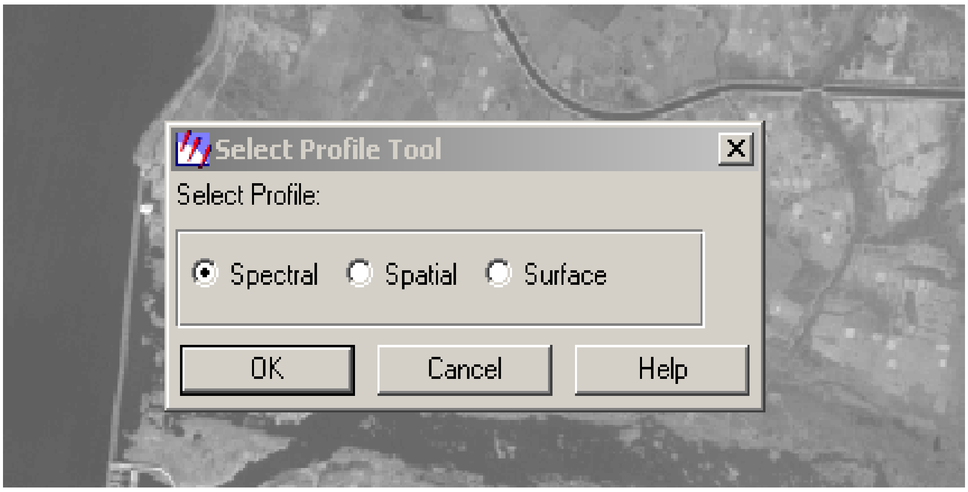
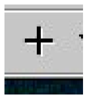
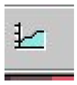


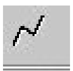
Figure 7 Profile tool

Choose Spectral from this menu and hit OK. A new screen will appear:

Click on the cross button on this NEW Spectral Profile menu  and then click somewhere in the water on the image.

A line will appear on your graph that describes the spectral profile at given point. Now choose a point over an urban area and see that you will get a different spectral profile on your graph.

8. This part of the exercise shows you how ERDAS can help you visualize how different wavelength reflect along a transect of the land surface. Close the Spectral Profile window to get rid of your profile points. Click again on the graph button in the toolbar  in the Viewer window, but this time choose Spatial and hit OK. A similar looking window as for the Spectral Profile will appear; however, notice the axes are different.

Click on the line button . On the image, click once with the left mouse button to start drawing a straight line. Each time you want to change the direction of the line click on the left mouse button.

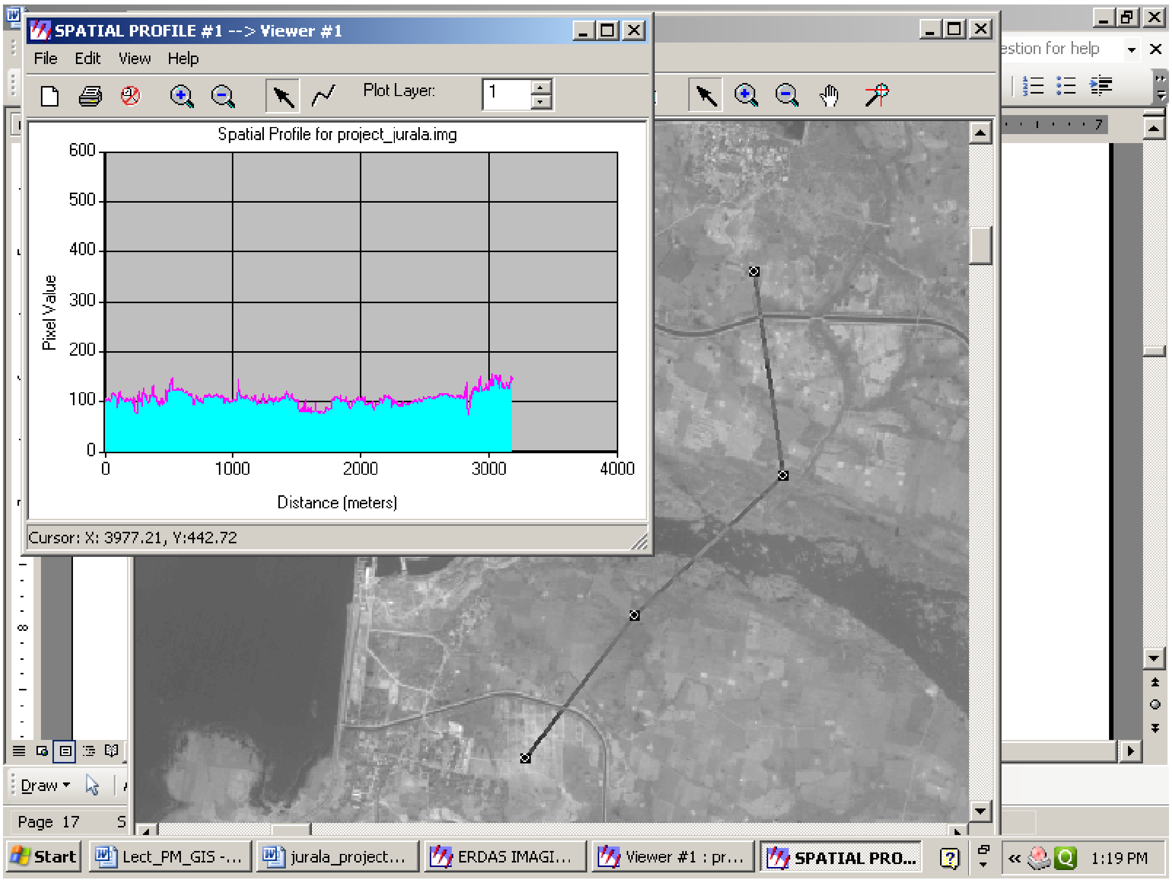
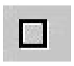


Figure 8 Spatial profile

To stop drawing the line and to display the results on your graph, double click with the left mouse button.

9. The next exercise will use the Spectral Profile Surface, which is similar to the Spatial Profile, except that it is in 3D. Close the Spatial Profile table and click again on the graph button in the Viewer toolbar. Choose surface and hit OK. You guessed it.....another graph will appear:

Click on the square button in the graph window  and choose and area of interest (AOI - get use to this term) on the image. To do this, click once on the image with the left mouse button and a little x will appear . Click and hold with the left mouse button on this x and drag the resulting rectangle to the areal extent you desire. Release the mouse button and a graph will appear.

Now change the "PLOT LAYER" value in the Surface Profile window to display the surface of each of the bands of reflectence within the profile AOI.

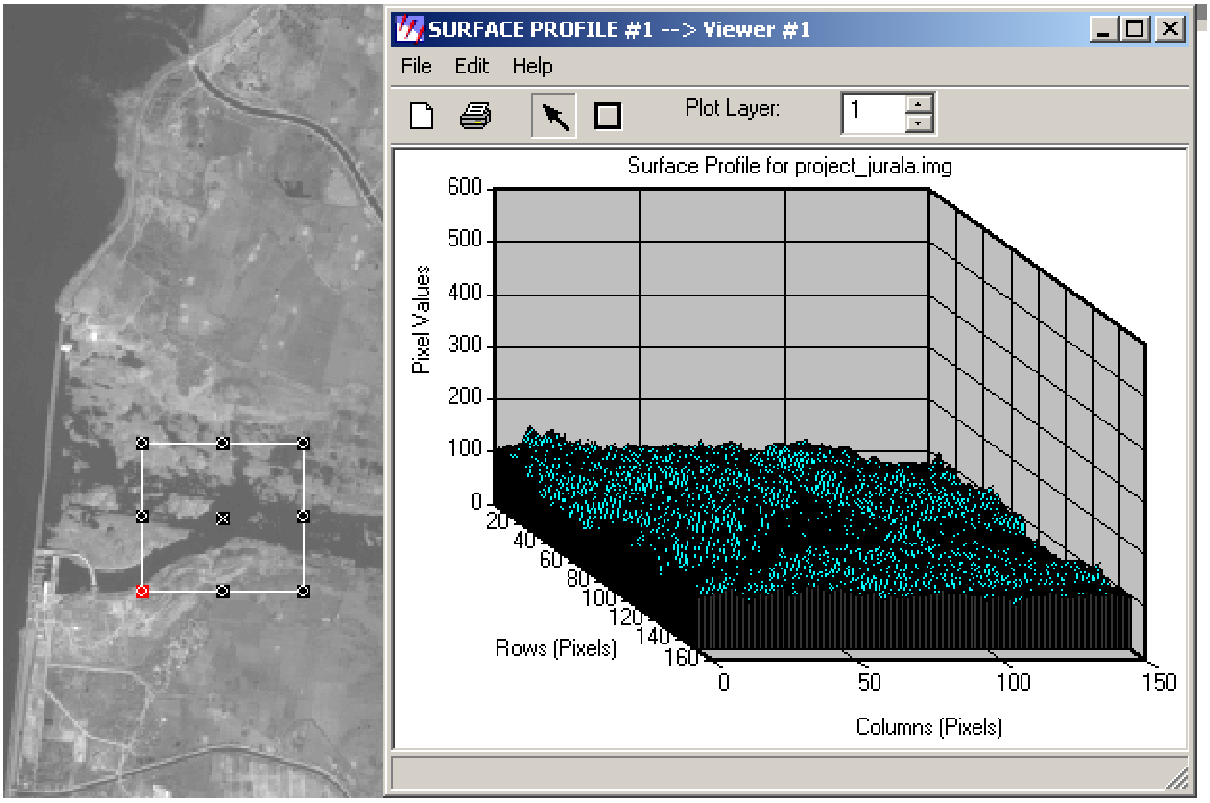


Figure 9 Surface profile

GEO-REGISTRATION AND CORRECTION

By this time you should be able to open for display an image file, select the band combinations that work best for your purpose, and examine the spectral and spatial profiles of the data.

The basic procedure will be to:

- display files
- start Geometric Correction tool
- record Geometric (ground) Control Points (GCPs)
- resample the image
- verify

1.) Begin by opening the file which you wish to geo-register. (This may be D:\PM_Jurala.img) and display it and "fit" it in a viewer. As your mouse moves within the display window note that the coordinates displayed in the lower left of the viewer are in "row" and "column".

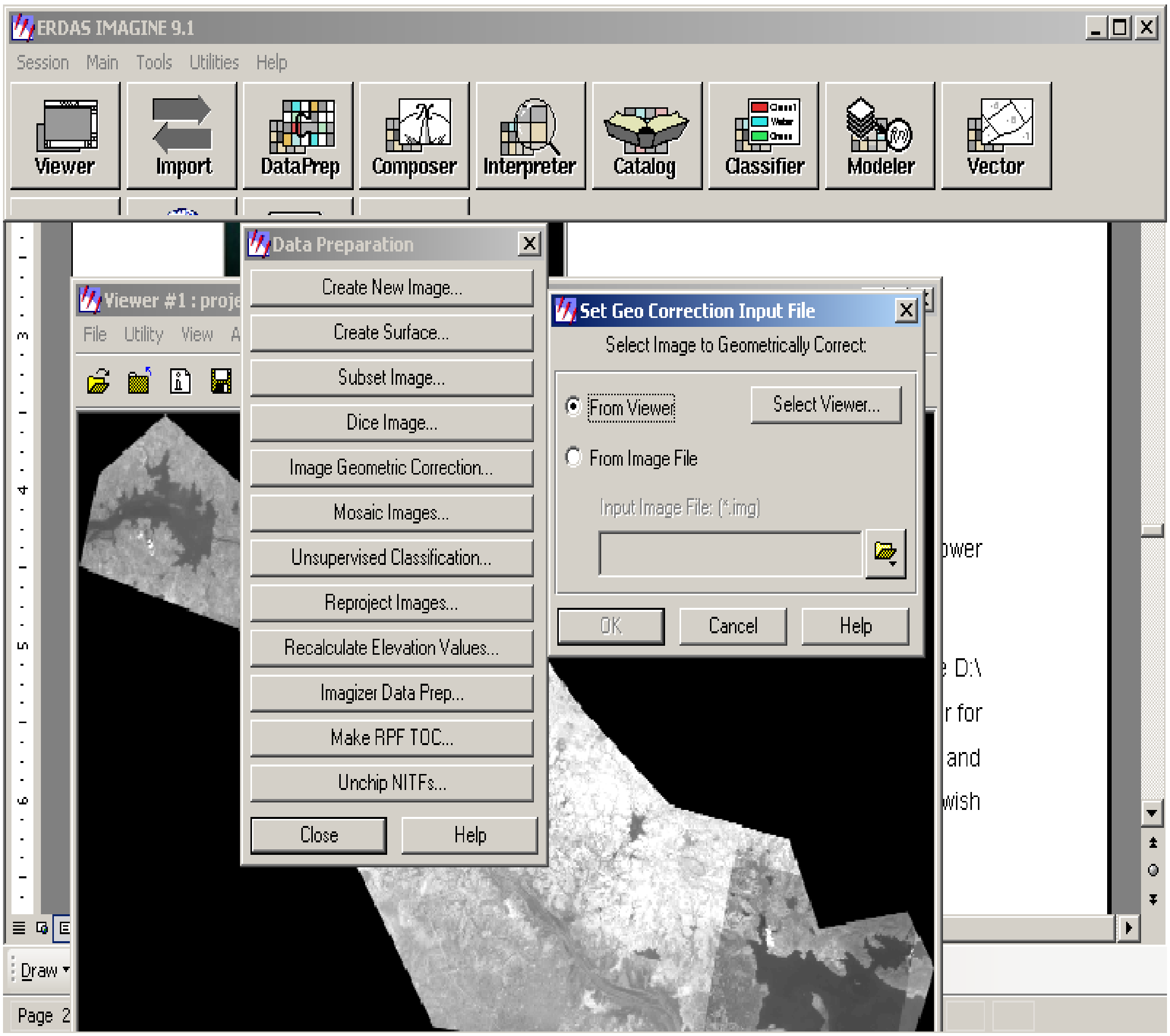


Figure 10 Select image to geometrically correct

Again, note the pixel coordinates in the lower left.

2.) Display an existing geo-registered image in a second viewer. (This may be D:\ toposheet.img). Once again, note the coordinates in the lower left of the viewer for this geo-registered image. This image is geo-registered to the UTM projection and coordinate system. If you don't feel you understand map projections you may wish to visit the USGS site call Map Projections.

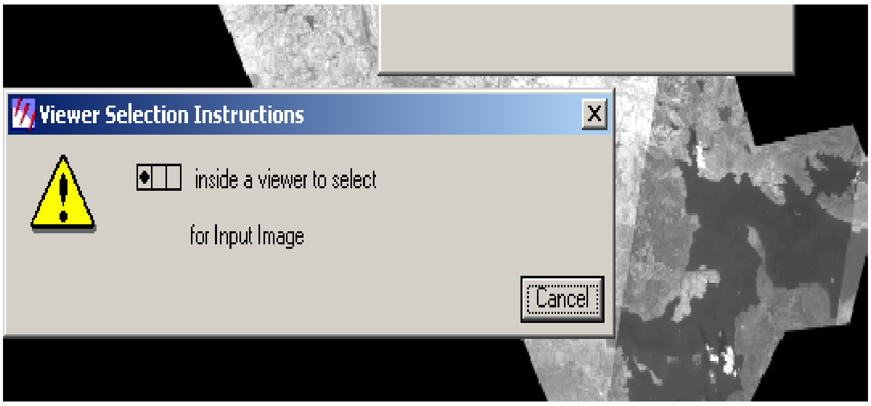


Figure 11 Viewer selection window

3.) Start the Geometric Correction tool from the viewer displaying the file to be rectified.

Select **RASTER** > Geometric Correction from the viewer's menu bar and Polynomial from the dialog box.

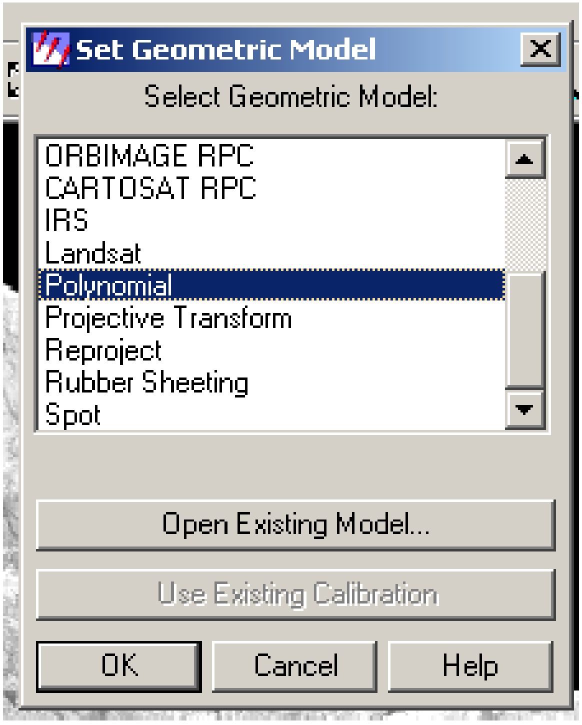


Figure 11 Set geometric model window

Each of these geometric models relate to specialized tasks. The polynomial model has the most general application.

