DIGITIZATION OF UNIVERSITY OF ILORIN WATER SUPPLY AND LANDMARK INFRASTRUCTURES USING ArcGIS

(Approved Final Year Project Proposal)

By

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1.0 INTRODUCTION

The importance of water cannot be over emphasized because it is a major factor in the socio economic development of any country. Despite its availability, water supply has become global crisis because of high demand which results in its unsustainability as the coverage of house hold water supply hardly improved since 1990 (Odaro 2012). The socio economic life of man can never be completed in the absence of water and as a result of this, man has been struggling to make sure water is never out of his reach (Mathew and Faruq 2016).

The most popular way to make water available in quantity and quality for a set of people is through water distribution system (WDS). WHO and UNICEF (2000) made it clear that a number of factors like low water pressure, intermittent service and ageing of infrastructure are responsible for the inadequacy of water distribution system in developing countries like Nigeria. However, to meet the required quality and quantity of water supply, proper provision of sustainable water distribution system must be made. With all the importance and problems challenging water supply delivery, it is practically tedious to improve without reference to geospatial data through an information technology.

IT of the geographic information system (GIS) which is a computer based information system used to digitally represent and analyze geographic feature present on the earth surface and the event that takes place on the features. GIS is designed to work with spatial referenced data and coordinates. The world has a long history of GIS application in planning and resource management dating back to the 1960s (Bangbo 2010). The application of GIS in spatial planning support tools have an important advantage through changing the valuation standards to visually illustrate and depict the implications of different spatial decisions and alternatives course. The capabilities needed for decision making readily available in a single system make GIS a great tool for integrating in digitizing and planning processes. GIS provides functions for development and preparation of accurate spatial information for input to network design optimization in digitization. It also facilitates post optimization of spatial analysis and graphical output display for evaluating results.

Geo-spatial information exists in real world in term of space with location and time can be represented in form of maps, databases and statistical representation through coordinates (Akinyele and Borroffice, 2004). Coordinates are geo-spatial information used to represent the location of natural or man-made features on the earth surface. They are set of values that define a position with a spatial reference (ESRI, 2000). Geo-spatial information plays a significant role in the planning, designing, location, and maintenance management of water distribution network (WDN). Furthermore, most components of water infrastructure are referenced to the surface of the earth (Audu and Ehiorobo, 2010). One major part of the GIS is the ability to overlay various layers of spatially referenced data, which allow the users to determine graphically and analytically just how structure and objects like roads and water distribution system interact with each other.

Research has shown that more than 80% information can be geographically referenced (Dangermond, 1996) and about 85% of all information has some spatial contents (Parker 1996).

The Environmental System Research Institute (ESRI) defined GIS as "a computer based tools for mapping, storing and analyzing things that exist and events that happen on earth". GIS technology integrates common database operations such as query. GIS is also a spatial data base of digital maps which store information on various phenomenal and their location. With GIS, questions like location, measurement, condition, trend routing, pattern modeling can be answered (Maguire and Dangermond, 1991). One of the main strength of GIS is that they enable the use of map and their data base to engage in scientific visualization. GIS is a computerized system for storage, retrieval, manipulation, analysis, and display the graphically referenced data.

GIS is designed to work with data referenced by spatial or geographic coordinates. In other words, GIS is both a database system with specific capability of spatially referenced data, as well as a set of operation for working with data. The use of geographic information systems (GIS) in the utility industry cannot be overemphasized, as GIS allows not only for the accurate mapping of infrastructure features but also the ability to add attribute data to those features. GIS can be used to collect, store, analyze, and visualize all facilities like roads and buildings that are spatially referenced. It is also used in the professional works like agriculture e.g forest management (Manjula 2010), medicine (Najafabadi 2009) and marketing (Turk 2014). Among other capabilities of GIS it enables user to store and display large amount of data graphically to greatly enhance the interpretation and analysis. When a utility stores their data in spatial format, they can also use GIS software to query and analyze specific attributes of their data (Mathew and Faruq 2016). Water utilities in particular utilize GIS for the mapping of system infrastructure to replace existing paper maps or to create maps when none were had before. GIS therefore will be used in this project to produce the digitized water supply infrastructure.

