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ANALYSIS AND VISUALIZATION TO MITIGATE LOAD DISTRIBUTION & QUALITY LEVEL ISSUES OF ELECTRICAL DISTRIBUTION NETWORK USING GIS: CASE STUDY OF JORPATI, KATHMANDU, NEPAL

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ABSTRACT

Electricity represents the engine of contemporary society. Thus huge increase in demand of electricity is anticipated in days to come. With increase in demand, distribution network of electricity will become increasingly complex. This will evoke the challenges for operators to interpret these massive complicated data with comprehensive and rapid response in a constructive manner. Traditional approaches of management will become inefficient.

The objective of this study is to present optimal solution for distribution network management. This paper illustrates approach to simulate distribution network in terms of what asset it has, where they are, their condition and how they are performing using GIS. Simulation of physical assets using GIS and GPS, replicate cloned environment of physical distribution network on computer of operator's desk. Thus enable operators on visualizing fault location, haphazard installation of meters/poles/transformers, installation of renewable power resources, utility asset management, optimizing electrical lines routing, power monitoring, and forecasting load directly from work desk of operators.

Keywords: GIS, GPS-Survey, EDN, Simulation, Mapping.

I. INTRODUCTION

Mountainous Country like Nepal, possess enough potentials to generate electricity from hydropower. But still only 70% of the total population in country has access to electricity and out of this share, 45% uses the national grid while 25% uses off-grid solutions such as solar and micro-hydro power [1]. This clearly indicate requirement of huge expansion in distribution network to meet the demand. For such expansion of distribution network, traditional management approaches of electricity distribution will become inadequate as manual approaches to monitor the system will become inefficient. Efficient day-to-day operation require accurate real-time information on what asset it has, where they are, their condition and how they are performing. Real-time information on physical assets of the electricity distribution network play key role on exact analysis of blocks through clear visualization of bottlenecks. This enable organization on making better strategic and operational decision on mitigating load distribution & quality level issues. In this connection. GIS tool can be of great strength for management of the data. It is an emerging software technology to analyze spatial data, through attribute and location analysis or spatial modeling [2].

System operators will require assistance from the technology that could support them on making optimal strategic & operational decisions laid on real field facts. In this connection, GIS can be a sophisticated tool to simulate and organize real field data to a computer system linking the database to map. GIS tool enable operators on visualizing real-time distribution network from their desk for efficient day-to-day operation.

II. METHODOLOGY

Data is one of the most essential and vital aspect of any research studies. Efficacy of research highly depends on accuracy of data. Degree of data accuracy is directly proportional to level of manual process involved on data collection. Computer assisted data survey associates less manual process. Requisite of computer assisted survey escalates further when it comes to data to be captured along with its spatial attribute. Footing point for this research is acquisition of precise up-to-date data. Research acquire data on physical assets (such Substation, Feeder, Transformer, Pole, and Consumer) of distribution network along with spatial linkage. These

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data are collected using GPS based mobile/tablet survey. GPS based survey links latitude, longitude, and time data along with other domain related attributes entered during data collection [3].

Research data then will be mined to determine responsible factors on physical assets of distribution network that are affecting quality of service. Responsible factors can be highlighted comparing data against indicators that are determined from classification of physical assets based on its location, connected load associated with physical assets, in-between distance among physical assets, accuracy of physical location of physical assets, balances of load on physical assets, compatibility among connected nodes of physical assets, geographical complexity of physical assets etc.

Result of mined data is applied to articulate level of criticality based on calculation of impact. Bottlenecks on network along with their degree of impact will be used to establish priority order. These priority order will enable setting up of protocol for alert and notification mechanism.

