# Assessment of Physical status and Irrigation potential of Canals using ArcPy

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## Abstract:

High resolution satellite data and Geographic Information System (GIS) are successfully being used for inventory of irrigation infrastructure, facilitating monitoring on near real time basis, assessment of physical status and hydraulic connectivity from the source and Irrigation Potential with reference to a given time frame and proposed design. In the present study a geodatabase schema is created to organize geospatial canal irrigation data and stand-alone Python scripts are developed to create a toolset using ArcGIS library (ArcPy). 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, synopsizing the manual effort.

Keywords: Irrigation Potential, GIS, Remote Sensing, ArcPy, monitoring, tools

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Introduction

Crop yields on irrigated farms are usually 2-2.5 times greater when compared to rain-fed farms. The essentiality of irrigation has been identified by government of India long back. At present India has around 90 million hectares of its land under irrigation and the Central Water Commission has proposed to increase it by 10% by 2017. Accomplishment and maintenance of such a big project requires proper monitoring and auditing to ensure timely completion of the infrastructure and proper utilization of resources.

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 monitoring irrigation infrastructure and assessment of irrigation potential created through inventory of irrigation infrastructure derived from satellite data.

This project is done to avail the efficacy of GIS at offline desktops using ArcPy (ArcPy is a site-package that builds on the successful ArcGIS-scripting module) in automatizing the complex GIS processes of assessing physical status of canals, hydraulic connectivity and Irrigation Potential created and their comparison with the proposed design. A database schema has also been design to provide common standard for designing, structuring and grouping of input data so that data related intricacy can be avoided.

Methodology

Methodology followed in this study can be divided into two major sections:

i) Database schema development

ii) Tools development.

Database Schema Development

For this project, we require near real time digitized canals extracted from the high resolution satellite image, point data of Direct Pipe Outlets (DPO), hydraulic structures and hydraulic gap points. We also require proposed canal infrastructure data. Entering, integration and processing of spatial and non-spatial data in GIS environment needs to follow a well-defined database schema. Hence, a database schema is developed in the following manner:

Designing a Geo-database

It’s a first step that 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 Table 1.

Creating a New Geo-Database and defining its structure

A new file geodatabase is created in ArcCatalog, that should have one feature dataset which contains all the feature classes, one high resolution satellite image and dBase tables. Feature dataset is required for creating topology between or among the feature classes. These steps are elucidated in Figure 1.

Spatial and non-spatial data entry

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

Define Additional Properties

For this project, we need to define subtypes and topological relationship. Subtypes create subclasses of a feature class that allow separate identity of subclasses. Here, it is required to have subclasses of canals so that different canal types have separate identity and can be displayed using the same feature class. Point features (Hydraulic structures, hydraulic gap points and DPOs) should coincide with line features (canals). Therefore, it is essential to build topological relationship and assign topology rules.
**Tools Development**

It involves following steps:

**Understanding the Requirement**
The first step of tool development is to understand the requirement and its complexity. It has been framed as follows:

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

**Design Logical Schema**
After comprehending the requirements associated with this task, an outline of logical steps were prepared. These steps are as follows (Figure 2):

- 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.

**Python Scripting**
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 data 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 (hydraulic gap points)
- Calculating Irrigation Potential and IP balance
- Creating a layer of hydraulically connected canals
- Creating a layer of hydraulically disconnected canals
Figure 1 - Creation of new geo-database

Figure 2 - Logical Schema for script writing
Final make-up of scripts
A new toolbox is created in ArcCatalog and scripts are added into it. After adding scripts, 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.

![Figure 3 - Screen Shot of Developed Tools](image)

Results
Total seven script tools have been successfully developed for this project and copied to Arc Toolbox with their scripts. 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 in Figure 3.

**Canal Infrastructure Assessment** tool adds new fields viz. length difference (difference between proposed and calculated length), critical percentage (97% for short canals (<50km) & 98% for long canals (>=50km)), 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 canals using **Pending Canals** tool. This produced layer can be used for visualization (Figure 4).

**Irrigation Potential** tool 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 (Figure 5).
Figure 4 - Map highlighting pending canals

Figure 5 - Map showing hydraulically connected and disconnected canals
Figure 6 - Snap shot of text and .csv reports

Figure 7 - Visualization of canal infrastructure in Web Viewer
**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 6.

The output feature class can be converted into `.kml` format and imported to any web viewers 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 (Figure 7).

**Conclusion**

The present customized desktop application 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. Calculation of irrigation Potential involves complexities related to network data but IP tool has managed to solve these complexities without using network analyst objects. These tools encompass the feature of auto-report generation for idealistic conceptualization of irrigation project monitoring, therefore, synopsizing the manual effort.

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