2.0 Justification of the study

Little or no work has been done on digitization of university of Ilorin water supply infrastructure and landmark structures. The university is one of the second generation universities in Nigeria. As such is indicative in the increased number of candidates it admitted every session. This also leads to increase in the landed area it is occupying for more lecture rooms, hostels, and offices to accommodate the population. As the university's population increases so also the pressure exerted on water supply infrastructures. This invariably compounded the operation and management of water supply service delivery for the university community. This study will therefore contribute scientific knowledge to solving the tedious task of water supply infrastructure management. The project outcome will also help in future decision making concerning water distribution network expansion and management.

3.0 AIM AND OBJECTIVES

The aim of this study is to digitize university of Ilorin water supply and landmark infrastructure using GIS. Other objectives to achieve this aim are:

I. To carry out reconnaissance survey of the water supply infrastructure in order to familiarize with the entire project area and facilities in the campus.
II. To produce a geospatial and georeferenced map of water supply infrastructures (i.e WDS, appurtenances and dam) and landmark structures (i.e Stadium, Afolabi Toye road and Auditorium, and Senate Building among others.
III. To produce digitized map of item II above.
IV. To produce a documented digitized map of University of Ilorin which will serve as guide in locating water distribution system and landmark structures that will aid maintenance strategies and decision making concerning future water distribution system expansion.

4.0 SCOPE OF WORK

The scope of the study will cover digitization of water supply infrastructures such as dam, reservoir, treatment plant, boreholes and landmark such as auditorium, senate building, center mosque, chapel, stadium and Afolabi Toye road. The project will be limited to the University of Ilorin and it is a component of the ongoing study, titled “Evaluation and Management of Water Supply Infrastructure in Higher Education Institution (HEIs) Setting Using Coupling of Hydraulics-GIS Geo-data Based Modeling as a Decision Support System (DSS)”.

5.0 LITERATURE REVIEW

5.1 Water Distribution Network (WDN)

Water distribution network consist of interconnected series of components which include pipes that conveys water from the source to the desired destinations. The distribution components form a large proportion of total investment in any water supply system (Rao, 2002). Water distribution system account for 40-70% of the total cost of the water supply system (Izinyon, 2017), hence its proper planning, design, operation and layout is of great importance. WDN in made up of components such as water reservoir, pipes, pumps, storage tanks, junctions and valves. Public water depends on the distribution system to provide an uninterrupted supply of pressurized potable water to all consumers. Pipes are used as a medium of conveying water from source to destination with the efficiency of pumps that give the water required head to travel through the pipes. A water distribution system consists of three major components: distribution piping network, pumps and distribution storage (Lansey, 2000).

Pipes can be primary, secondary or distribution in function and can come in concrete, steel, cast iron and plastic (PVC) material. Primary pipes are known as mains and are the skeleton of water distribution system. They carry large quantity of water from the pumping plant to storage tanks and from storage tanks to various parts to be served. Secondary pipes carry water from the primary pipes to various areas for normal supply or for firefighting. Secondary pipes system form smaller mains within the primary mains and should be only a few blocks apart and not more than 400mm diameter while Distribution are uniformly spaced horizontal and perpendicular pipes. These pipes supply water to fire hydrants and service pipes of the residential and other buildings like offices. The size of these pipes is determined according to the demand. The diameter should not less than 150mm for fire hydrant and 75mm for residential buildings (Douglas, et al., 1995).

5.2 Remote Sensing

Remote sensing is the process of detecting and monitoring the physical characteristic of an area by measuring its reflected and emitted radiation at a distance from the targeted area. The search for less expensive and more efficient ways to observe earth motivated man in developing remote sensing satellite. The remote sensing image based databases are fastest growing archives of spatial information. Remote sensing tools are the technological tools that are used to collect and analyze spatially referenced objects in relation with satellite in an environment. The tools that are related to the project work are (i) Gooogle Earth (ii) GPS and (iii) GIS.