4.) Two dialogs boxes will appear. The Geo Correction Tool menu will be used now. You can close the Polynomial model Properties (you will be selecting these parameters later)

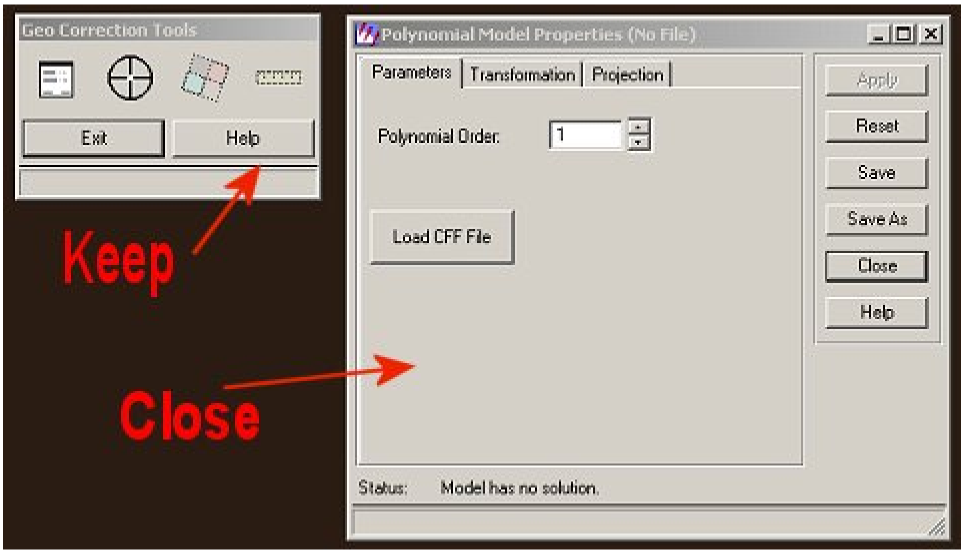


Figure 12 Polynomial model properties

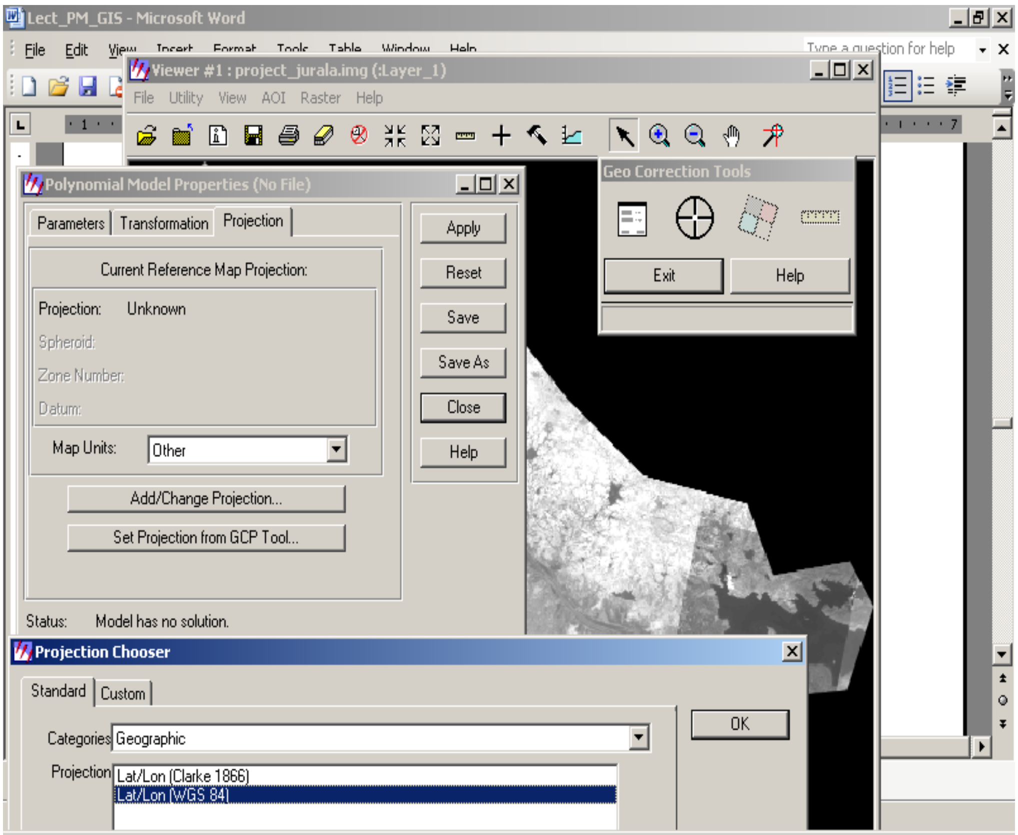


Figure 13 Setting projection properties

5.) The next dialog box is the Reference Setup dialog. Note all the different way in which, you can collect reference points. Select the option to use the *Existing Viewer* and click **OK.**

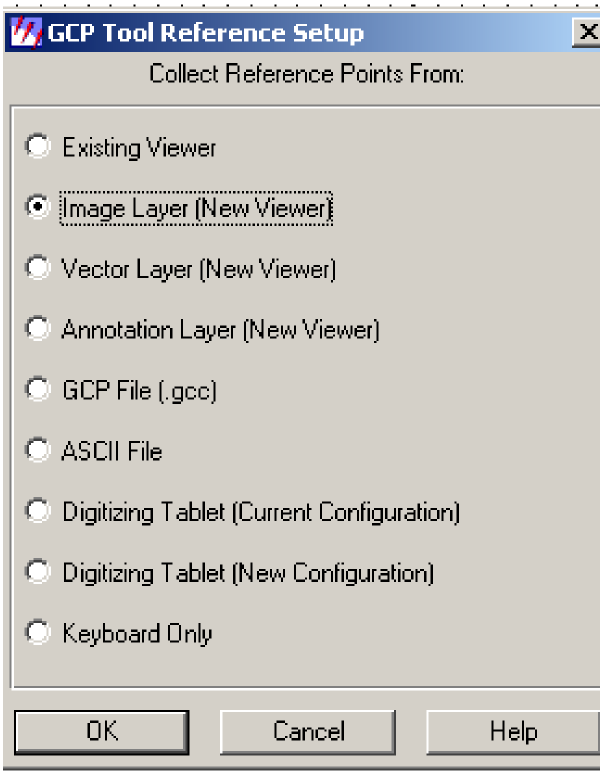


Figure 14 GCP tool ref setup

You will be prompted to click in the Viewer from which you wish to select the reference coordinates. Click in your second view – study ***area.shp*** or ***toposheet.img.*** The reference map information dialog will open. Make sure the information is correct (which it is) and click OK.

6. You are now ready to begin assigning real world coordinates to the non-geographic registered image. Your display will be filled with widows.

First, each viewer now has it's own "zoom" window above it. The zoom window display that part of the image which is inside the "box" (some time called the link box). The Ground Control Points (GCPs) are the small targets which are place on the image using the GCP tool.

It is a good idea to click on the "non-registered" image first. You can move the GCP with your mouse, and the GCP can be placed in either the Viewer or in that viewer's zoom window. The coordinates for each GCP is place in the GCP Tool CellArray (the table in the

lower third of your display). The Xinput and Yinput are the coordinates of the image to be registered and the Xreference and Yreference are the coordinates of in the image that has already been registered.

Your procedure is click on the GCP icon  and then click on a location in the first viewer that are easily identifiable in both images (the GCP #1 will be placed at that point and it's coordinates will be filled into the CellArray). Then click again on the GCP icon and this time click on the same location in viewer two (a corresponding GCP #1 will be placed at that point along with it's real world coordinates in the CellArray) REMEMBER, you can move the GCPs in the zoom window for better placement. Just click on the arrow icon .

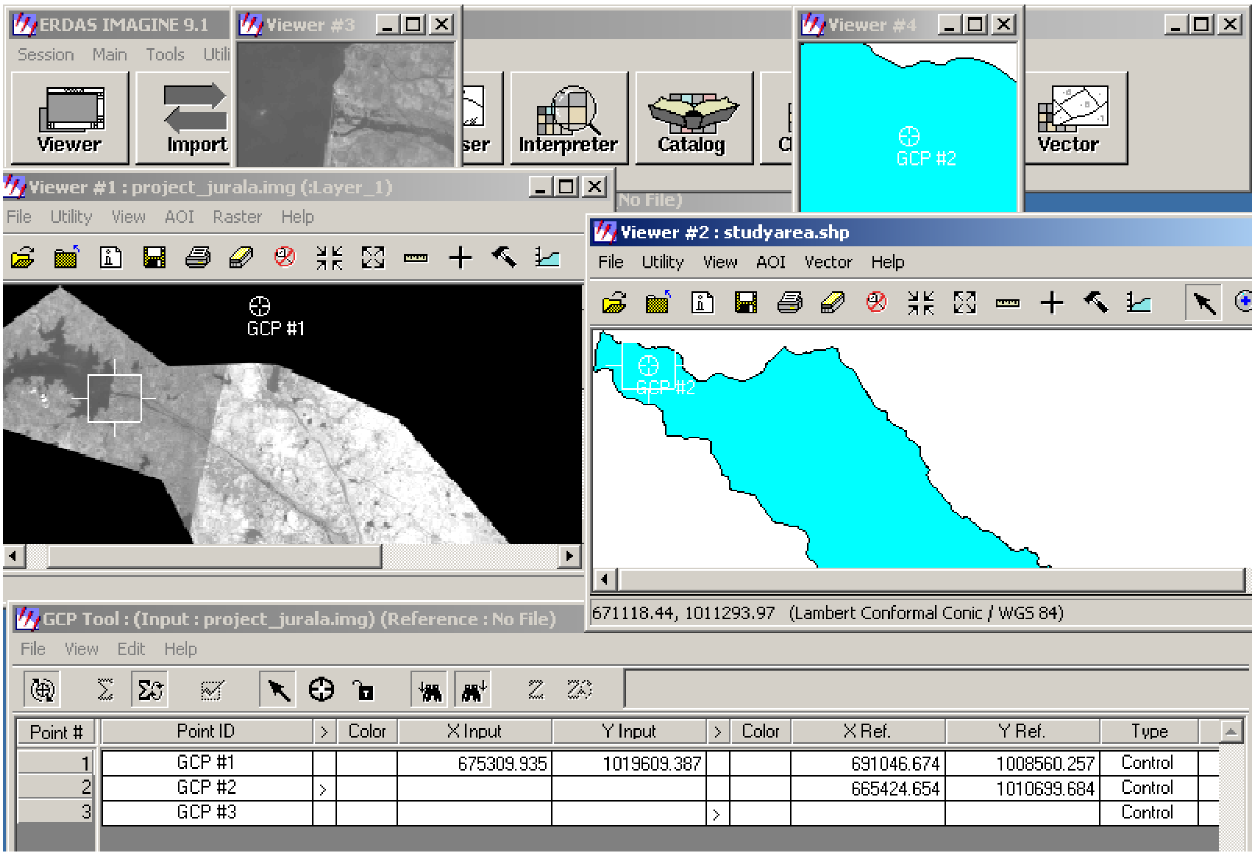


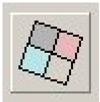
Figure 15 GCP tool

You see that after you have collected Three or more matching pairs the software will begin to place GCPs for you in an automatic mode. Also, you can right-hold you mouse button in the Color column of the Cell Array table to change the color of the GCP points.

Repeat this procedure until you have all the points you want. (try to get 7 or 8 at a minimum). To delete a GCP, select the GCP in the Cell Array and then right-hold in the POINT # column to select Delete Selection.

When you have finished your points should spread out over the image.

7.) Clearly there is much more you can do with this tool. For now we will accept the limited number of points and accept the solution to the transformation. Our next task is to resample the image. Re-sampling is the process of calculating the values for the rectified image and creating the new file. All of the raster data layers (all bands) in the source file are re-sampled. The best known algorithms for re-sampling are *Nearest Neighbor, Bilinear Interpolation, and Cubic Convolution*. We'll use the *Cubic Convolution* algorithm.

Click on the re-sampling icon from the Geo Correction Tool Menu . The resample dialog opens. Enter a file name for the output (know where on the drive you will put the file) - select the Bilinear Interpolation re-sampling method - click to exclude zero file values in the statistics. Also set the Output cell size to 30.00. Click OK. This shouldn't take much more that a minute or two for this size of file.

A job status dialog opens to let you know when the processes is complete.

8.) Verify the rectification by displaying the new image in a viewer and Geo. Link the reference image with the new image and use an Inquire Cursor to check that they are geo-registered to each other.

MOSAIC AND SUBSET OF IMAGES

Dr R N Sankhua
Director,
NWA, CWC, Pune

First of all we will take up mosacking procedure to join all the 8 images together. This is done by the menu of ***DATA PREPARATION*** then ***MOSAIC IMAGES*** from NOW here is one method to **mosaic** multiple Images (individual blocks) together. Once you have all your clipped images, you will want to put them back together for your unsupervised classification. Do the following:

1. Click the **DATA PREP** button, and select **MOSAIC IMAGE**

2. Click **EDIT** and **ADD IMAGE** or use the button. Add all your clipped images

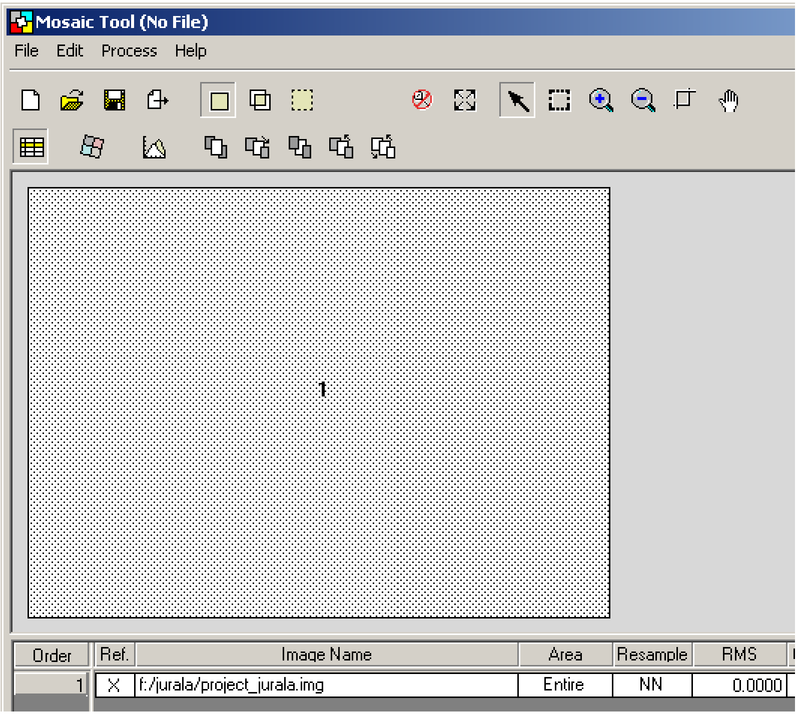


Figure 1 Mosaicking images

3. Then click **PROCESS** and **RUN MOSAIC**

4. This will make a new .img file with all your clipped images included.

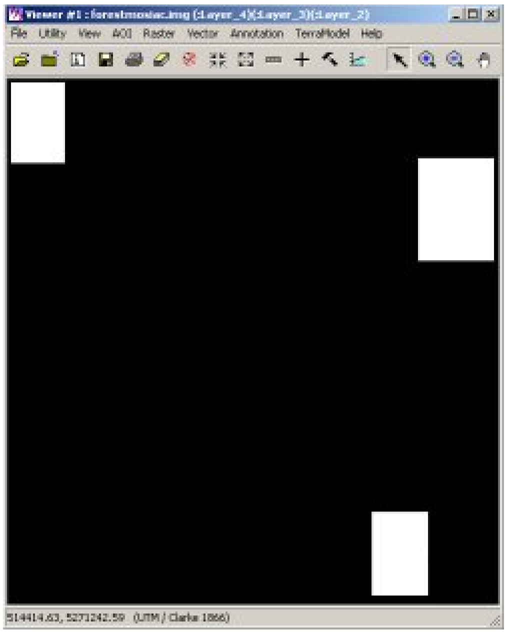


Figure 2 Mosaicking images added

5. You'll need to contrast stretch the resulting image. **Raster --> Contrast --> General Contrast**. Try the linear option.

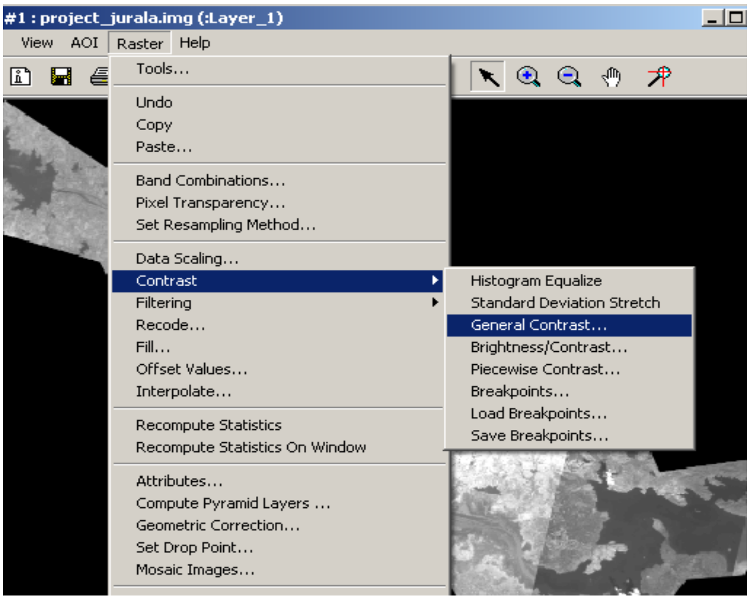


Figure 3 General Contrast setting for images

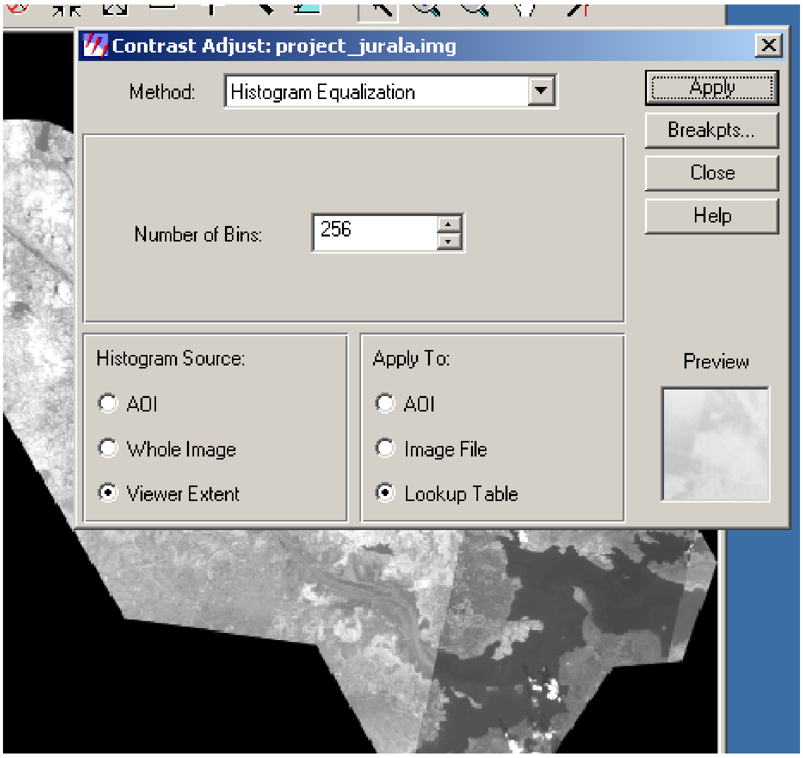


Figure 4 Contrast adjust

You can play with the contrast to make the visual that you like.

There are multiple ways to clip (subset) an image, many of them use the subset command. The method that I have used and found to work the fastest is the following:

2. In the Viewer window go to **File --> Open --> Raster Layer.....** and find the folder. Open the "**img**" file from the folder.