In order to deliver actual benefit to system operator in rapid & precise decision making from this research, it is equally important to comprehend harvested information with nice presentation mechanism. Research will borrow support of GIS to derive approach of presentation. Derived approach will allow representation of information in pictorial format. Pictorial representation of information can quickly be grasped. Following figure portrays methodology described in this methodology section

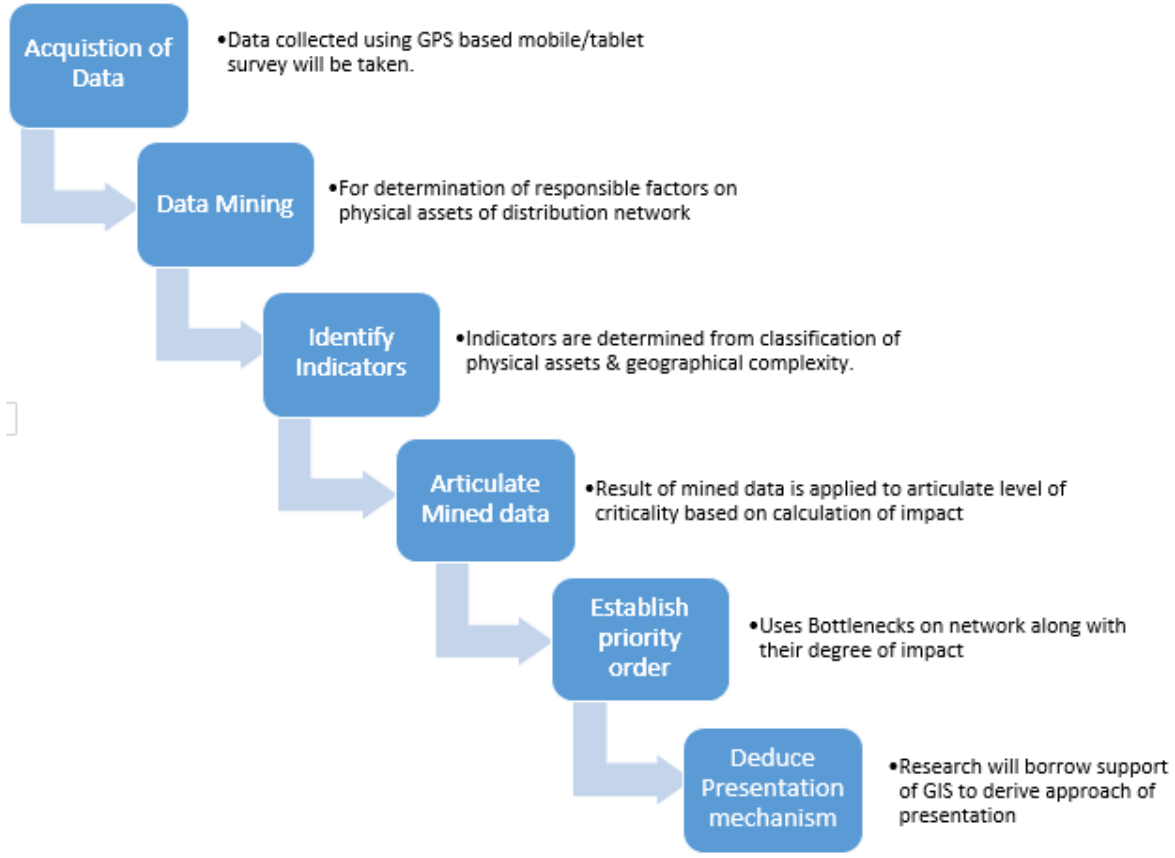

Figure 1: Block diagram of methodology.

Though GIS technology offers remarkable capabilities for decision making but rendering competent decision making highly depends on data consistency. Data collected using GPS need to meet the position accuracy requirements. If the data will be used for site-specific analysis that requires high position accuracy differential GPS (DGPS) receivers will be necessary. Small variation of location for this research does not much effect on outcome, hence GPS can be utilized here for capturing of spatial attributes.

GIS database require referencing from a base map or base data layer. Reference datum of all the data layers must be the same. Ideally, the database should be referenced to a very accurate base map. A datum is a mathematical model of the Earth over some area. The projection system used for this research is the UTM (Universal Transverse Mercator) as Nepal lies in the UTM zone of 440N and 450N [4].