i. Google earth map

This is a web-based service that detailed information about geographical regions and sites around the world. It is a virtual globe, map and geographical program that it produces earth's map by the superimposition of images obtained from spatial Satellites, aerial photography and geographic information system (GIS). Google map offers aerial and satellite view of many places. It aids data acquisition and storage technology. Among increasing and relevant data acquired and processed, there is a strategic segment satellite images, also known as remote sensing images. Digitizing is the process of converting features on a paper map or aerial images into digital format. Digitizer like GIS in conjunction with the editing tools in ArcMap can be used to create new features or edit existing features on a digital map. Digitizing is the process of making visible images editable on screen, creating attributes and classes for the features to which changes can be made on a long run. Spatial and non-spatial attributes can be assigned. Before digitization, the map must be georeferenced (Manjula et al., 2010)

Google earth functions by displaying images from the satellite in different resolutions of the earth's surface, allowing users to view components like buildings, roads, and utilities of a particular area of the earth, looking perpendicularly down or at an oblique angle. The degree of resolution available is based on the points of interest of the user but most land except for some Islands is covered in at least 15 meters of resolution. For other parts of the surface of the earth, 3D images of terrain and buildings are available. Google earth map would be used to provide detailed information about the geographical region and site of the University of Ilorin landed area. It will be used to collect aerial images of University of Ilorin from satellite and provide geographical information system like measuring, layering, image interpretation and interpretable marks for digitization.

ii. Global positioning system (GPS)

GPS is a spatial satellite navigation system that provides location and time information in an environment. It is a popular system because of its accuracy and portability. GPS is capable of producing accurate data including location, time, speed and the measure of data quality (Stopher et. al., 2008). The transmitted orbit data are used to determine the travel time of signals of the individual satellite. This device would be used to collect coordinate data of university of Ilorin for this project. GPS functions appropriately in an obstruction free area and where line of sight to four or more GPS satellites is possible. It can contribute substantially in a more supplementary fashion to some of the interactive operations that should become an asset for assessing, understanding, mapping utility and service facility using GPS and solving complex urban environmental issues (Akanbi et al. 2013). Spatial satellites help the GPS to pinpoint locations, this is achievable when the GPS receiver locates at least four of the satellites and uses the data to figure out the distance and deduce the location. A GPS receiver monitors multiple satellites and solves equations to determine the precise location of the receiver. It provides critical positioning information.

iii. Geographic information system (GIS)

GIS can be described as the general purpose computer based technologies for handling geographical data in digital form in order to capture, store, manipulate, analyze and display diverse set of spatial or georenferenced data (Burrough and MCDonell, 1998). GIS provides for input coordinates registration, transformation, management, query, analysis, modeling, map composition and production of cartographic and map (Akanbi, et al., 2013). It therefore functions as a base system to capture, store, edit, display, and plot geographically referenced data. GIS thus incorporate a data base management system. The integrated framework of Remote sensing techniques and GIS framework greatly reduces time, effort and expenses in using geographical data. ArcGIS Desktop will be the type of GIS software used in this project. It is an integrated suite of advanced GIS applications. It includes a series of windows desktop applications, ArcMap, ArcCatalog, ArcToolbox, and ArcGlobe with user interface components (Manjula et al., 2010). Using these applications and interfaces in union, the water distribution system and infrastructure of the University of Ilorin will be digitized. Map and image data will be exported to GIS which will be used to produce visual representation of the data, analyzing the data, interpretation of the data and data storage for future use. It will also be used for relating, integrating and analyzing information from spatial images.

5.3 Review of Earlier Work

Remote sensing and GIS were the employed to examine the area covered by the WDN in Osogbo. Analogue water utility map, google earth image and Landsat image covering the project area were acquired and converted to digital form. ASTER GTM was used to generate elevation map. The analogue water utility map were merged with CorelDraw and converted to JPEG after which they were imported to ArcGIS where they were converted to vector entities. The water utility map was geo-referenced with coordinates from GPS. Onscreen digitizing using polygon tools was done on google earth to get the extent of the study area and was saved as KML format. The digitized map was imported into ArcGIS and with the DEM from ASTER GTM, satellite digitization of the water distribution network was done and the area covered by WDN was determined. The research established that just 32% of the project area was covered by WDN and suggestion of sitting new reservoir in the developing area of the metropolis was raised. (Mathew and Faruq. 2016)