3. Click on **UTILITY** --> **INQUIRE BOX**

4. Move the box and enlarge it to include the area you want to clip

5. Click the **DATAPREP** button, and select **SUBSET IMAGE**

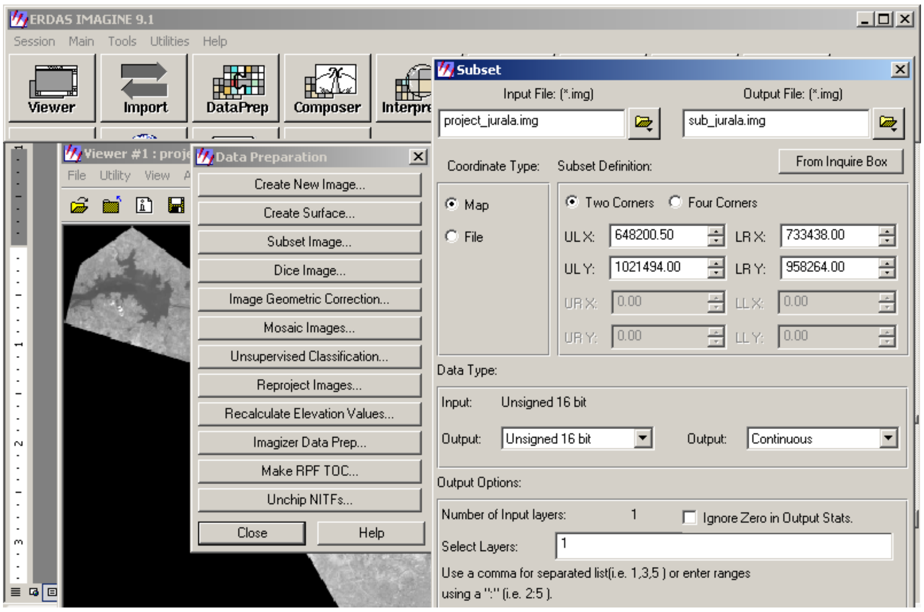


Figure 5 Sub setting image

6. Fill out the options selecting the image input and output, and click on **FROM INQUIRE BOX** button. This will make a .img file that contains the area, layers, and data type you selected.

REPEAT those steps until you have the subsets you wish to work with.

7. Click AOI from menu. Click tools and select polygon tool to create a polygon.

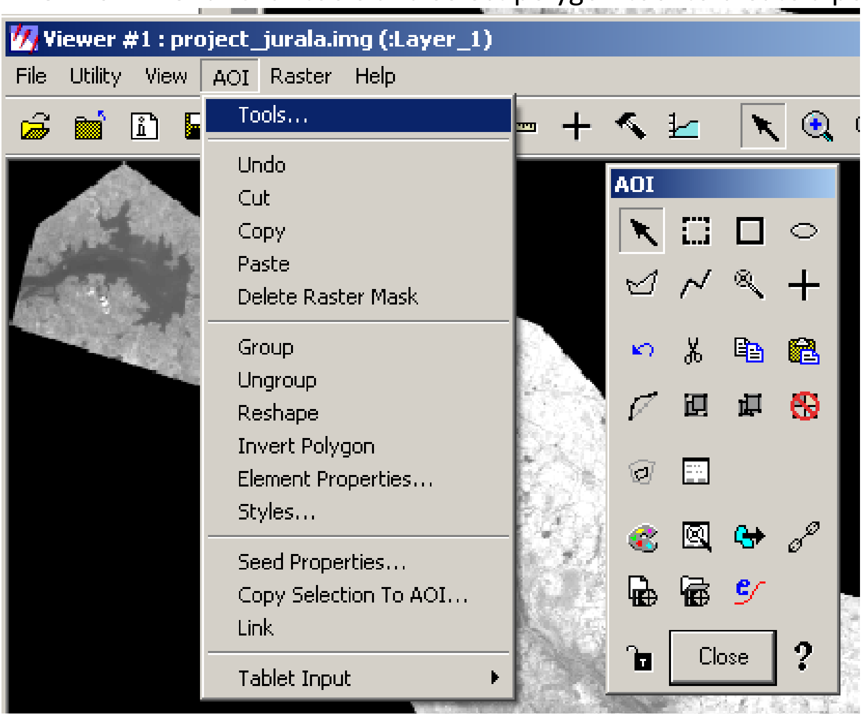


Figure- 6. AOI tool for polygon marking

8. Subset the image as per the AOI polygon. Now you got the study area image for further processing.

INTRODUCTION AND PRINCIPLES OF GIS

Sunil Kumar,
Director,
NWA, CWC, Pune

Introduction

Geographic Information System (GIS) is a computer based system designed to accept large volume of spatial data derived from a variety of sources and to store, retrieve, analyse, manipulate and display these data according to use specifications. Geographical objects include natural phenomena such as railways, canals, roads, rivers, soil type etc. Geographical data describe objects from the real world in terms of their position with respect to known co-ordinate system, their attributes that are unrelated to position and their spatial interrelations with each other, which describe how they are linked together. Conventionally, mapping map analysis, measurements were done manually. With the advent of computer technology software were written to handle geographic data on the computers. This has resulted in GIS which represents now rapidly developing field lying at the intersection of many disciplines namely cartography, computing, geography, photogrammetry, remote sensing, statistics, surveying and other branches concerned with handling and analysing spatially referenced data.

Basics of GIS

Mapping Concepts, Features

A map represents geographic features or other spatial phenomena by graphically conveying information about locations and attributes. Locational information describes the position of particular geographic features on the Earth's surface, as well as the spatial relationship between features, such as the shortest path from a fire station to a library, the proximity of competing businesses, and so on. Attribute information describes characteristics of the geographic features represented, such as the feature type, its name or number and quantitative information such as its area or length. Thus the basic objective of mapping is to provide

- descriptions of geographic phenomenon
- spatial and non spatial information
- map features like Point, Line, & Polygon.

Map Features

Locational information is usually represented by points for features such as wells and telephone pole locations, lines for features such as streams, pipelines and contour lines and areas for features such as lakes, counties and census tracts.

Point feature A point feature represents as single location. It defines a map object too small to show as a line or area feature. A special symbol of label usually depicts a point location.

Line feature A line feature is a set of connected, ordered coordinates representing the linear shape of a map object that may be too narrow to display as an area such as a road or feature with no width such as a contour line.

- **POINTS (CITIES, WELLS, VILLAGES)**
- **LINE (RAILS, ROADS, CANALS)**
- **AREA (RESERVOIR, WATERSHEDS, LAND USE CLASS)**

DATA MODEL

Geographic data are represented in GIS in a particular manner and the approach is called model. There are two models- raster and vector

Raster: The geographic data are divided in grid cells
Data Structure-run length encoding, chain coding and quad tree

Vector: represented by points and lines
Data Structure -spaghetti & topological

To know why and how a GIS can help us, we must know what a GIS is and what it can be used for

What is a GIS?

—Questions a GIS can answer
— Applications of GIS
—The elements of GIS

WHAT IS A GIS

AN ORGANISED COLLECTION OF COMPUTER HARDWARE, SOFTWARE, GEOGRAPHIC DATA AND PERSONNEL DESIGNED TO EFFICIENTLY CAPTURE, STORE, UPDATE, MANIPULATE, ANALYSE AND DISPLAY ALL FORMS OF GEOGRAPHICALLY REFERENCED INFORMATION

A PROGRAMME IS A GIS ONLY IF IT PERMITS SPATIAL OPERATIONS ON THE DATA

A GIS TYPICALLY LINKS DATA FROM DIFFERENT SETS. A GIS CAN PERFORM THIS OPERATIONS BECAUSE IT USES GEOGRAPHIC OR SPACE AS THE COMMON KEY BETWEEN THE DATA SETS

QUESTIONS A GIS CAN ANSWER

- **Location (What is at particular location?)**
- **Condition (where is it…..?)**
- **Trends (What has changed since….?.)**
- **Patterns (What spatial patterns exist ?)**
- **Modelling (What if…….?)**

Application Areas

- Water resources planning
- Land use planning
- Geodesic mapping
- Environmental applications
- Cadastral mapping
- Urban and regional planning
- Route selection of highways
- Mineral exploration
- Census and related statistical mapping
- Automatic cartography
- Natural resources mapping
- Surveying

Components of GIS

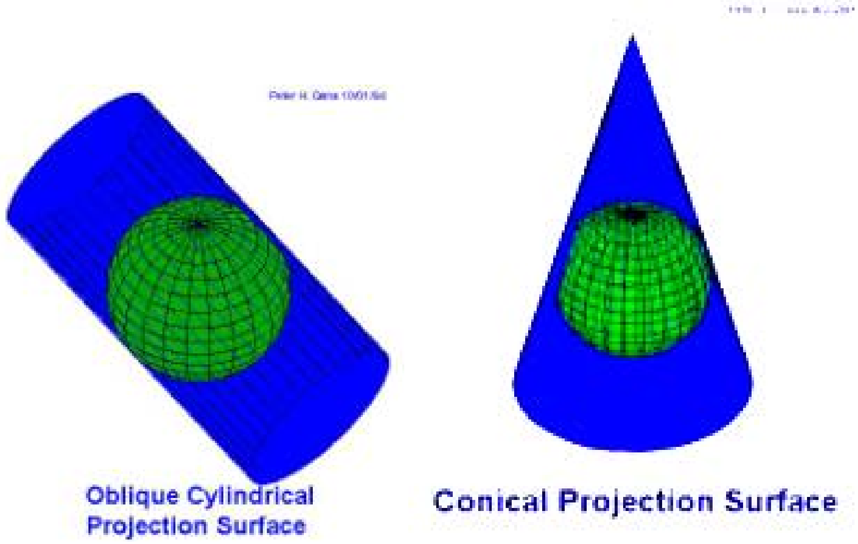
- Data encoding and input processing - (Digitizer, scanner, computer files)
- Data manipulation
- Data management
- Data retrieval
- Data analysis, modelling and cartographic manipulations (Overlay, intersection, identity, union, search, neighbourhood, distance, dissolve, classification reclassification, query etc)
- Data output(maps, graphs, photographs)

Map projection-

Map Projection is a systematic drawing of parallels of latitude and meridians of longitude on a plane surface for the whole earth or part of it on a certain scale so that any point on the earth surface may correspond to that on the drawing. A network of latitude and longitude is called ***graticule.***

- Map Projection is preparation of *graticule* on a flat surface.
- *Projection* means the determination of points on the plane as viewed from a fixed point.
- A flat surface will touch globe only at one point and other sectors will be projected over the plane in a distorted form. The amount of distortion increases with the distance from tangential point.

- Equal area or *homolographical* Projections
  (In this case graticule is prepared in such a way that every quadrilateral on it may appear proportionately equal to in area to the corresponding spherical quadrilateral.)
- Correct shape or *orthomorphic or Conformal* Projections
- True bearing or *azimuthal* Projections

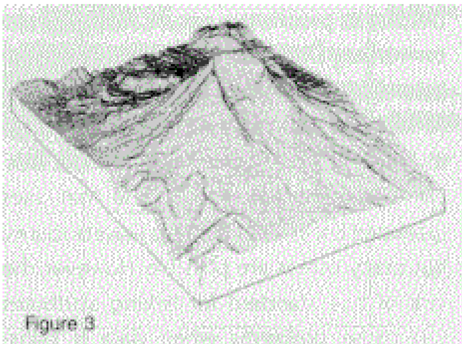


Polyconic, UTM etc.

Geometric rectification/ geo-referencing

Statistics- measurement, summary

DEM and Visualisation
Contouring, Hill shading, Perspective viewing, Fly through
Slope and aspect, extracting drainage



DEM

GIS packages

ARC/INFO (1969-ESRI Redlands California, USA), PAMAP GIS, SPANS (spatial analysis System-TYDAC Tech, USA,)

Modular GIS Environment (MGE)

IDRISI, GRASS, MAP/INFO, PROGIS

Indigenous GIS Packages- ISROGIS (12 modules) such as

Create, Edit, Make, Analyse, Attr-DB, Layout, Query, Map mosaic, 3D Module, Symbol Manager, Graphic User Interface (GUI)

GRAM^{++}, GEO-SPACE – RRSSC

GEOGRAPHIC DATABASE

- **A GIS does not hold maps or picture-it holds a database**
- **If one has to go beyond making pictures, one need to know three things about every feature stored in the computer; what it is, where it is, and how it relates to other features**
- **GIS gives the ability to associate information with a feature on a map and to create new relationships**

HARDWARE AND SOFTWARE RESOURCES

- **The rapidly increasing power and the relative affordability of workstations now provide the user access to powerful machines for GIS operation dealing with large and complex data set and other decision-support tools such as hydrologic models, statistical packages, and optimisation programs**
- **With advancement in software development relating to GIS application more and more features are getting available on PC version of GIS packages**
- **Commercial GIS packages like Arc-Info, MapInfo, Intergraph, Spans etc. available in the market**
- **Most of the packages function under open GIS system**
- **Before a GIS package or peripheral is acquired, inter-compatibility should be confirmed.**

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ISSUES PERTINENT TO WRD&M

- **Critical role of water in human and natural environment. Role of GIS is important in management of the precious resource**
- **Water related data can have high precision (canal location) or can be Fuzzy (wetland perimeter)**
- **surface representation by DEM using GRID, TIN or contours required for hydro-geologic application of GIS**
- **Length, area and quantity computation, overlay of thematic layers and buffer zone generation important for WRD application**

APPLICATION IN WATER RESOURCES

1. **Hydrologic/hydraulic modelling for basin Planning**
2. **WR and Irrigation potential assessment**
3. **Identification of WRD project sites**
4. **EIA studies and environmental monitoring**
5. **Command area monitoring**
6. **Disaster management**

Network Analysis

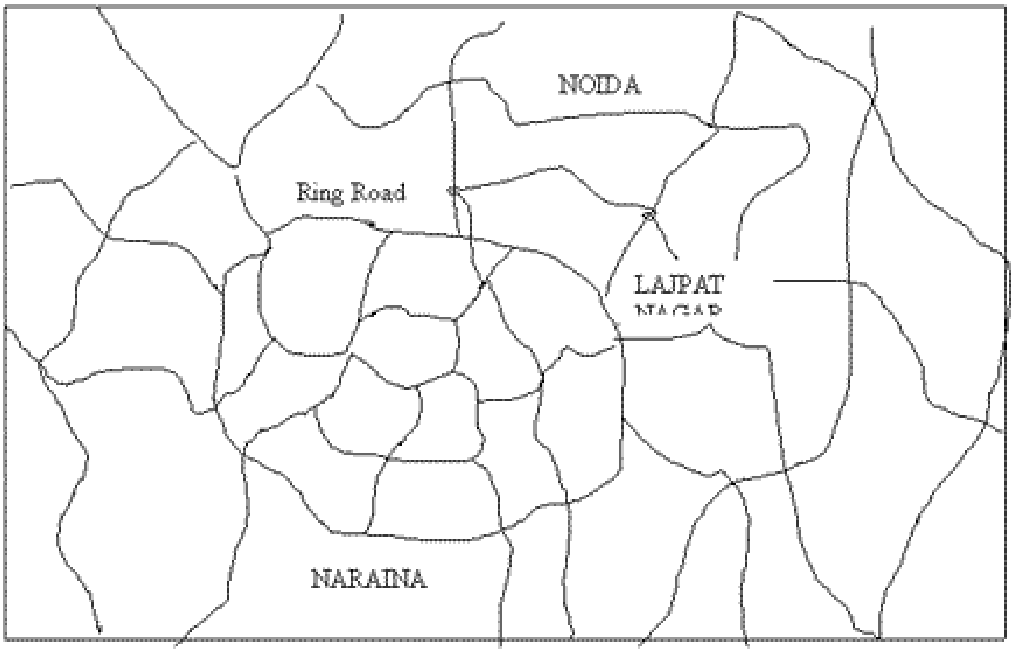
Network models are based on interconnecting logical components, of which the most important are:

1. "Nodes" define start, end, and intersections
2. "Chains" are line features joining nodes
3. "Links" join together points making up a chain.

This network can be analyzed using GIS.A simple and most apparent network analysis applications are:

- Street network analysis,
- Traffic flow modelling,
- Telephone cable networking,
- Pipelines etc.

The other obvious applications would be service centre locations based on travel distance. Basic forms of network analysis simply extract information from a network. More complex analysis, process information in the network model to derive new information. One example of this is the classic shortest-path between two points. The vector mode is more suited to network analysis than the raster model.



A Road Network *Image*

CAPABILITIES OF GIS

- **Presentation Graphics**
- **Data Query**
- **Spatial Query**
- **Routing and Minimum path**
- **Buffering**
- **Overlay**
- **Distance, Adjacency and Proximity analysis**
- **Misc. analysis likes neighbour analysis, network analysis, 3D Analysis etc.**

PRESENTATION GRAPHICS

- **Thematic mapping is a means offered by GIS to draw map elements using patterns or colour based on a particular attribute**
- **Thematic mapping can be classified as**
  - **Polygon thematic**
  - **Line thematic**
  - **Point thematic**
- **Thematic maps usually involve only a few map layers and limited amounts of data**

DATA QUERY

- **Much of the data collected by businesses are spatially referenced**
- **Non GIS user querying such a data base are limited to tabular views of the results of query**
- **A GIS user can view the results on a map apart from the regular tabular view**
- **Most important benefit is that the GIS user can see the spatial distribution which is hidden for the non GIS user**
- **Thus the GIS user is offered a "*powerful lens*" which makes hidden data visible to him**
- **This type of data base query is also called the "*show-me*" query**
- **Most available GIS packages are designed to effortlessly perform data queries**
-

SPATIAL QUERY

- **In this form of a query the user relies on the map as a querying tool**
- **Typically the data base is accessed by pointing to specific map feature**
- **GIS will then search the data base, and find those records that qualify, for presentation**
- **Spatial queries can be through**
  - **Pointing a feature**
  - **Spatial windows (Circular/Rectangular)**
- **Spatial queries are also called "tell-me" queries**

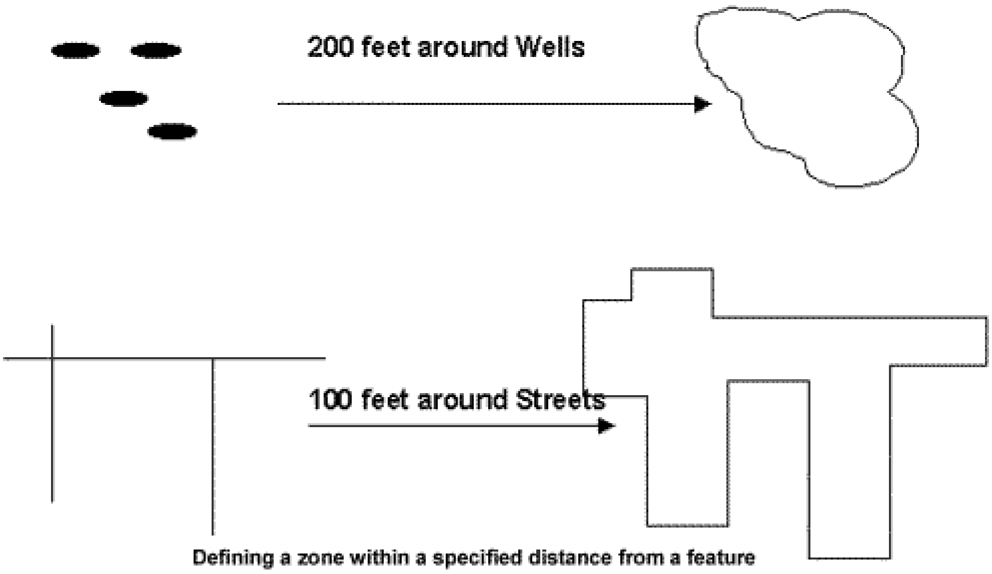
ROUTING AND MINIMUM PATH

- **Answer lies in the ability to find the shortest-path along a transportation network**
- **Routing involves "legal" travel from one point to another along a designated network**
- **Minimum path analysis involves finding out the shortest, fastest or most appropriate route**

BUFFERING

- **A buffer is a zone of fixed width around a map feature**
- **Buffer around a point takes the shape of a circle**
- **Buffer around a line takes the form of a corridor**
- **Buffer around a polygon taken the form of a bigger polygon**
- **Most of the GIS packages can buffer points, lines and polygons**
- **Very few packages are capable of handling concave polygons**

Using these operations, the characteristics of an area surrounding in a specified location are evaluated. This kind of analysis is called proximity analysis and is used whenever analysis is required to identify surrounding geographic features. The buffer operation will generate polygon feature types irrespective of geographic features and delineates spatial proximity. For example, what are the effects on urban areas if the road is expanded by a hundred meters to delineate a five-kilometer buffer zone around the national park to protect it from grazing.