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III. MODELING AND ANALYSIS

Study area selected for carrying out this research is Jorpati Distribution Center of Nepal Electricity Authority. Jorpati is located near Kathmandu of Nepal with mix of hilly and plain region. Heterogeneous region along with different category of consumers connected to distribution network make Jorpati Distribution Center appropriate for this research.

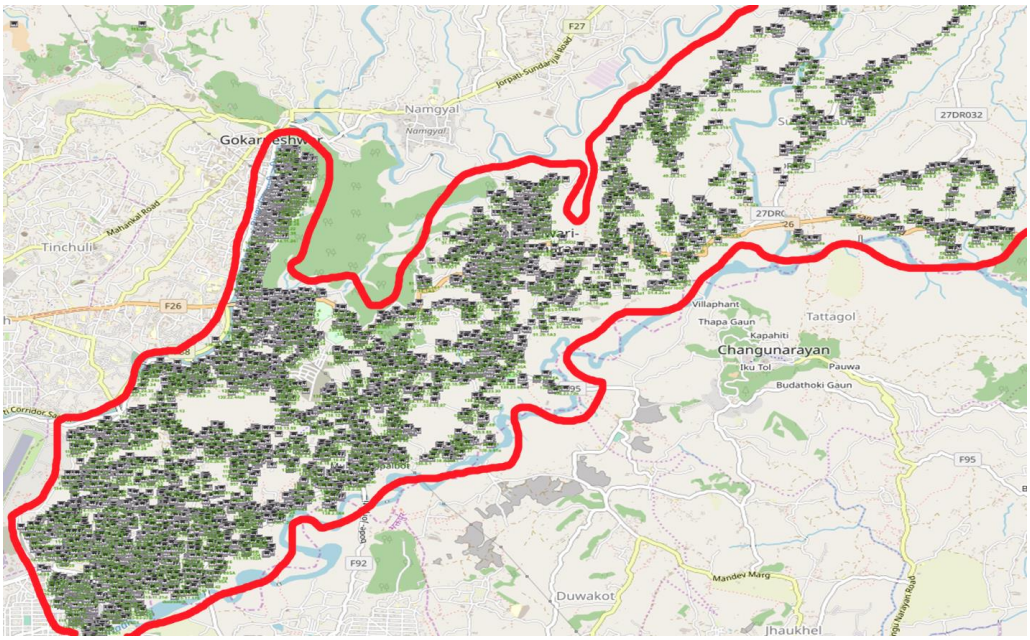

Figure 2: Geographical extent of Jorpati (Kathmandu, Nepal) Area.

Data needed for this research is collected using GPS based mobile/tablet survey software application developed on Android platform. Data schema sought for this research will be as follows:

Consumer Meter Schema

Column Name	Data Type
id	varchar
general_info_id	varchar
unique_id	varchar
ConsumerNO	text
Consumer_Name	text
Consumer_Type	text
MeterNO	text
MeterCapacity	text
ApprovedLoad	text
Meter_Conn_Type	text
CTRatio	text
PTRatio	text
PoleNumber	text
Photo	text
update_by	varchar
update_date	varchar
disabled	int
Longitude	double
Lattitude	double

Pole Schema

Column Name	Data Type
id	varchar
general_info_id	varchar
unique_id	varchar
SSName	text
FeederName	text
FeederType	text
PoleNumber	text
PoleCombination	text
PoleType	text
PoleSize	text
Photo	text
LineType	text
HT_ConductorType	text
HT_ConductorSize	text
HT_ConductorExist	text
LT_ConductorType	text
LT_ConductorSize	text
LT_ConductorExist	text
HT_WireCombinatio	text
LT_WireCombinatio	text
LineSupply_Transf	text
ServiceConnection	text
ConsumerNOs	text
Longitude	double
Lattitude	double

Transformer Schema

Column Name	Data Type
id	varchar
general_info_id	varchar
unique_id	varchar
SSName	text
FeederName	text
Place	text
TransformerNO	text
CompanyName	text
MfgDate	text
CommDate	text
Transformer_Capac	text
VoltageLevel	text
Transformer_Owner	text
MCCB_Rating	text
Earthing	text
Silicage_Pot	text
OilLevel_In_Tank	text
Photo	text
Longitude	double
Lattitude	double

Figure 3: Survey Data Schema

It is expected that GPS based data schema after data mining will allow reaping following information needed for the research:

- Line segments identification.
- Associating location with other attribute of consumer meter, pole & transformer.