Michael et al., (2011), applied GIS technique to investigate the water supply network of a section of Tarkwa municipality in South Western Ghana. Digital maps of the study area were re-projected. Analogue maps of the mains and lateral pipelines were scanned and geo-referenced to the same projection. The pipelines, node and valves were then manually digitized, their attribute tables created and a geo-database model was developed. A geo-database to support improved performance, operation and cost of asset replacement was also created. Data used for the study includes shape files of roads, contour lines, cultural features and the analogue map of primary, secondary and attributes information of the pipelines. The valves and hydrants location points were acquired with GPS receiver. Method used for this study included development of a geo-database, building geometric network and carrying out spatial and attribute queries in GIS. Spatial analysis was used to generate map and graph was plotted using attribute data. The analysis of the pipeline network database indicates that more than half of the Tarkwa network is over aged and require replacement. The study also provides detailed spatially referenced information on pipelines and the associated cost of replacement as they reach the designed life span.

Pindiga and Sani (2015) carried out a research study in Bauchi state of Nigeria in order to provide answers to the question of where WDN fails or needs emergency repair and how can the problem be traced and solved without disrupting other users. The data used involved analogue map showing Bauchi WDN and geographical coordinates from GPS. The analogue maps were scanned and converted to digital raster format which were imported into GIS for georeferencing using on ground coordinates of the analogue utility map as the image coordinate on system and digitization was done afterwards. The outcome of the research was a representation of data in form of spatially referenced digital map showing the WDN connections and appurtenances which can easily be used to trace water distribution system for proper repair and maintenance.

Dhara and Gautam (2015) used GIS to digitize the entire village of bawaliyari Taluka Dholera, India. The study examined the WDN and source of water in the village so as to be able to plan for a new WDN. The three tools used in this project to complement GIS are 3D analyst, georeferencing (GIS tool) and spatial analyst. The data used are toposheet, google image, shape files, elevation values of nodes, and triangular irregular network (TIN). Georeferencing tools were used to geo-correct the toposheet and images in relation with coordinates, 3D analyst was used to create TIN file and raster, spatial analyst to create contour from the raster and extraction tool was used to extract elevation data from digital elevation modem (DEM). Geo-referencing of the toposheet and Google image was done using Geo-referencing tools. The shape files, WDN, and Nodes were prepared by digitizing the map of the village on google map and the village's toposheet. DEM of the study area was prepared using SRTM image. The village polygon feature and the elevated storage reservoir were planned at highest elevation so as to take advantage of natural head when new WDN is put in place.

6.0 METHOD

This involve field and desk works. An implementation procedure for digitizing water distribution infrastructure and landmark structures of the University of Ilorin follows the schematic diagram in figure 1. The field work covers the practical activities that cannot be carried out without visiting the project area. It includes gathering of information about the project data in the real natural environment while the desk work activities will involve data collation, extraction of university of Ilorin map, geo-referencing and digitization.