Using Buffer

Overlay Operations

The hallmark of GIS is overlay operations. Using these operations, new spatial elements are created by the overlaying of maps. There are basically two different types of overlay operations depending upon data structures:

Raster overlay It is a relatively straightforward operation and often many data sets can be combined and displayed at once.

Vector overlay The vector overlay, however is far more difficult and complex and involves more processing.

Logical Operators The concept of map logic can be applied during overlay. The logical operators are Boolean functions. There are basically four types of Boolean Operators: viz., OR, AND, NOT, and XOR.With the use of logical, or Boolean, operators spatial elements / or attributes are selected that fulfill certain condition, depending on two or more spatial elements or attributes.

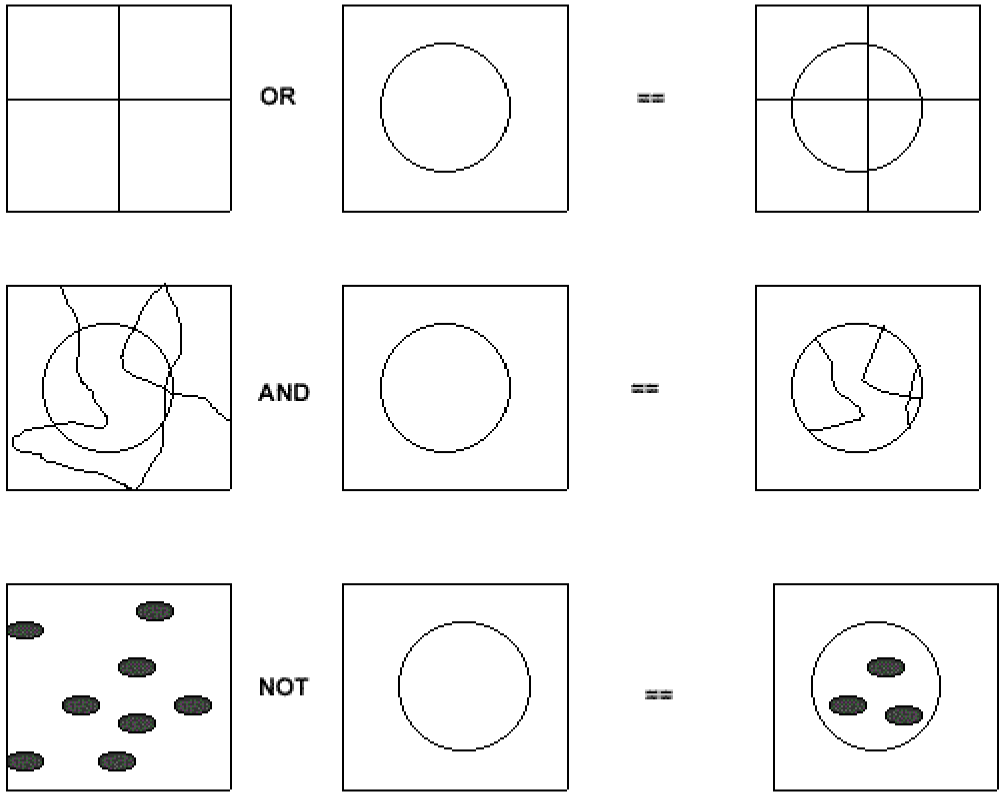
Vector Overlay During vector overlay, map features and the associated attributes are integrated to produce new composite maps. Logical rules can be applied to how the maps are combined. Vector overlay can be performed on different types of map features: viz., Polygon-on-polygon overlay

Line-in-polygon overlay

Point-on-polygon overlay.

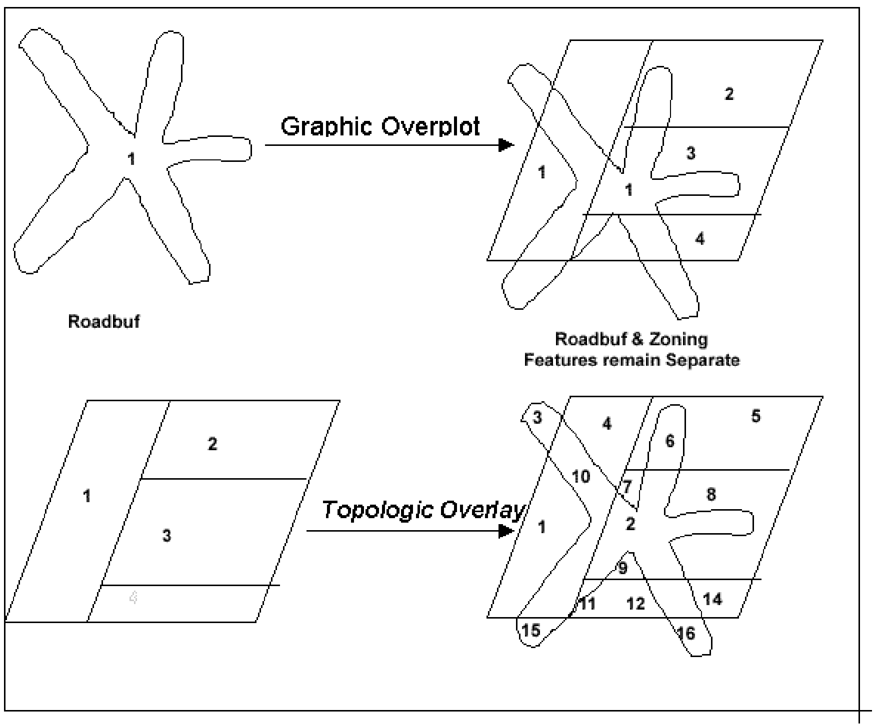
During the process of overlay, the attribute data associated with each feature type id merged. The resulting table will contain both the attribute data. The process of overlay will depend upon the modelling approach the user needs. One might need to carry out a series of overlay procedures to arrive at the conclusion, which depends upon the criterion.

Polygon-on-Polygon Overlay



Polygon-on-Polygon Overlay

Difference between a Topologic Overlay and a Graphic Over plot



DISTANCE, ADJACENCY AND PROXIMITY ANALYSIS

- **Distance analysis refers to the ability to calculate *distances* from a map or along a transportation network**
- **Adjacency analysis refers to the ability to determine which of the map features TOUCH or are adjacent to other map features**
- **Proximity analysis refers to the ability to determine which of the map features are NEAR or in the neighbourhood of the referred map features**
- **All available GIS packages can estimate aerial distances**
- **A more limited set can estimate distances along road network**
- **Very few GIS packages can "*directly*" perform adjacency/ proximity analysis**

Analysis of Geographic Data

ANALYSIS - What? & Why? The heart of GIS is the analytical capabilities of the system. What distinguish the GIS system from other information system are its spatial analysis functions. Although the data input is, in general, the most time consuming part, it is for data analysis that GIS is used. The analysis functions use the spatial and non-spatial attributes in the database to answer questions about the real world. Geographic analysis facilitates the study of real-world processes by developing and applying models. Such models illuminate the underlying trends in geographic data and thus make new information available. Results of geographic analysis can be communicated with the help of maps, or both. The organization of database into map layers is not simply for reasons of organizational clarity, rather it is to provide rapid access to data elements required for geographic analysis. The objective of geographic analysis is to transform data into useful information to satisfy the requirements or objectives of decision-makers at all levels in terms of detail. An important use of the analysis is the possibility of predicting events in the another location or at another point in time.

ANALYSIS - How? Before commencing geographic analysis, one needs to assess the problem and establish an objective. The analysis requires step-by-step procedures to arrive at the conclusions. The range of geographical analysis procedures can be subdivided into the following categories.

- Database Query.
- Overlay.
- Proximity analysis.
- Network analysis.
- Digital Terrain Model.
- Statistical and Tabular Analysis.

Spatial Analysis

It helps us to:

- Identify trends on the data.
- Create new relationships from the data.

- View complex relationships between data sets.
- Make better decisions.

Geographic Analysis

Analysis of problems with some Geographic Aspects.

- Alternatives are geographic locations or areas.
- Decisions would affect locations or areas.
- Geographic relationships are important in decision-making or modelling.

Some examples of its application:

- Nearest Neighbour.
- Network distances.

Planar distances

Tabular Statistical Analysis

If in the above road network we have categorised the streets then in such a case the statistical analysis answers questions like

- What unique categories do I have for streets?
- How many features do I have for each unique category?
- Summarize by using any attribute?

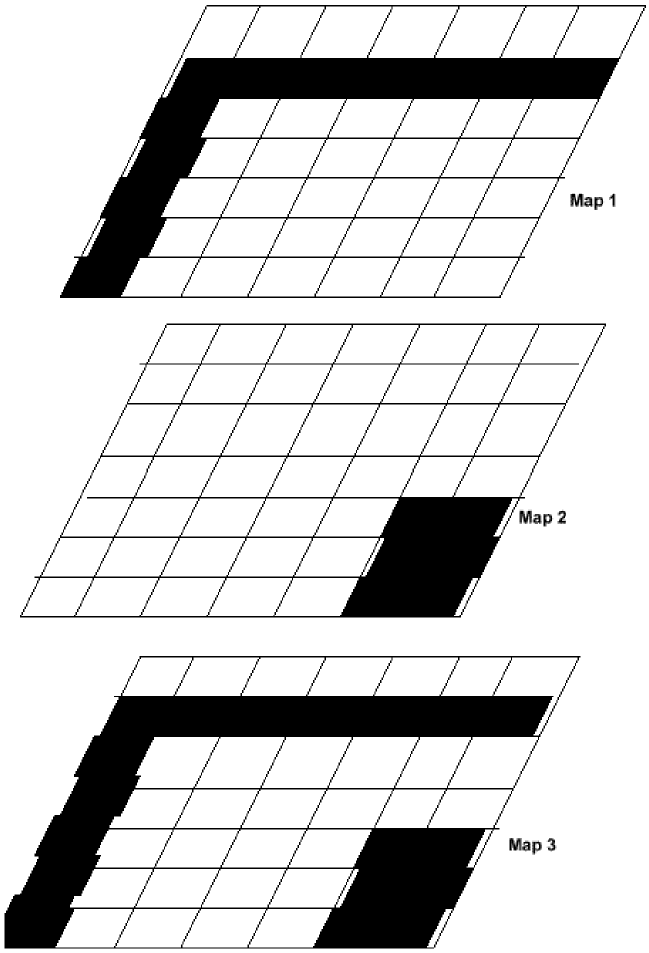
Database Query The selective display and retrieval of information from a database are among the fundamental requirements of GIS. The ability to selectively retrieve information from GIS is an important facility. Database query simply asks to see already stored information. Basically there are two types of query most general GIS allow: viz., Query by attribute,

Query by geometry. Map features can be retrieved on the basis of attributes, For example, show all the urban areas having the population density greater than 1,000 per square kilometer, Many GIS include a sophisticated function of RDBMS known as Standard Query Language (SQL), to search a GIS database. The attribute database, in general, is stored in a table (relational database mode.) with a unique code linked to the geometric data. This database can be searched with specific characteristics. However, more complex queries can be made with the help of SQL. GIS can carry out a number of geometric queries. The simplest application, for example, is to show the attributes of displayed objects by identifying them with a graphical cursor. There are five forms of primitive geometric query: viz., Query by point, Query by rectangle, Query by circle, Query by line, Query by polygon, A more complex query still is one that uses both geometric and attributes search criteria together. Many GIS force the separation of the two different types of query. However, some GIS, using databases to store both geometric and attribute data, allow true hybrid spatial queries.

Conditional Operators

Conditional operators were already used in the examples given above. The all evaluate whether a certain condition has been met.

= eq 'equal' operator<> ne 'non-equal' operator< lt 'less than' operator<= le 'less than or equal' operator> gt 'greater than' operator>= ge 'greater than or equal' operator. Many systems now can handle both vector and raster data. The vector maps can be easily draped on to the raster maps.



Raster Overlay

CURRENT AND FUTURE ROLE OF GIS

- **Users should periodically examine the requirement for GIS and whether their system continues to meet those needs**
- **GIS is yet to be used in a large way for terrain visualisation, 3-D analysis, resource information and organisation planning.**

Reference

Sankhua, R N (1999 to 2010), Lecture notes on GIS training courses, NWA

PRINCIPLES OF MONITORING THROUGH GIS

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INTRODUCTION

Monitoring is the process of collecting information about the actual execution of planned tasks and factors, which might affect their execution; analyzing these in relation to the plan and exercising control so that the deviations from the plan are minimal. The assessment of irrigation potential created in a project by first identifying and mapping of irrigation canal networks and tagging the status of completion of the entire conveyance and distribution system, various irrigation & drainage structures, etc. (e.g., complete/incomplete / pending)

Project command area maps and relevant ground truth information were used for precise boundary delineation of the study area. The individual ortho-corrected CARTOSAT pan scenes were mosaicked to create AIBP Component area satellite database as has been illustrated in the previous chapter. This database was used to inventory irrigation infrastructure.

THE MAIN OBJECTIVES

Monitoring of projects is executed to

- *i.) Set performance standards*
- *ii.) Ensure implementation of construction programme*
- *iii.) Review the organizational and management capabilities of the project organization and procedural difficulties being faced by them*
- *iv.) Compare actual physical and financial achievements with the set targets*
- *v.) Identify deviations, shortfalls, lagging areas etc occurred and anticipated along with their effect on the overall implementation programme and inter-related activities and analyze their causes*
- *vi.) Suggest corrective measures for overcoming the bottlenecks/problems*
- *vii.) Review the project, suggest modifications in the implementation procedures, programme and targets*
- *viii.) compile the information on physical and financial status*

STAGES

The entire monitoring exercise comprises of the following **stages**:

1. ***Preliminary preparations***
2. ***Field visit***
3. ***Collection of information/data & review of the status of the project***
4. ***Wrap up meeting with Project Authorities***
5. ***Preparation of status Report***
6. ***Follow up of the action points***

1) Preliminary preparations

The Project Authorities should be intimated and requested to compile the information in the prescribed formats and make available the same to the monitoring team immediately after reaching the project site.

2) Field visit

During field visit, efforts should be made to physically inspect all the works in progress in the project. However, if it is not possible to inspect all the works due to certain limitations, at least the major and critical works must be inspected. Discussions may also be held with the contractors at site as regards the progress of their works vis-a-vs. the agreed programme.

3) Collection of information/data and review of the status of project

All the relevant information/data may be collected during discussions with Project Engineers in the field and from records available in the project offices. Based upon this, the status of the project may be reviewed and the critical issues may be identified for further clarification/discussion with project authorities.

4) Wrap up meeting with project authorities

The ***physical and financial progress*** of the project and the critical issues may be discussed in the wrap-up meeting with the Project Authorities and ***action points*** may be identified for follow up action by the concerned agencies.

5) Preparation of status report

The critical issues requiring immediate attention of the state Government may be communicated separately through a letter from CE (CWC) concerned to the Secretary to the state government with a copy to all concerned. The ***detailed status report*** of the project may be prepared within a month and sent to all concerned for necessary action.

6) Follow up of the action points

The action points incorporated in the status report may be followed up. Project Authorities may be advised to indicate the status of the action points in their quarterly progress reports.

L-section of the dam and ***Bar, Tee Charts*** and ***Dot Charts*** of various canal systems indicating their progress and future programme may be enclosed. The deviation of work should also be provided in respect of;

i.) *Expected deviation in completion schedule of any major components of the project or the project as a whole.*

ii.) *The measures taken to check the delay probable effect on construction schedule.*

IRRIGATION POTENTIAL

Ultimate potential of the project, potential created up to last year programme for current year and achievement.

(b) Reasons for lag in potential

(c) Status of utilization vrs creation

(d) Statement of distributary-wise ultimate potential and potential created so far, may be enclosed as Annexure.

PHYSICAL PROGRAMME & PROGRESS OF DIFFERENT COMPONENTS OF THE PROJECT

Sl No.	*Item*	*Unit*	*Total estt. qty.*	*Progress up to last year*	*Programme for current year*	*Achievement for the year to the end of.....*	*Likely date of completion*
1.	**A. HEADWORKS** Dam/Barrage Earth Work i) Excavation ii) Embankment Masonry Concrete Gates	 Tcum Tcuin Tcum Tcum Nos					
2.	**Main canals** Earth work Lining Structure	 Tcum Km. Tsqm Km. Nos					
3.	**Branch canals** Earth work Lining Structure	 Tcum Km. Tsqm Km. Nos					
4.	Distributary	Km					
5.	Water courses	Km					

STATUS REPORT PARA

PART - I EXECUTIVE SUMMARY

An executive summary preferably not more than 2-3 pages comprising of following information may form the first part of the status Report.

Para 1 Project in brief

Location, components, benefits, estimated cost, year of approval, inter-state aspects, if any, year of start, targeted date of completion, external source of funding, if any,

Para 2 Organizational and Management aspects

Adequacy of organizational set-up vis-a-vis physical & financial programme

Para 3 PHYSICAL PROGRESS

Percentage completion of various components of the project and achievement of potential (*This we will take up in this training*)

Para 4 Financial progress

Latest expenditure details, outlays for the current plan/year.

Para 5 Issues in Focus

Only critical issues needing immediate attention of the Government/Project Authorities

PART - II

1 Project components as being executed

Describe here the project location, its scope, benefits and components as being executed. Salient features of the project may be given in **Annexure.**

2 Changes in the scope

Changes in the scope of the project, if any, as

APPROACH OF MONITORING THROUGH GIS AND RS

Basic approach involved in the training would consist of mapping of **existing** irrigation infrastructure in the project and comparing it to the **proposed** irrigation infrastructure, thus assessing the Irrigation Potential created in the project command. Brief procedural steps involved in the GIS study are depicted below:

- Planning for acquisition of fresh **High resolution CARTOSAT** satellite data during the period using the Lat / Long or path/row. The toposheet of the area need to be studied for deriving the latitude and longitude of the area of interest and from utility software (SDSU) of NRSC the path row for the satellite can be assessed. Information covering AIBP component.
- Preparation of AIBP component vector polygon shape files using the field maps. Preparation of AIBP component area mask under each of the projects.

- Procurement of cloud free precision corrected Cartosat satellite data acquired during the period time window covering all those projects which are in progress as on April 2007.
- Preparation of field database on irrigation infrastructure and Irrigation Potential.
- Edge matching and mosaicking of **CARTOSAT** satellite data tiles and preparation of satellite database.
- Identification and mapping of existing Irrigation Infrastructure consisting of Irrigation canal network up to Minor / Sub-Minor level, Cross drainage, irrigation and other structures as on the date of satellite overpass date.
- Comparison of above information with proposed Irrigation infrastructure, AIBP schedules/targets, to create planned I.P
- Assessment of Irrigation Potential (I.P) created based on the extent of accomplishment in irrigation canal network creation with **hydraulic flow continuity** as on the satellite data acquisition date.
- Conduct random field visits for ground truth to check for satellite data analysis.
- Finalization of assessment of I.P created preparation of maps, statistics and study report generation.
- All the vector layers (Irrigation Infrastructure) along with attribute information will be developed in GIS / Image Processing software.

METHODOLOGY

Steps in Monitoring in GIS

1) Field data collection- Collection of Maps, tables showing canal network CCA.IP proposed, IP created as on specified date
2) CARTOSAT data acquisition
3) Field database creation on IP and Irrigation infrastructure
4) CARTOSAT database creation- mosaicking and subsetting
5) Geo- database creation- Creation of all vector layers along with attributes
6) Inventory and mapping of Irrigation infrastructure and base layers
7) Assessment of Irrigation infrastructure and IP- Comparison of proposed and satellite derived IP based on hydraulic connectivity

8) Ground truth verification
9) Preparation of report encompassing the synopsis of analysis

A) ASSESSMENT OF IRRIGATION INFRASTRUCTURE

The canal network interpreted from satellite data is organized in the geo-database as per the scheme designed for the project. Lengths and off take change of each canal are derived automatically from the canal layer. This information along with the field reported canal length and off-take chainage are tabulated and used to calculate the percentage progress of irrigation infrastructure by comparing the proposed canal length with the satellite derived length. In some cases there may be gaps in the canal section due to different reasons or due to non-existence of some hydraulic structure. Under these circumstances the length of the canal that is continuous from its off-take point is only considered and compared with the planned canal length for assessment of irrigation potential created.

There are different scenarios which determine whether a particular canal is completed or not. Accordingly, the remarks column in irrigation infrastructure table is filled.

Identification and mapping of existing irrigation canal network with Main canal/Branch canal/Distributaries/Minors & Sub-minors to be from the satellite image through onscreen digitization using ERDAS IMAGINE image processing software and GIS software by displaying the image at suitable scales. In addition to the canal network, irrigation and other structures including Cross Drainage Structures viz. aqueducts, super passages, syphons, H.P. drains, road/cart/foot bridges etc. were identified and marked on to the digital database. The above irrigation infrastructure was identified and mapped using the image interpretation key.

Thus, the inventory of information in terms of number of canals (main canals/branch canals/distributaries/minors/sub-minors etc.), their off-take chainages and respective lengths was made. In addition to this, the status of canals was also assessed in terms of ***complete or incomplete or pending*** based on satellite data inventory information. Then, random ground checks were made for verification and confirmation of image interpretation details.

DIFFERENT SCENARIOS

Canal completed- When the entire canal length is identified from satellite data as per the field design, the canal is assumed to be complete. If the length does not match exactly, then 98% for long canals or 97% for short canals those canals are assumed to be complete.
Canal short in length- If the Canal is completed up to certain length and pending beyond.

Gaps in middle reaches- Whenever gaps exist in different stretches of the canal, the canal is assumed to be incomplete. The length of the canal that continuous from off-take is only considered for irrigation potential assessment.

Gaps due to pending structures - Whenever the canal is discontinuous due to pending structures, the canal is assumed to be incomplete. In such cases, the length of the canal that is continuous from off-take is only considered for IP assessment. The cases where the pending structure affects the hydraulic connectivity of a canal includes river crossing, road crossing etc.

No Off-take connectivity- Whenever a canal is not connected to its parent canal even the canal is constructed this is taken as incomplete.

Canal pending- If a particular canal is not identified in the satellite image as per the field design, it is taken as incomplete.

B) ASSESSMENT OF IRRIGATION POTENTIAL CREATED

The details of Irrigation potential proposed under each canal as per the field data available is provided in table for presenting irrigation potential information. Satellite based assessment of irrigation potential is done based on the physical status of canal, i.e. completed; gaps existing in various canal structures; pending crops drainage structures; pending irrigation structures such as regulators, etc. causing hydraulic discontinuity. The process for the assessment of irrigation potential is described in this section along with a case study.

The **Inputs/Parameters** required from the **field data** and **satellite data derived irrigation infrastructure** information are:

1. **Proposed length** of canal
2. **Satellite derived lengths**; physical progress of canal construction for the corresponding canal
3. IP proposed under each canal
4. **Gaps** existing in different stretches of the canal network,

   -Number of gaps and gap lengths their changes -derived hydraulically connected length of a particular canal.
5. Number of **DPOs (Direct Pipe Outlet)**, their contribution to the **Irrigation potential** as per field data; their **chainages** – to assess the hydraulic connectivity.

The steps to be followed for the satellite based assessment of irrigation potential creation. Irrigation potential assessment is made based on physical status of canal and its hydraulic connectivity to the source or irrigation. As explained earlier, canal network hierarchy consists of Main canal – Branch canal-Distributary-Lateral-sub lateral, etc. and may vary from one project to another project. In addition to this, irrigation potential is also created through the Direct Pipe Outlets (DPOs) from Main canal / Distributary, etc.

THE METHOD FOR ESTIMATION OF IP UNDER VARIOUS CANALS

- If the satellite derived canal length and chainage is found to be comparable and there are no cross drainage structures ending / under construction indicating hydraulic flow continuity, then it is considered as **irrigation potential creation is complete** under that particular canal.
- If the distributary wise satellite derived canal network is found with anomalies in terms of length (like shortening) either due to incomplete canal structures, pending work incomplete cross drainage / irrigation structures, then that canal wise Irrigation Potential (IP) is considered as **incomplete.**
- If the minor is observed to be completed as proposed, the designated IP is then considered as created. Further, if minor is incomplete due to any reasons as explained earlier in this section, the irrigation potential created is estimated proportionally **based on the hydraulically connected length of Minor.**
- All the irrigation potential values of **minors and DPOs** which are hydraulically connected and completed are summed up to arrive at the total IP created under the **distributary.**
- All the irrigation potential values of **Distributaries an DPOs** which are hydraulically connected and completed are summed up to arrive at the total IP created under the **Main canal**.
- All the irrigation potential values of **Main Canals and DPOs** which are hydraulically connected and completed are summed up to arrive at the total IP created under the **Branch Canal.**
- All the irrigation potential values of Branch Canals and DPOs which are hydraulically connected and completed are summed up to arrive at the total IP created under the Irrigation Project.

ASSESSMENT OF IRRIGATION POTENTIAL

Based on the above satellite based inventory of canals and structures information and their status, the Irrigation Potential (IP) created in the study area was assessed as given below:

- The distributary wise satellite derived canal network is inspected in a ***hierarchical sequence*** for ***hydraulic flow continuity or discontinuity***, anomalies in terms of length and absence of a particular canal altogether (Minor / Sub-minor etc), if any. This information is compared with proposed canal network information supplied by project authorities (Revenue Survey project maps, T-diagrams and Statements showing canal chainage, CCA, Irrigation intensities and IP created).
- If the distributary wise satellite derived canal network is found ***comparable and there are no Cross-Drainage*** (CD) and other irrigation structures pending / under construction indicating hydraulic flow continuity, then that distributary Irrigation Potential (IP) is considered as completed. The IP created is taken as proposed Irrigation Potential (estimated based on ICA and irrigation intensity) of the distributary.
- If the distributary wise satellite derived canal network is found with ***hydraulic flow discontinuities*** either due to incomplete canal stretches or due to incomplete structures, then that distributary (IP) is considered as incomplete. Then the IP created under that distributary is assessed by aggregating the IP of various canals up to that point (from the off take point of distributary/minor/sub-minor) including ***Direct Pipe Outlets*** (DPO's) on distributaries.
- If the distributary wise satellite derived canal network is found with ***anomalies in terms of length*** (like shortening) either due to pending work or terrain conditions, then that distributary Irrigation Potential is considered as incomplete. Then the IP created under that distributary is assessed by aggregating the IP of various canals up to that point (from the off take point of distributary/ minor/sub-minor) including Direct Pipe Outlets (DPO's) on distributaries.
- The ***balance Irrigation Potential*** (IP) is assessed as the difference between proposed IP and IP created under each distributary.
- Though balance Irrigation Potential (IP) is assessed as above, the canal network completed beyond the points of hydraulic discontinuity and canal length anomalies

were also mapped and reported.

The satellite data assessed irrigation potential using the above methodology is compared with the field reported irrigation potential estimates and the balance Irrigation Potential thus assessed at Distributary level, Branch Canal and Project level is reported and discussed in the following sections.

For easy understanding let us see some examples.

EXAMPLE- 1

Proposed **IP** = 250 ha

Proposed length : 3km

Satellite derived : 2.5lkm

(canal is not connected to main)

Satellite derived IP= 250 ha* 0/3.0 =0 ha

Status: **Incomplete** – Not connected to Distributary

EXAMPLE- 2

Proposed **IP** = 150 ha

Proposed length : 2km

Satellite derived : 1.5lkm

(canal is complete up to 1km, and hydraulically connected)

Satellite derived IP= 150 ha* 1.0/2.0 = 75 ha

Status: **Incomplete**

DPO 2 (25 ha)

Total proposed I. P = 425 ha

Result: *Total IP created*= IP from minor 1 + Minor 2 + DP) =0+ 75 +25 =100 ha

Please Note:

1) All the IP values of minors and DPOs which are hydraulically connected and completed are summed up to arrive at the total IP created under the minor.

2) If there are no DPOs, the IP created is estimated proportionally based on the hydraulically connected length of the canal.

Some commonly used terms are given below for easy understanding of the GIS procedure.

LEXONOMY

Ancillary Data- Secondary data pertaining to the study area, such as topographic, demographic, climatology, etc.,

Band - A wavelength interval in the electromagnetic spectrum.

Command Area- represents the area irrigated or capable of being irrigated either by gravitational flow or by lift irrigation or by any other method and includes every such area by law in force in the State; also referred as ayacut.

Cross Drainage structures -are structures constructed across canals for passing the drain include super passage, Pipe culvert, depressed hume pipe culvert, aqueducts.

Cultivable Command Area (CCA)- is the portion of the Gross Cultivable Area, which is cultivable.

Digital image- is an image where the property being measured has been converted from a continuous range of analogue values to a range expressed by a finite number of integers, usually recorded as binary codes from 0 to 255, or as one byte.

Digitization- Process of converting an analog display into a digital display

Distributary- is the tertiary artery of the canal water delivery system. It takes off from the main canal.

Field Channel- is the tertiary irrigation unit which takes off from an outlet to deliver water to individual farm fields or a group of farm fields.

Geometric Correction- Image processing procedure that corrects spatial distortions in an image

Gross Command Area (GCA)- is the total area, which can be irrigated in a project command. It includes the area covered by roads, culverts, settlements, uncultivable area etc.

Ground Truth- The purpose of ground investigation in remote sensing is to give the investigator or operational user a realistic portrait of the target. These ground observations (called 'ground truth') are necessary in both research and operational applications.

Intensity of Irrigation- is the ratio of the actual area irrigated in a season to the total cultivable command area; expressed as %.

Interpretation- The process in which a person extracts information from an image.

Irrigation infrastructure- is the structures constructed in an irrigation project to create irrigation potential include canal network , head regulator, cross regulator, canal off-take structures, cross drainage structures, drop structures, roads, road bridges, cart bridges, and foot bridges, etc.

Minor- is ***fourth*** artery of the canal water delivery system. It takes off from the distributary and can be a ridge canal irrigating on both sides. It is also sometimes referred as lateral.

Orbit- is the path traced out by a satellite in space as it moves around the earth.

Path-Row- Index-System for locating satellite remotely sensed images.

Pixel- Picture element-In a digitized image, the area on the ground represented by each digital number

Sub Minor- is ***fifth*** artery of the canal water delivery system. It takes off from the minor or Lateral and can be a ridge canal irrigating on both sides. It is also sometimes referred as sub-lateral.

RESOLUTION

Resolution is defined as the ability of discrimination of the smallest object by a sensor. Resolution of a remote-sensing is of different types.

- **Spectral Resolution**: is determined by the band-widths of the electro-magnetic radiation of the channels used. High spectral resolution, thus, is achieved by narrow bandwidths width, collectively, are likely to provide a more accurate spectral signature for discrete objects than broad bandwidth.
- **Radiometric Resolution**: is determined by the number of discrete levels into which signals may be divided.

- **Spatial Resolution**: in terms of the geometric properties of the imaging system, is usually described as the Instantaneous Field of View (IFOV). The IFOV is defined as the maximum angle of view in which a sensor can effectively detect electro-magnetic energy.
- **Temporal Resolution**: is related to the repetitive coverage of the ground by the remote-sensing system.

NB: Q-GIS 1.8 Lisboa** can be down loaded from **Google** just writing the term in it. Many **Plug-ins** for free of cost can be downloaded from net for different uses. Here we will be using **Q-GIS 1.8 Lisboa for hands on. If required the add-on plug ins will be added to the Q-GIS platform for acquiring the details.

The CARTOSAT image will be used for the Jurala Irrigation Project, which consists of identifying all the features like canal, roads, railway, reservoirs, rivers, Cross drainage structure, etc by digitization, and matching it with the field data for any discrepancy and reporting the results.

MAPPING THE INFRASTRUCTURE AND CANAL CONVEYANCE AND DISTRIBUTION SYSTEM

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INTRODUCTION

In this session, the entire canal conveyance and distribution system, various irrigation & drainage structures you are required to map in GIS. For accomplishing the work you are to know about the AIBP components and the part of work completed from the project authorities. The data for which has already been supplied by NRSC collecting from the Project authorities. Below is the flowchart methodology for doing the mapping. We will only be considering irrigation project for which data is supplied for mapping within the 5 days training time frame.

INTERPRETATION ELEMENTS

The following eight elements are mostly used in image interpretation; size, shape, shadow, tone, color, texture, pattern and associated relationship or context.

(1) **Size**:

A proper photo-scale should be selected depending on the purpose of the interpretation. Approximate size of an object can be measured by multiplying the length on the image by the inverse of the photo-scale.

(2) **Shape**:

The specific shape of an object as it is viewed from above will be imaged on a vertical photograph. Therefore the shape looking from a vertical view should be known. For example, the crown of a conifer tree looks like a circle, while that of a deciduous tree has an irregular shape. Airports, harbors, factories and so on, can also be identified by their shape.

(3) **Shadow**:

Shadow is usually a visual obstacle for image interpretation. However, shadow can also give height information about towers, tall buildings etc., as well as shape information from the non-vertical perspective-such as the shape of a bridge.

(4) **Tone**:

The continuous gray scale varying from white to black is called tone. In panchromatic photographs, any object will reflect its unique tone according to the reflectance. For example dry sand reflects white, while wet sand reflects black.In black and white near infrared infrared photographs, water is black and healthy vegetation white to light gray.

(5) **Color**:

Color is more convenient for the identification of object details. For example, vegetation types and species can be more easily interpreted by less experienced interpreters using color information. Sometimes color infrared photographs or false color images will give more specific information, depending on the emulsion of the film or the filter used and the object being imaged.

(6) **Texture**:

Texture is a group of repeated small patterns. For example homogeneous grassland exhibits a smooth texture, coniferous forests usually show a coarse texture. However this will depend on the scale of the photograph or image.

(7) **Pattern**:

Pattern is a regular usually repeated shape with respect to an object. For example, rows of houses or apartments, regularly spaced rice fields, interchanges of highways, orchards etc., can provide information from their unique patterns.

(8) **Associated relationships or context**:

A specific combination of elements, geographic characteristics, configuration of the surroundings or the context of an object can provide the user with specific information for image interpretation.

INTERPRETATION KEYS

The criteria for identification of an object with interpretation elements are called an **interpretation key**. The image interpretation depends on the interpretation keys which an experienced interpreter has established from prior knowledge and the study of the current images. Generally, standardized keys must be established to eliminate the differences between different interpreters.

The eight interpretation elements (size, shape, shadow, tone, color, texture, pattern and associated relationship), as well as the time the photograph is taken, season, film type and photo-scale should be carefully considered when developing interpretation keys. Keys usually include both a written and image component.

An **image interpretation** map is usually produced by transferring the interpreted information to a base map which has been prepared in advance. The requirements of the **base map** should be as follows.

(1) Proper map scale to enable appropriate presentation of interpreted information
(2) Geographic coordinate system to establish the geographic reference
(3) Basic map information to be printed in light tones as background which results in enhancement of interpreted information

Normally a topographic map, plan map or orthophotomap is used as a base map.

A topographic map with a scale of 1:50,000, 1:100,000 or 1:250,000 is usually the preferable base map for higher resolution satellite image interpretation.

For oceanographic purposes or marine science, charts with a scale of 1:50,000 to 1:500,000 should be used as the base map.

Orthophotomaps are more easily used by cartographers for the transfer of interpreted information, particularly in the case of forest classification.

The methods of transfer of information to a base map, are as follows.

(1) Tracing

The interpreted image is traced on to a base map by overlaying on a light table.

(2) Optical projection

The interpreted image is projected via a lens and a mirror onto a base map. The optical zoom transferscope or mirror projector is very useful for image interpretation.

(3) Grid system

Grid lines are drawn on both an image and a base map. Then the interpreted information in a grid on the image is transferred to the corresponding grid on the map.

(4) Photogrammetric plotting

Aerial photographs are interpreted into a thematic map using a photogrammetric plotter.

MONITORING OF IRRIGATION PROJECTS USING BHUVAN WEB SERVICES

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INTRODUCTION

Monitoring and evaluation of irrigation projects must play a more important role in the future if the irrigation management process is to be improved. The process is complex, since a large number of regular, specific tasks must be performed, both concurrently and sequentially, and coordinated by a variety of professionals within available time and resource constraints. For any evaluation to be used, it must be credible- objective, accurate, and fair. Reports should be clear, unambiguous, balanced in terms of strengths and weaknesses, and contain justifiable conclusions and recommendations. For monitoring and evaluation to succeed, irrigation managers need to develop a new evaluative mind-set that enables them to appraise their projects' performance objectively, reflect on what has been learned for future use, and adjust policies on the basis of that knowledge whenever necessary.