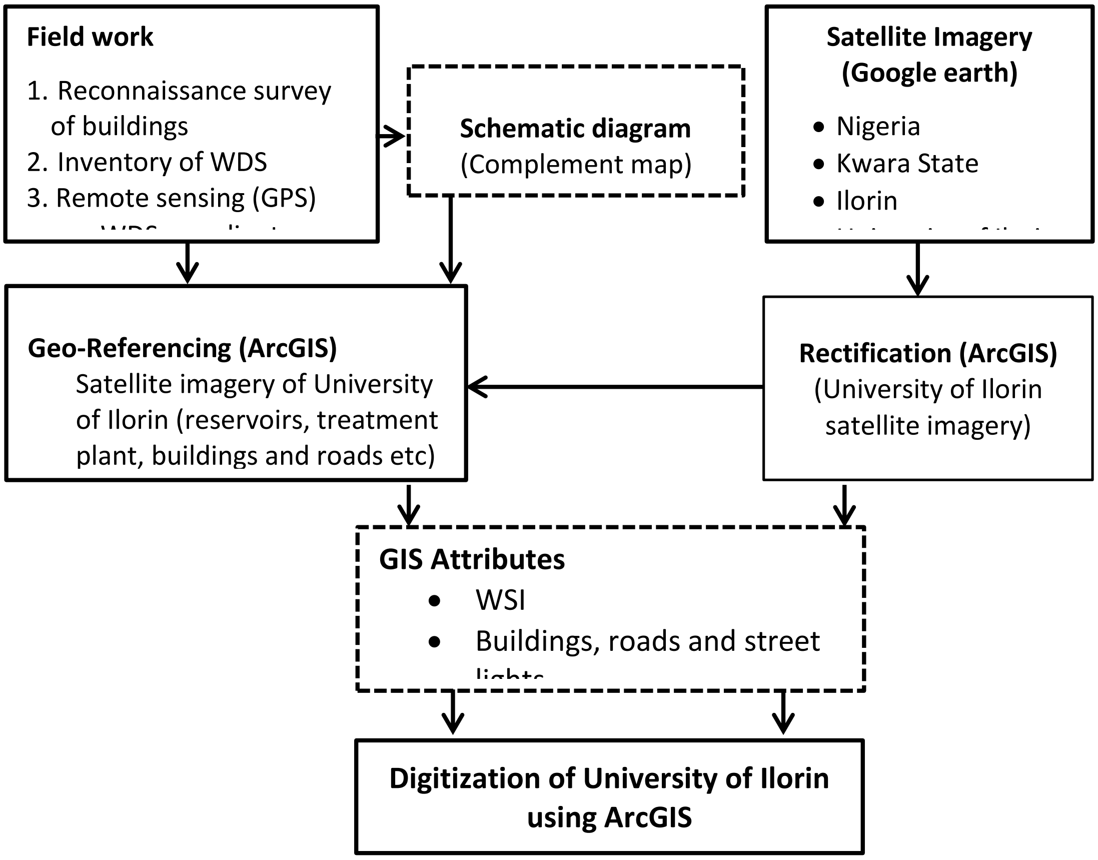


Figure 1. Schematic Diagram of Project Execution.

6.1 Field Work

The reconnaissance survey will take two approaches (i) physical survey (ii) remote sensing. In this project, the physical inventory would involve visitation of the project area in order to locate and identify positions of water distribution system such as primary water network, dam, bridges and treatment plant. Hand drawn sketches of each of the mentioned facilities and positions of landmark structures will be noted. The WDS sketches will also guide digitization. Remote sensing on the other hand will involve the use of GPS as a receiver from satellites to capture coordinates of related facilities, particularly WDS by locating the pipe lines and navigating around it holding the GPS.

6.2 Satellite Imagery

The satellite image of university of Ilorin inform of map will be extracted from google earth and saved as JPG. The schematic drawing showing the positions of WSI, roads and land mark structures will be used to complement downloaded map. The image data will give appropriate direction and guide when digitizing. Map data contains the location and shape of geographical features. A map uses three basic shapes to present real world feature: points, line and area. A map is a data structure that stores data in the form of key and value. To download satellite images, the Google Earth application will be launched on the system with functional internet, map of Kwara state will be extracted from the by marking out the boundaries and saving the image for printing. The same thing will be done for map of Ilorin which is embedded in Kwara state map. The university map will be extracted from by zooming on the map to a reasonable resolution on Google Earth in order to make the image clearer and to locate facilities and features in the university. The area occupied by the university map on Google Earth will be navigated with the previous resolution so that no part will be left out when georeferencing and digitizing then the map will be saved as JPG.

6.3 Rectification

Image rectification is a transformation process used to project multiple images onto a common image surface, it helps to correct a distorted image into a standard coordinate system. The downloaded map from Google earth is in projected coordinate i.e longitude and latitude which comes in spherical macular (Orbital shape) which will be converted to flat or plane map in order to be able to georeference and digitize the features present in the map. Rectification will be carried out by changing the projected coordinate to geographic coordinates system, this would be achieved by choosing WGS 1984 web Mercator on ArcGIS

6.4 Geo-referencing

Goreferencing involves matching of rectified image coordinate with the on ground coordinate of the features present on the map. When georeferencing, a well-defined object such as stadium within the map will be taken note of. This is done to ascertain that referencing is done for the same location in raster and aligned layers. To geo-reference the map, the georeference toolbar will be enabled and four control points will be added to the map at the far end corners through “add control point”. The toolbar layer list would display raster and CAD layer as valid data types. The layers must have the same coordinate system. To add the links a known location e.g stadium on the university map would be clicked, then the image would be zoomed to layer. The control points will be added by left clicking, while the cursor is still on the map and without moving the cursor right clicking will be done to select “input DMS of longitude and latitude” for the control points which can be edited. The Google map would be opened again in order to check the just added coordinates. A more accurate coordinate would be displayed at the bottom of the screen and they will be taken note of by writing them down. The coordinates at the bottom of the screen will be imputed into the map after switching back to ArcGIS. Minimum of four control points will be added with the same procedure after which the map will be geo-referenced. The geo-referenced map will be saved by clicking georeferencing then update georeference.

6.4 Digitization

Digitizing on GIS is the process of converting geographic into vector data by tracing the features, the digitized feature are captures in polygon, line, circle, point etc. Digitization can be done in several ways which includes manual, head up and automated digitizing. In this project work, head up digitization also called on screen will be done. The extracted university map which already in raster form and geo-referenced will be digitized. On screen digitization will involve tracing of futures related to project on the geo-referenced university map, these futures will be captured as in table 1.

Table 1: Feature Capture on GIS

Features	Capture	Color
1. Buildings	(polygon)	Yellow
2. Road	(line)	Black
3. Roundabout	(Circle)	Green
4. Dam	(polygon)	Blue
5. Reservoir	(Circle)	Blue
6. Pedestrian	(Line)	Yellow
7. Street light	(Circle)	Red
8. Treatment plan	(Rectangle)	Blue

The digitized map will be documented so as to provide proper guide for maintenance and decision making. Digitization on the other hands is the on screen tracing of features on scanned or digital map which are displayed on computer screen, it could also involve insertion and manual tracing of future on already geo-referenced map. In this project on screen digitization and geo-referencing will be carried out.

7.0 Project Management

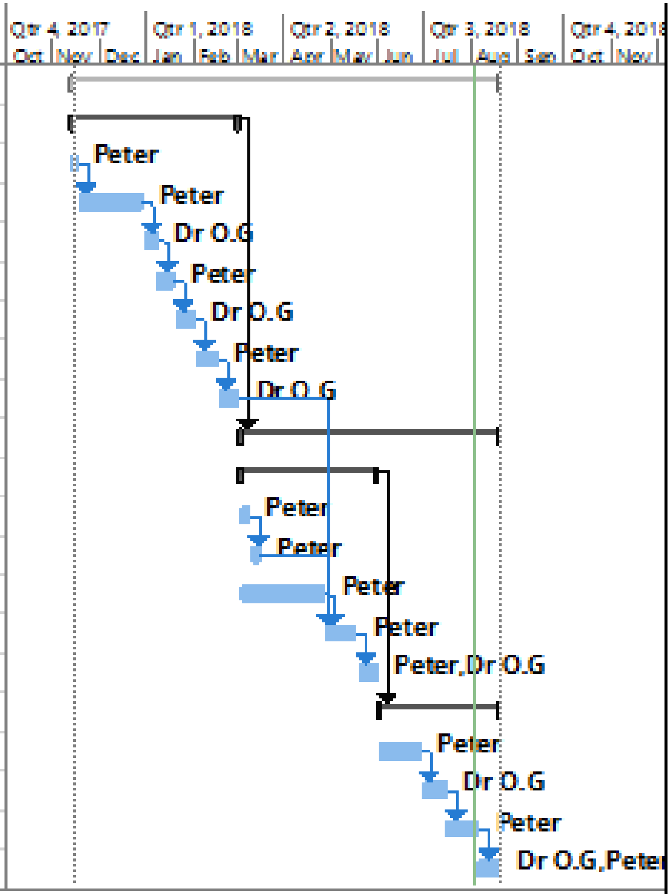
The project management involves the required step needed to achieve the aim and objectives of the project in estimated time. The expected expenses budgeted and time scheduled in order to execute the project effectively and achieve the aim and objectives are shown in the table 2 and figure 2 respectively.