The gainful use of high resolution **CARTOSAT** satellite data for inventory of Irrigation Infrastructure (canal network, conveyance & distribution system), assessment of progress of Irrigation works, closer visualization of spatial irrigation utilization patterns, assessing the impact of irrigation developmental programme on the performance of irrigation command and to address the performance at Water Users level in the participatory irrigation management approach.

DEFINITION OF MONITORING AS PER CWC

Monitoring is the process of collecting information about the actual execution of planned tasks and factors, which might affect their execution; analyzing these in relation to the plan and exercising control, so that the deviations from the plan are minimal. This helps the central authorities to assess the real work done up to a time, so that necessary advises can be given to project authorities.

OBJECTIVES OF THIS TRAINING PROGRAMME

i.) Monitoring of Priyadarshini Jurala Project, Andhra Pradesh through spatial technique

ii.) Digital Image processing involved in the process of monitoring of irrigation projects through Remote Sensing and GIS

iii.) Assessment of irrigation potential created up to April 2007 using Cartosat high resolution satellite data and Identification of gap / critical areas in I.P creation

iv.) Inventory and Mapping of Irrigation Infrastructure consisting of canal network, cross drainage and other irrigation structures

v.) Assessment of Irrigation Potential (I.P) created as on April, 2007 as the data corresponds to April 2007.

Details of Methodology

Basic approach involved in the study consists of inventory and mapping of existing irrigation infrastructure viz. canal network, irrigation and other related structures from the Cartosat satellite data in a irrigation project and comparing with proposed irrigation infrastructure. Based on the completed irrigation infrastructure derived from the cartosat-1 satellite data and considering the hydraulic connectivity, the Irrigation Potential created in the project command
is assessed. Brief description of methodological steps involved in the study area given below:

(a) Overview of Methodology

1. Field data collection: Collection of preliminary and detailed field data consisting of map(s) showing proposed canal network and canal wise CCA/ICA, I.P proposed, I.P created as on March 2009 or any other date as required by the project .

2.Cartosat data acquisition planning and procurement : Preparation of AIBP component polygon shape file(s) using the field maps to plan for acquisition of fresh Cartosat satellite data
during April 2010 - June 2010 for all the projects (both completed / ongoing) . In case atellite data is not available, either for total project during the above period, the time window will be extended beyond Jun, 2011 till it is covered for completely ongoing projects. For completed projects, in addition to the above, the archived Cartosat data from April 2008 onwards will also be utilized.

3. Field database creation: Preparation of field database on irrigation infrastructure and Irrigation Potential information

4. Cartosat database creation: Edge matching and mosaic of Cartosat satellite data tiles and preparation of satellite database.

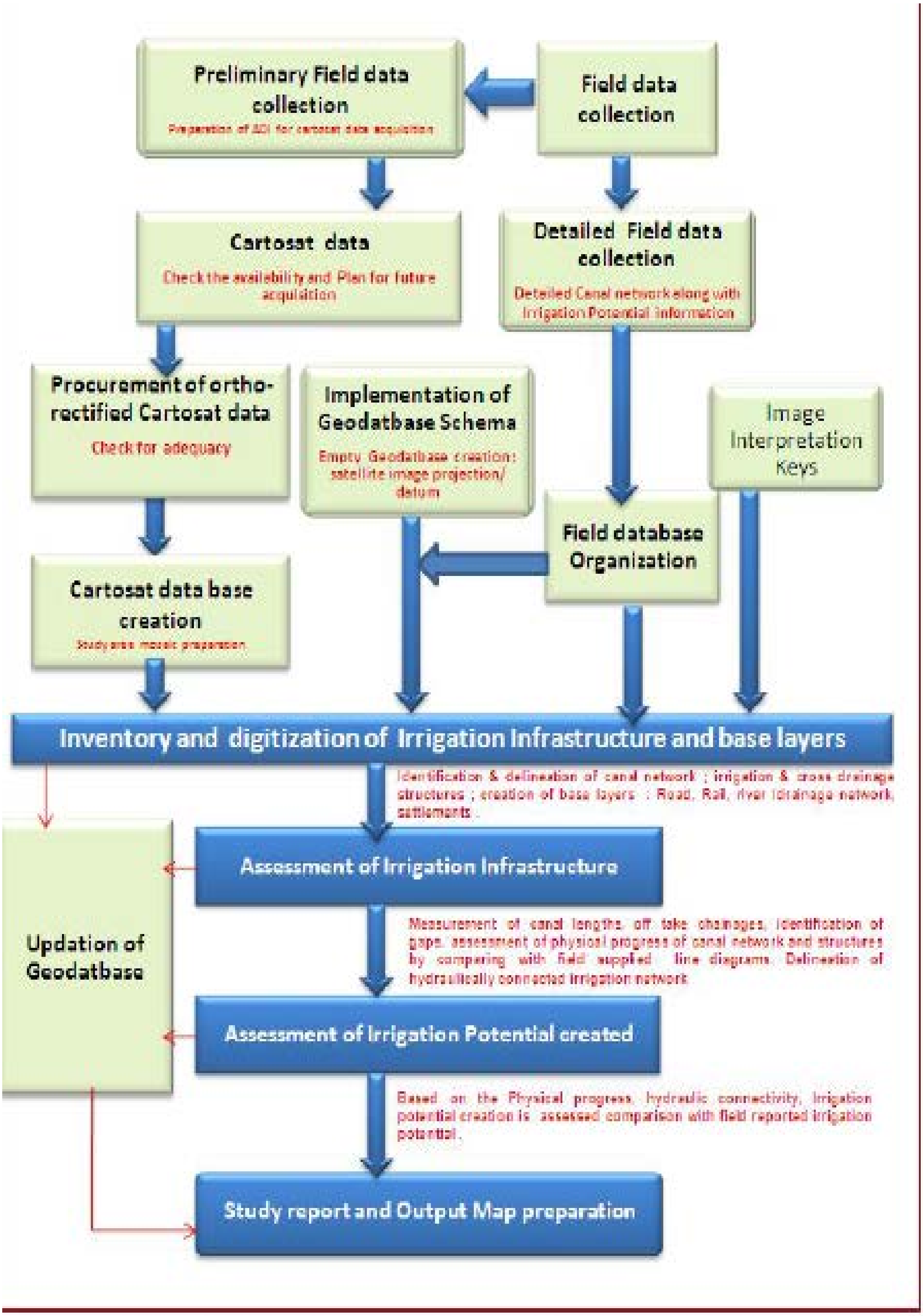
5. Geo-database creation: All the vector layers (Irrigation Infrastructure and base layers) along
with attribute information will be developed in GIS environment using geo-database schema developed for the project.

6. Inventory and mapping of Irrigation Infrastructure and base layers : Identification and mapping of existing Irrigation Infrastructure consisting of Irrigation canal network up to Minor /Sub-Minor level, Cross drainage, Irrigation and other structures as on the date of satellite overpass date. Identification and mapping of base layers consisting of study area boundary, rivers, streams, roads, railway lines, settlements, balance I.P polygons etc.

7. Assessment of Irrigation Infrastructure and Irrigation Potential created: Comparison of satellite derived information with proposed Irrigation infrastructure to create planned I.P under AIBP. Assessment of Irrigation Potential (I.P) created based on the extent of accomplishment in irrigation canal network creation with hydraulic flow continuity as on the satellite data acquisition date. Finalization of assessment of I.P created.

8. Ground truth field visit: Conduct of random field visits to check for satellite data interpretation.

9. Preparations of Outputs: Preparation of output map along with study report; Preparation of digital data backup for supply to user. Flow chart showing the over view of the methodology is provided here.



Process flow chart for the Irrigation Potential assessment

The **Inputs / Parameters** required from the **field data** and **satellite data derived irrigation infrastructure** information are:

1. **Proposed length** of canal.
2. **Satellite derived Lengths** ; Physical progress of canal construction for the corresponding canal.
3. Irrigation potential proposed under each canal .
4. **Gaps** existing in different stretches of the canal network,
- Number of gaps and gap lengths, their chainages – derived hydraulically connected length of a particular canal .
5. Number of **DPOs**, their contribution to the **irrigation potential** as per field data; their **chainages** – to assess the hydraulic connectivity .

The **steps to be followed** for the satellite based assessment of irrigation potential creation: Irrigation potential assessment is made based on physical status of canal and its hydraulic connectivity to the source of irrigation. As explained earlier, canal network hierarchy consists of Main canal – Branch canal-Distributary-Lateral-sub lateral , etc and may vary from one project to another project. In addition to this, irrigation potential is also created through the Direct Pipe Outlets (DPOs) from Main canal /Distributary, etc. Various scenarios that one would come across in different irrigation projects are briefly explained.

(Details of methodology has been described in NRSC manual).

GROUND TRUTH

The ground truth photographs have been taken from the actual site and have been compared with the corresponding images to have a clear visualization.

CONCLUSION

The endeavour of bringing together the this monitoring of Irrigation projects using online monitoring, the direction and decisions in this domain will shape our future in monitoring real time scenario of any irrigation projects with no software cost. The free plug ins can be loaded to the G-GIS to have a smart way of analyzing things.

AUTO REPORT ON ASSESSMENT OF PHYSICAL STATUS AND IP USING ARCPY

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&
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NWA, CWC, Pune

Introduction

The powerful visual and analytical capability of GIS together with high resolution satellite data makes it a very useful tool in assessing, managing and monitoring resources and responsibilities more efficiently. NRSC, ISRO has successfully corroborated its utility in the assessment of irrigation potential created through inventory of irrigation infrastructure derived from satellite data.
ArcPy is a site-package (site-package is the location where 3rd party packages are installed) that builds on the successful ArcGIS-scripting module. This package provides rich Python experience and is powerful enough to write large applications.

This work is done to explore the power of ArcPy in automatizing the complex GIS processes of assessing physical status, hydraulic connectivity and Irrigation Potential created and their comparison with the proposed design. In this lecture, the capability of ArcPy is demonstrated to generate a report on the monitoring of irrigation projects in Arc GIS platform.

Objectives

The present study has following objectives:

- To explore the potential of ArcPy in automatizing the complex and time consuming GIS processes.
- To create handy tools using ArcPy to assess physical status, hydraulic connectivity and Irrigation Potential created and their comparison with the proposed plan.
- To encompass the feature of auto-report generation for idealistic conceptualization of irrigation project monitoring in order to synoptize the manual effort.

Data Used

Spatial Data:
Satellite imagery, shapefiles of canal network, DPO, hydraulic structures and disconnected points/gaps.

Ancillary Data Used
Table showing proposed length and IP of canals and DPOs were used.

Methodology

The methodology followed in this study is summarized in Figure 1 and explained in detail later.

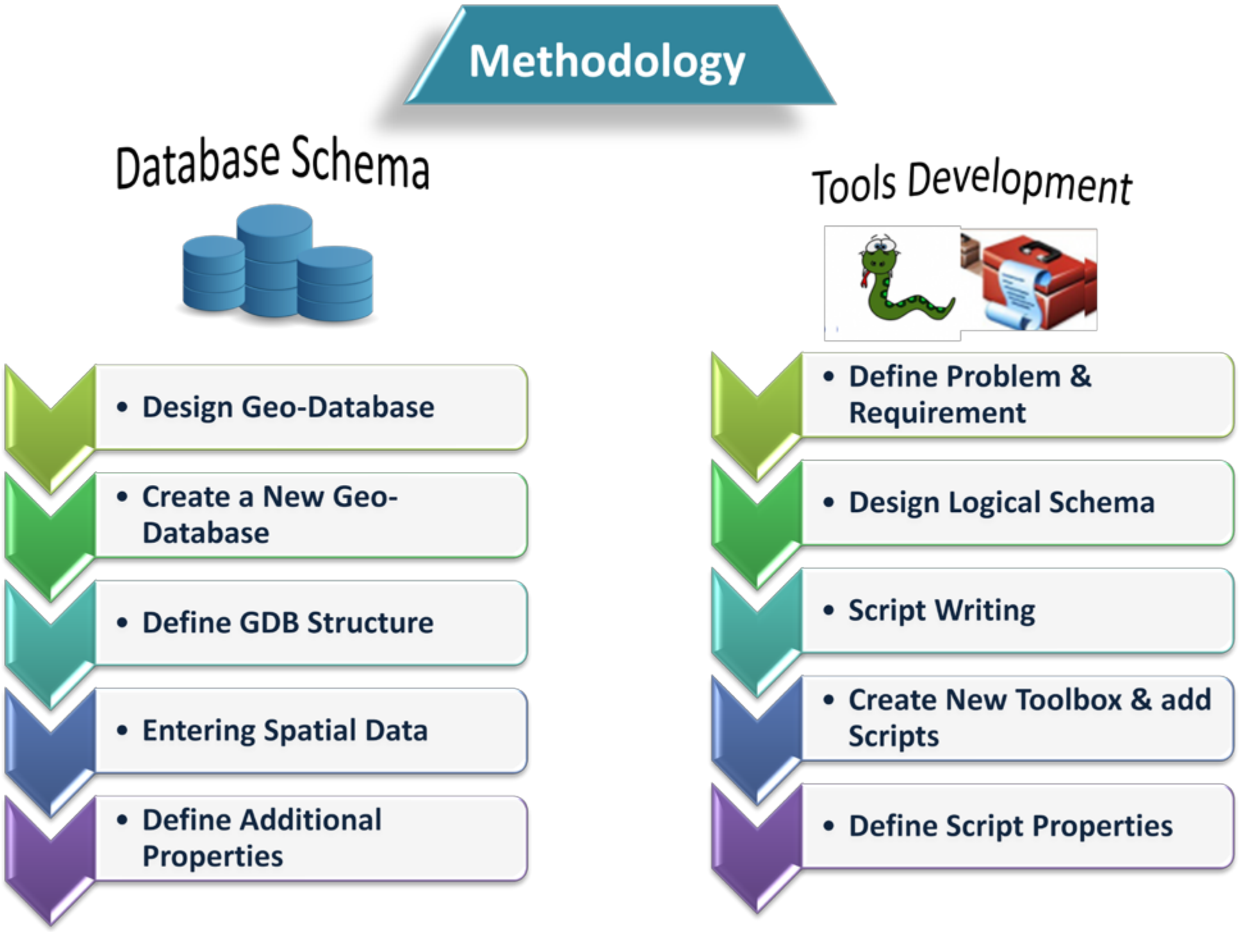


Figure 1 Conceptual Flow Chart

- ***Database Schema Development***

It involves following steps.

Design Geo-database

Designing a geo-database (GDB) involves conceptual planning for current and future needs of data contents and their logical grouping, selection of coordinate system, topological and modification rules. Logical data groups for this project are shown in Figure 2.

Create a New Geo-Database and defining its structure

A new file geodatabase is created in ArcCatalog. For this project, one GDB, one feature dataset which will contain all the feature classes, one high resolution satellite image and dBase tables are added in new geodatabase.

Feature dataset is required for creating topology between or among the feature classes.

Logical Data Groups	Data Layers	Spatial Type	ArcInfo Type
Imagery	**High resolution Satellite Image**		**Raster**
Planimetric	**Canals**	**Line**	**Line Feature**
	Direct Pipe Outlets (DPO)	**Point**	**Point Feature**
	Hydraulic Structures	**Point**	**Point Feature**
Proposed attribute data	**Canals**	**-**	**Geo-database Table**
	DPO		

Figure 2 Logical Data Groups

Enter spatial and non-spatial data

After creating GDB and its structure, next step is to enter data either by adding new one or by importing existing data from other locations. Digitization of canals should be done following flow the direction of canals. Set spatial reference which includes coordinate system, spatial domain and precision. All feature classes within a feature dataset should share the same spatial reference. These steps are elucidated in Figure 3.

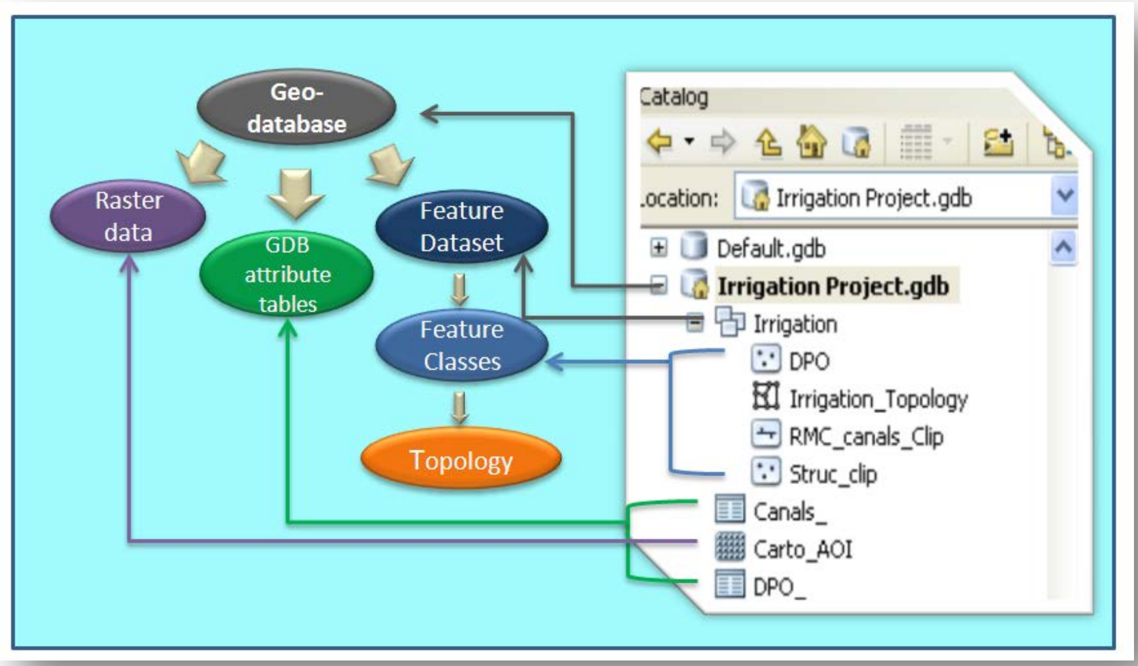
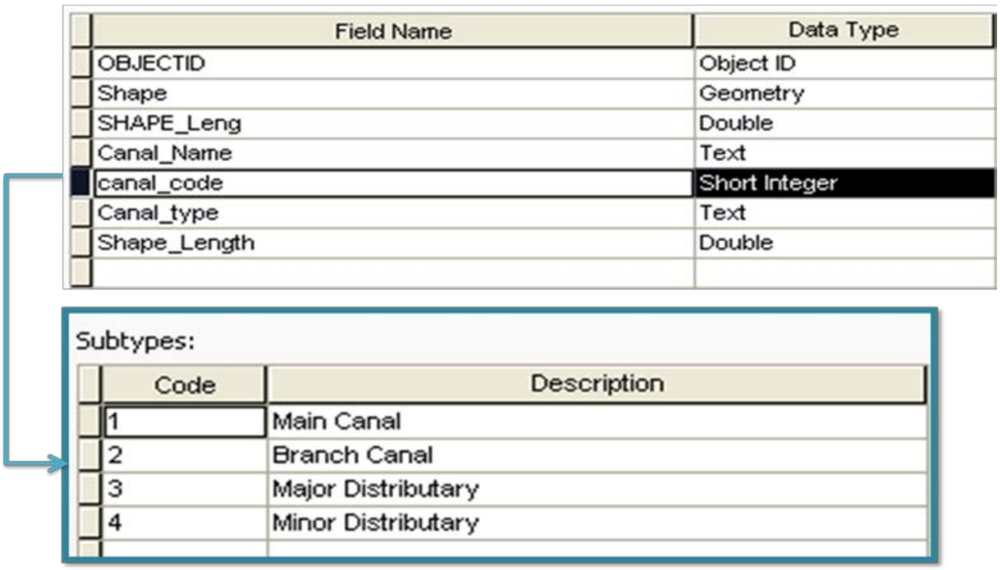


Figure 3 Creation of new geo-database

Define Additional Properties

Subtypes create subclasses of a feature class that allow separate identity of subclasses without creating new feature classes. In this project we also require to have subclasses of canals as separate identity for display purpose. See Figure 4.