Table 2: Budget

ACTIVITIES		EXPENSES (#)
1.	Survey expenses (service of personnel)	100,000
2.	Garmin GPS (hiring)	60,000
3.	Internet Facilities	10,000
4.	Project Documentation (printing and binding)	6,000
5.	Transportation (to and from hostel)	5,000
6.	Miscellaneous (Eatery, bottled water, recharge card)	5,000
	TOTAL	**186,000**

Fig 2: Project Time Schedule

ID		Task Mode	Task Name	Duration	Start	Finish
0			**Digitization of WDN & Infrastructure**	**199 days**	**Wed 11/15/17**	**Mon 8/20/18**
1			**Harmattan Semester**	**78 days**	**Wed 11/15/17**	**Fri 3/2/18**
2			Selection of Final Year Project	3 days	Wed 11/15/17	Fri 11/17/17
3			Sourcing Literature and Reading	30 days	Mon 11/20/17	Fri 12/29/17
4			Submission of First Project Proposal	6 days	Mon 1/1/18	Mon 1/8/18
5			Review of Proposal Write-Up	9 days	Tue 1/9/18	Fri 1/19/18
6			Submission of Second Draft	10 days	Mon 1/22/18	Fri 2/2/18
7			Review of Proposal for Submission	10 days	Mon 2/5/18	Fri 2/16/18
8			Proposal Defend(WEE593)	10 days	Mon 2/19/18	Fri 3/2/18
9			**Rain Semester**	**121 days**	**Mon 3/5/18**	**Mon 8/20/18**
10			**Project Execution**	**65 days**	**Mon 3/5/18**	**Fri 6/1/18**
11			Reconnaissance Survey	5 days	Mon 3/5/18	Fri 3/9/18
12			Collection & Analysis of WDN Data	5 days	Mon 3/12/18	Fri 3/16/18
13			Arc-GIS Software Skill Acquisition	40 days	Mon 3/5/18	Fri 4/27/18
14			GIS Digitization of Primary WDN	15 days	Mon 4/30/18	Fri 5/18/18
15			Review of Results with Supervisor	10 days	Mon 5/21/18	Fri 6/1/18
16			**Project Completion**	**56 days**	**Mon 6/4/18**	**Mon 8/20/18**
17			Final Draft Preparation	20 days	Mon 6/4/18	Fri 6/29/18
18			Submission for Correction	11 days	Mon 7/2/18	Mon 7/16/18
19			Project Documentation	15 days	Tue 7/17/18	Mon 8/6/18
20			Viva	10 days	Tue 8/7/18	Mon 8/20/18



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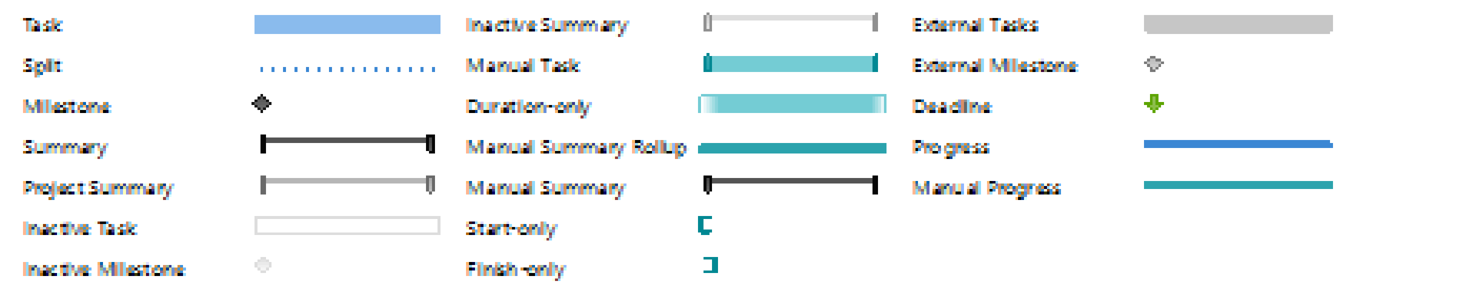

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