Field Name	Data Type
OBJECTID	Object ID
Shape	Geometry
SHAPE_Leng	Double
Canal_Name	Text
canal_code	Short Integer
Canal_type	Text
Shape_Length	Double

Subtypes:

Code	Description
1	Main Canal
2	Branch Canal
3	Major Distributary
4	Minor Distributary

Figure 4 Creating Subtypes of Canals

Point features (Hydraulic structures, disconnected points/Gap and DPOs) should coincide with line features (canals). Therefore, it is essential to build topological relationship and assign topology rules. Participating feature classes and their ranks, cluster tolerance and topology rules are shown in Figure 5.

- ***Tools Development***

It involves following steps:

Problem Definition

The assigned task in simple term is to develop a tool using ArcPy to check the progress and physical status of canal infrastructure, hydraulic connectivity and to calculate irrigation Potential (IP). It seems very simple but programmatically it is a bit complicated. It involves following complexities (also see Figure 6 for reference):

- How to find disconnected canals from point feature class (Hydraulic gaps)?
- If one canal gets disconnected, its all subsequent canals from that disconnected point/gap get disconnected. How to find these subsequent canals?
- How to calculate length of a canal up to the disconnected point?
- How to find disconnected Direct Pipe Outlets (DPO)?

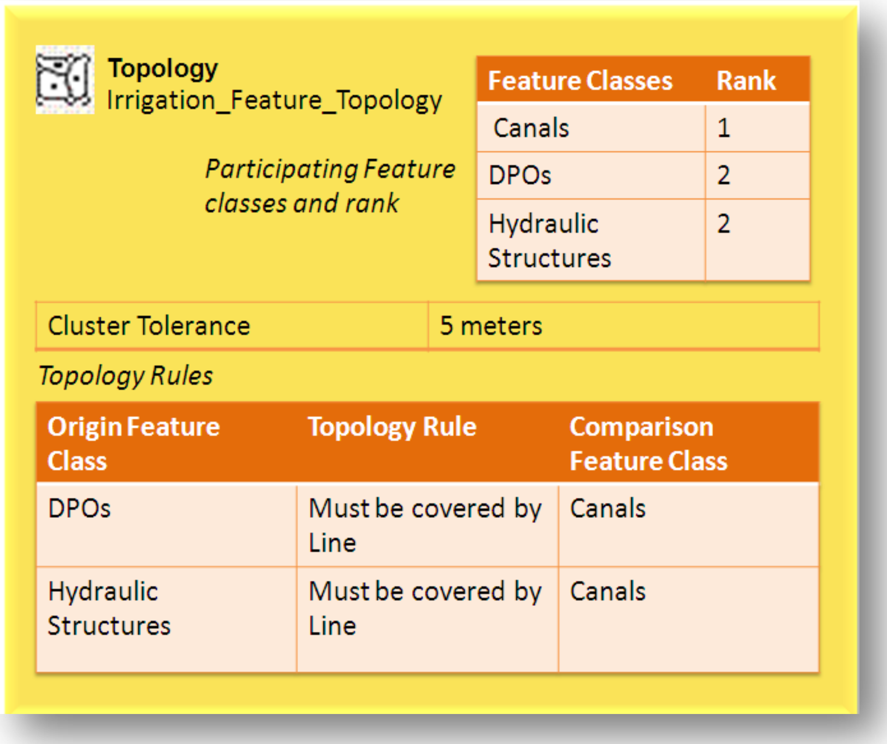


Figure 5 Topological Relationship

Design Logical Schema

After comprehending the problems associated with this task, an outline of logical steps were prepared. These steps are as follows (also see Figure 7):

- Get starting points (XY coordinate) of each canal.
- Split Canals at Gap points (it will split the canal on which gap point coincide)
- Using disconnected split canals get the coincident start points.
- These coincident start points are used to identify their respective canals.
- This process iterates till all the disconnected subsequent canals are identified.
- These disconnected canals are then used to find the disconnected DPOs.

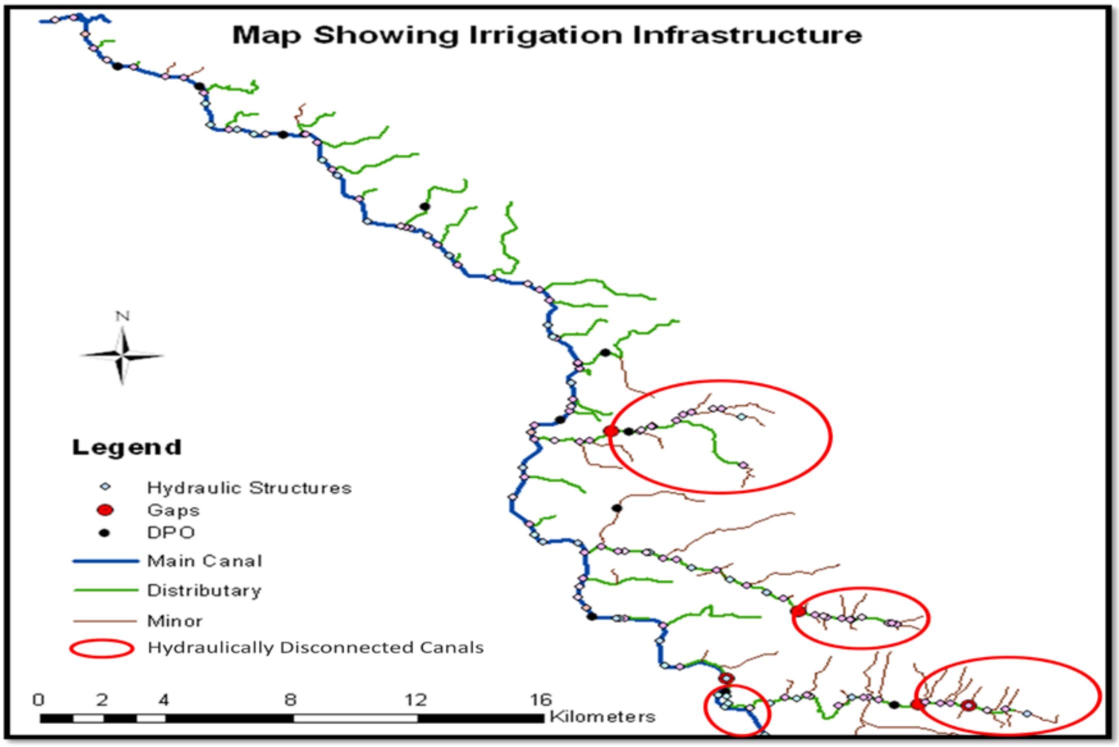


Figure 6 Map showing Irrigation Infrastructure

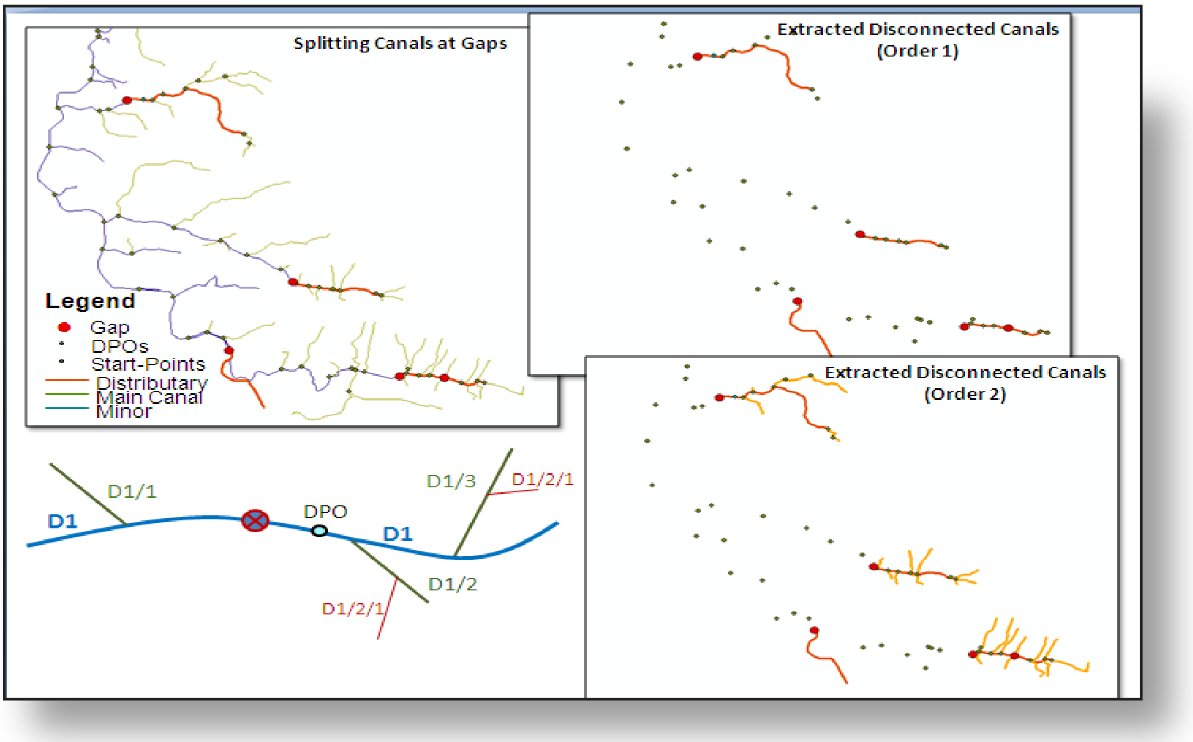


Figure 7 Logical Schema for script writing

Script writing

Using this logical schema stand alone scripts are written using ArcPy modules in pythonwin IDE. Different scripts are written for different purposes. These scripts are written for:

- Joining statements of proposed length and IP (in table format) with the spatial data.
- Assessing the physical status of canals and their work progress.
- Creating a layer of Pending Canals
- Creating a layer of hydraulically disconnected structures
- Calculating Irrigation Potential and IP balance
- Creating a layer of hydraulically connected canals
- Creating a layer of hydraulically disconnected canals

Create New Toolbox & add Scripts

A new toolbox is created in ArcCatalog and scripts are added as shown in Figure 8

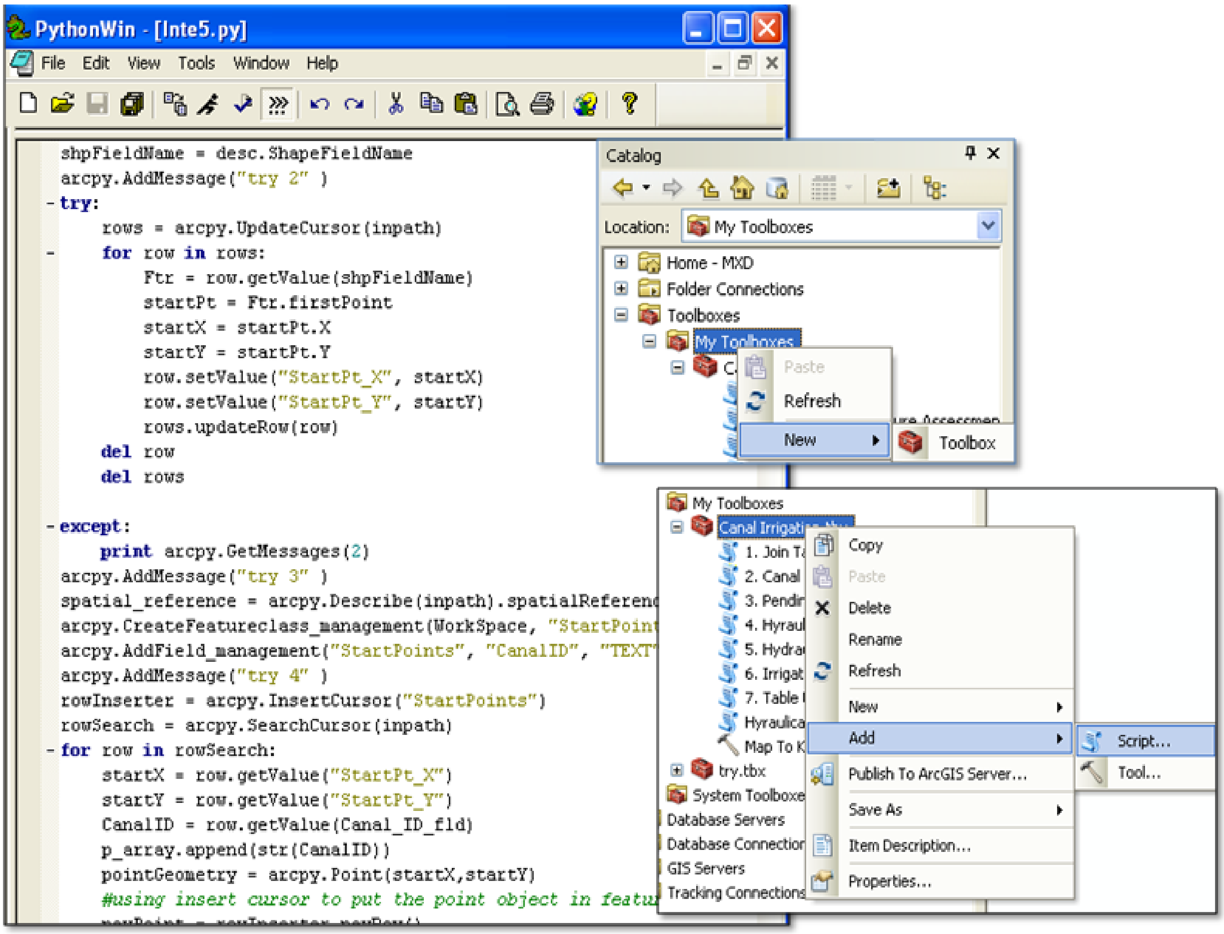


Figure 8 Steps to create new toolbox and add python scripts

Define Script Properties

After adding scripts now, the next task is to set properties. It includes assignment of name of tools, path of python stand alone script, setting of parameters properties. We can also write the description of each parameter for help section. See Figure 9

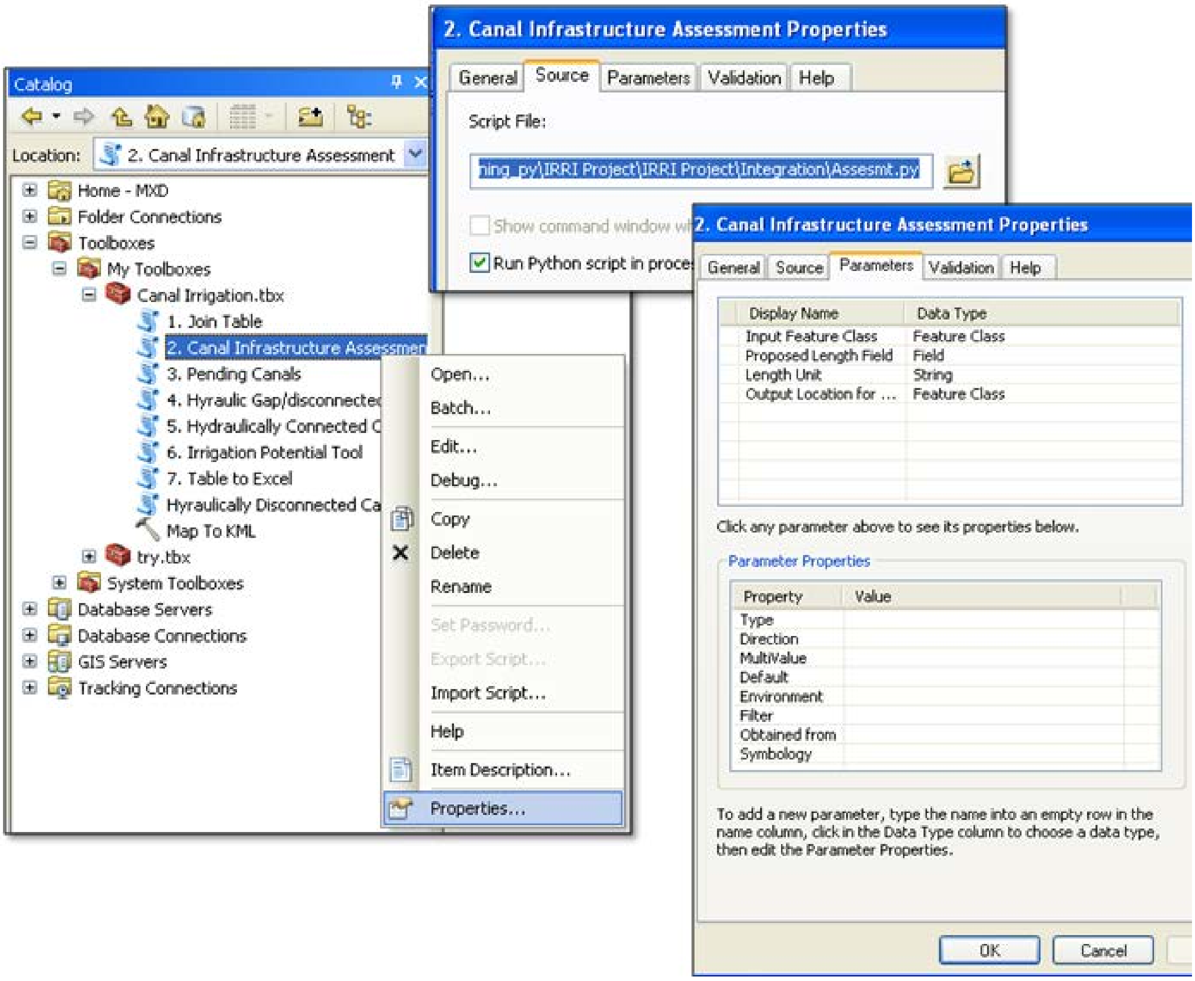


Figure 9 Setting Script Properties

Results

Total eight script tools are developed for this project. Each tool serves different purpose, output of some tools are used as an input for another tool and hence, they should be used according to their sequence. All the necessary instructions are provided in help section of script tools. Screen shot of Canal Infrastructure Assessment and Irrigation Potential tools are shown.

Canal Infrastructure Assessment tool takes less than one minute to run (for the present study area), adds new fields viz. length difference (difference between proposed and calculated length), critical percentage (97% for short canals(<50km) & 98% for long canals(>=50%)), work done in percentage and physical status (pending or complete). Attribute data containing value of proposed length must be joined before providing input to this tool. After running this tool input can be used to create a layer of pending canal using Pending Canals tool. This produced layer can be used for visualization. See Figure 11

Figure 10 Screen Shot of Developed Tools

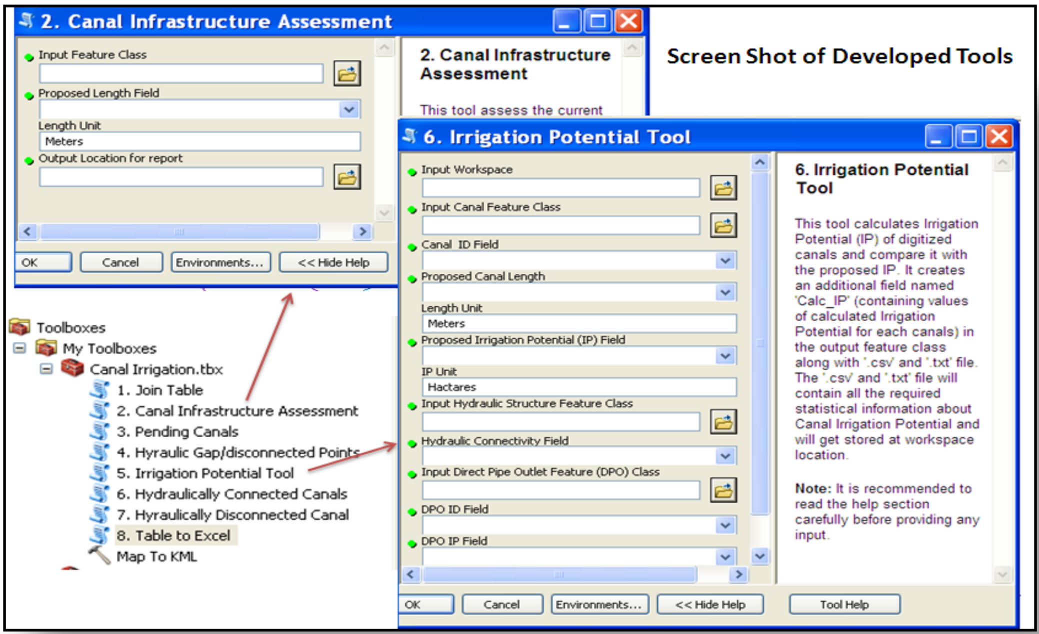
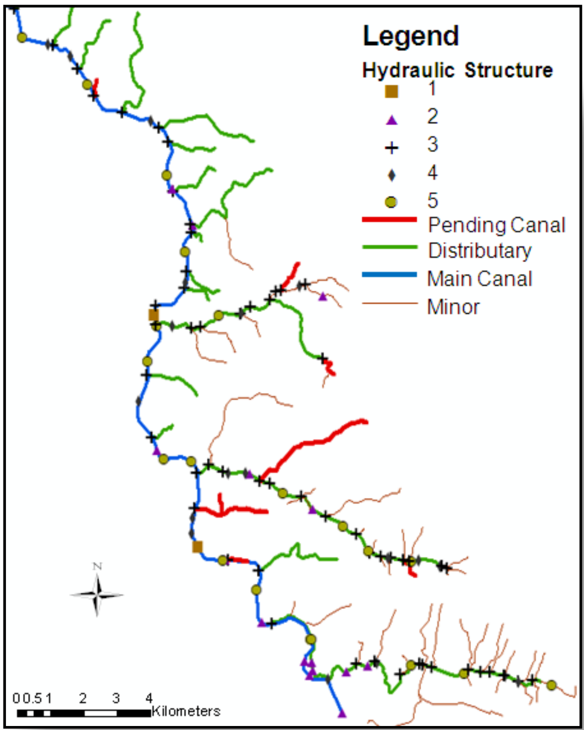


Figure 11 Map highlighting pending canals



Irrigation Potential tool takes around one and half minutes to run (for the present study area), calculates Irrigation Potential (IP) and balance IP. It creates a new feature class with added fields containing values of calculated IP and balance IP. This output feature class can be further used to create layers of hydraulically connected and disconnected canals using Hydraulically Connected Canal and

Hydraulically Disconnected Canal tool respectively. These two layers can be used together for better visualization. See Figure 12.

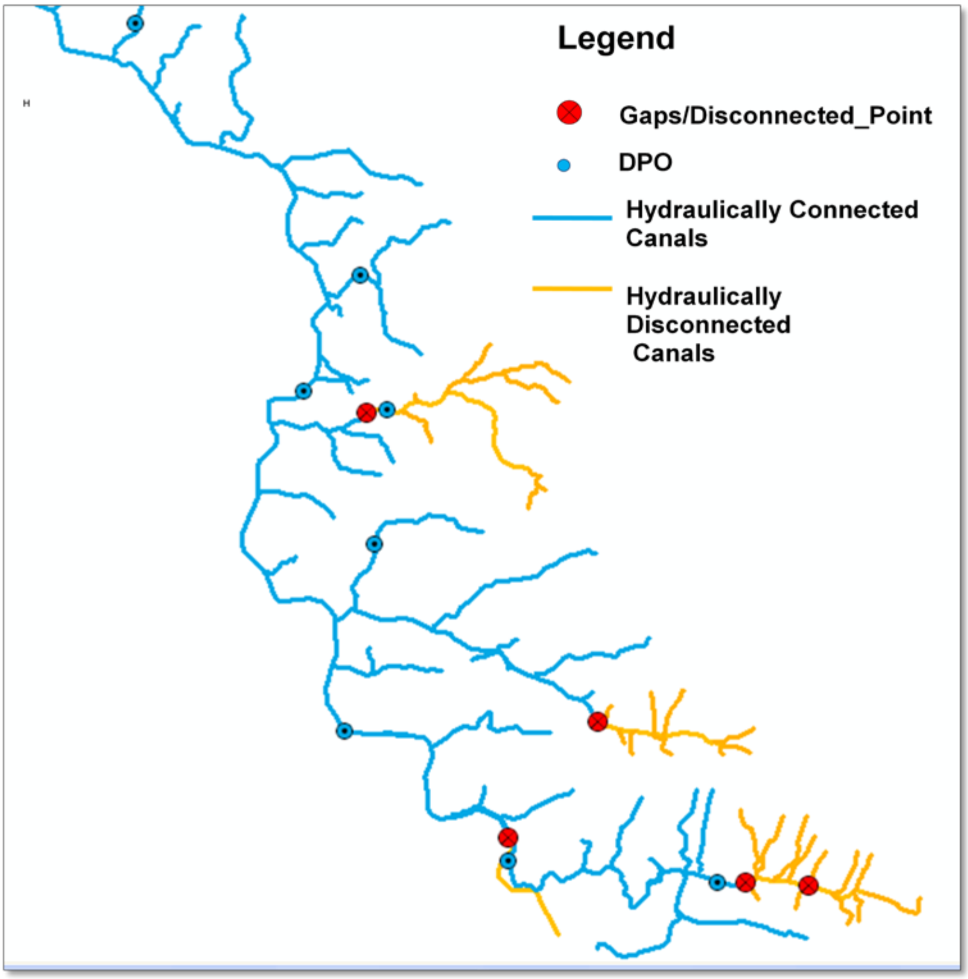


Figure 12 Map showing hydraulically connected and disconnected canals

Canal Infrastructure Assessment and Irrigation Potential tools also summarizes results in text file and copy all the fields in '.csv' (Comma Separated Value) file that can be open in excel format. This function facilitates instant auto-generation of report and reduces analysis time. These two files get stored in the provided workspace. Snap shots of repots with their icons are shown in Figure 13

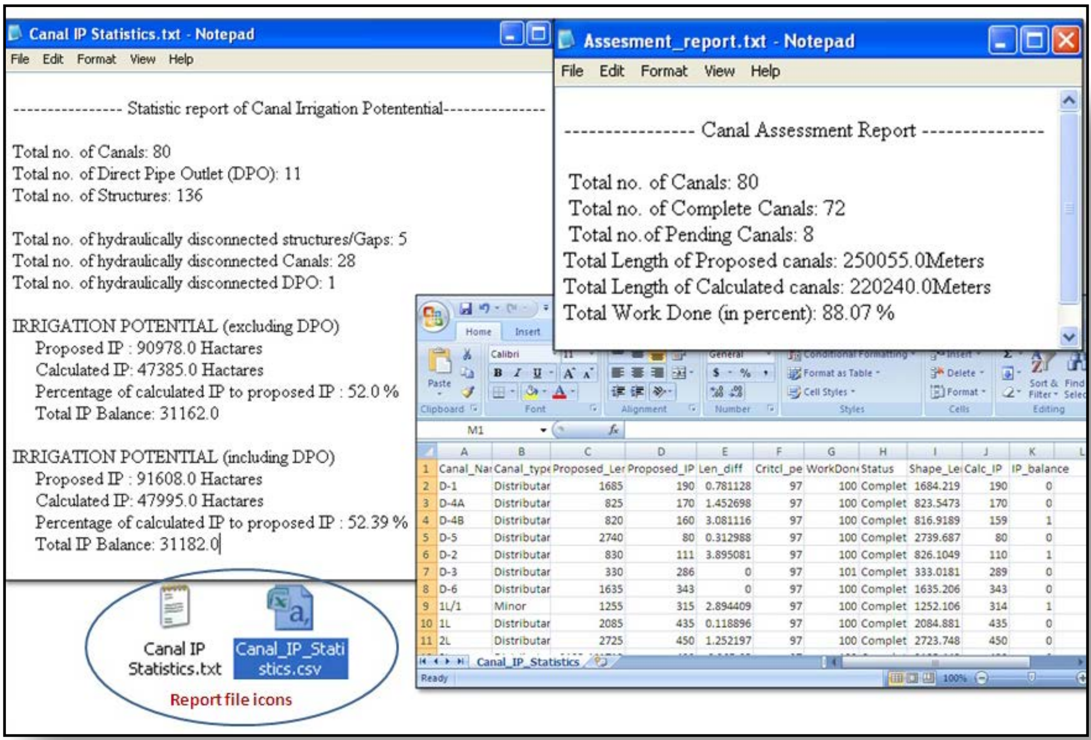


Figure 13 Snap shot of text and .csv reports

The output feature class can be converted into kml format and imported in Bhuvan or Google Earth for better visualization. The civil or hydraulic engineers can easily access all this important information using these freely available viewers. Knowing correct location of hydraulic gaps, incomplete and hydraulically disconnected canals and other structures along with the knowledge of connecting roads and affected farms, engineers can perform their tasks more efficiently. Snap shot of Google Earth is shown in Figure 14.

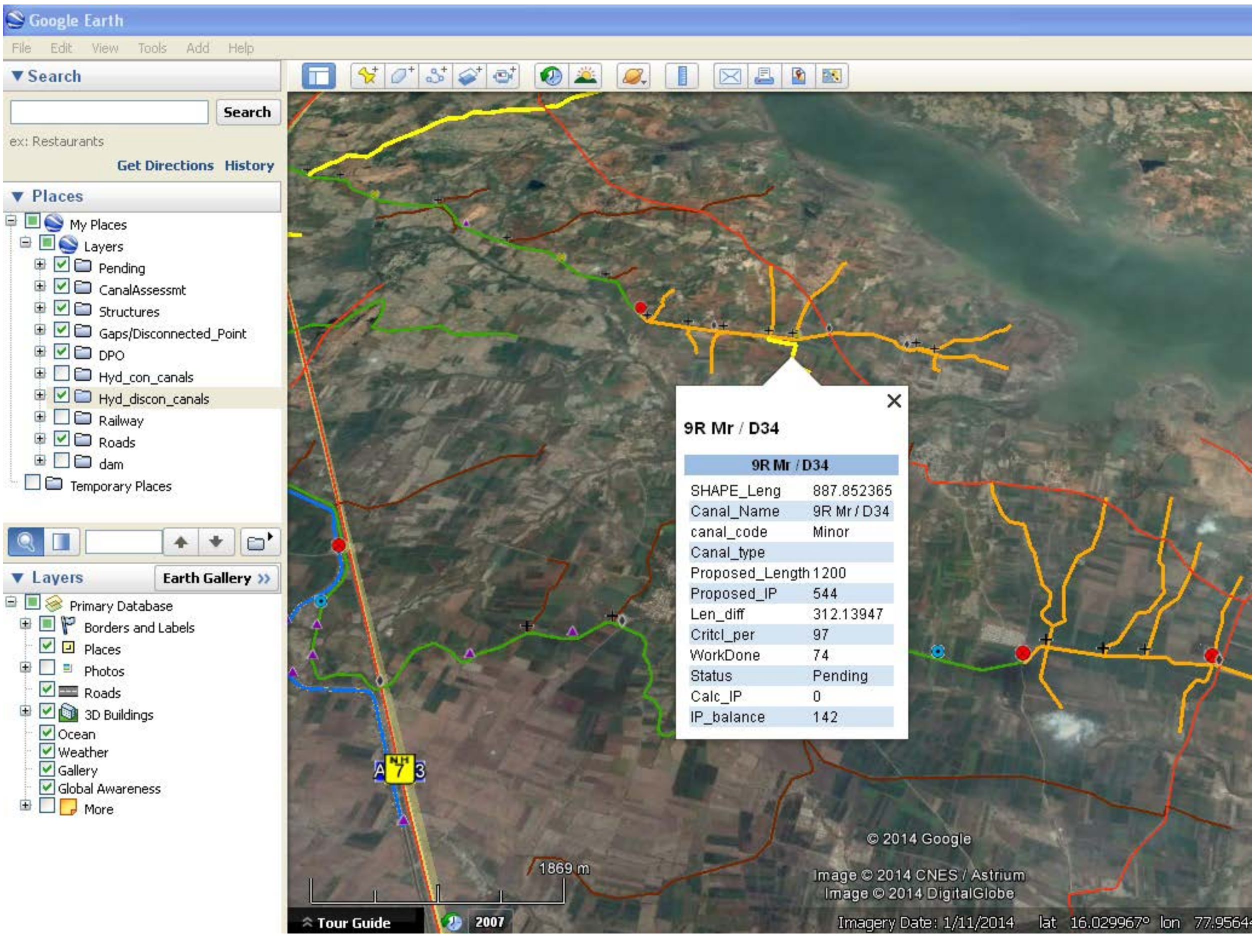
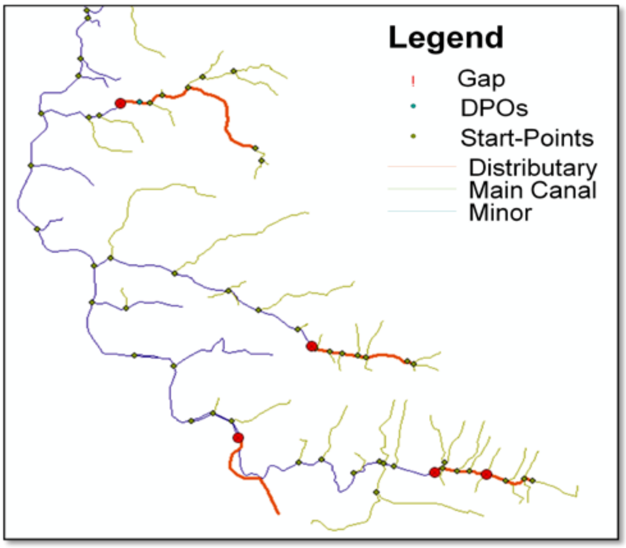


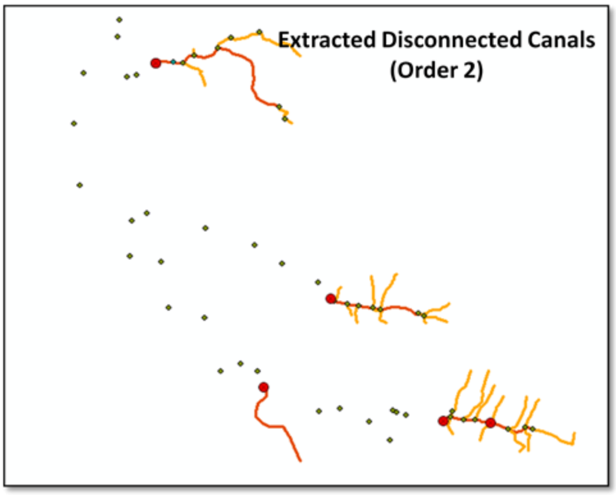
Figure 14 Visualization in Google Earth

Conclusion

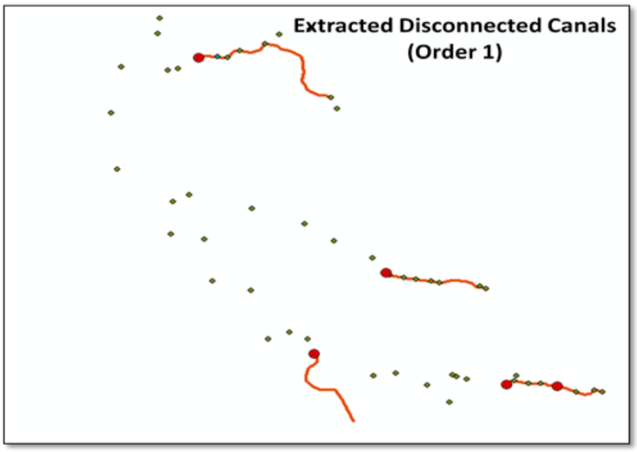
This study has explored the usefulness of ArcPy in automatizing the complex GIS processes of assessing physical status, hydraulic connectivity and Irrigation Potential created and their comparison with the proposed design. These tools encompass the feature of auto-report generation for idealistic conceptualization of irrigation project monitoring, therefore, synoptizing the manual effort.



Legend
Gap
DPOs
Start-Points
Distributary
Main Canal
Minor



Extracted Disconnected Canals
(Order 2)



Extracted Disconnected Canals
(Order 1)

nual on BHUVAN)