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- Establishing link among consumer meter, pole & transformer
- Map preparation.
- Calculation of load at each pole, transformer, transformer each phase.
- Classification of consumer meter, pole & transformer based on parameters
- Alarming zone identification &.
- Other miscellaneous needed for this research

PostgreSQL database will be used for this research to store and process data collected using computer assisted GIS based survey. PostgreSQL is open source database application. Its ability to integrate with POSTGIS makes database best fit for most of the GIS based research. PostgreSQL in association with POSTGIS provide many useful tools needed for spatial data analysis. This research require analysis on defining different thresholds/indicators needed for identification of alarming zones. Each node [consumer, pole, transformer, feeder & substation] will be processed against threshold calibrated. Notification & Alarms will be generated for the nodes crossing the alarm level. PostgreSQL/POSTGIS database will be quite useful for such analysis.

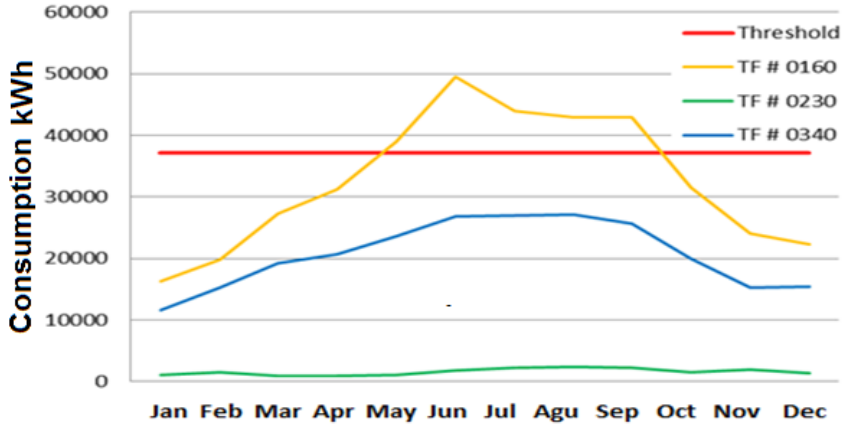

Figure 4: Threshold limit and consumption pattern to analyze alarming zone.

Generation of map from collected and processed data is another important aspect of this research. Collected data is stored on PostgreSQL/POSTGIS GIS database can easily be integrated with Geoserver to generate map. Being open source Geospatial web services engine, Geoserver is selected as appropriate candidate to generate map.

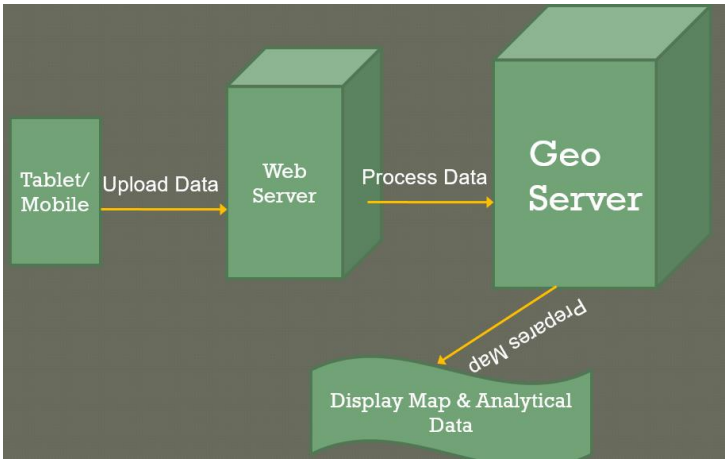

Figure 5: Process Flow Architecture.

IV. RESULTS AND DISCUSSION

Use of Geoserver, allow presentation of information in the form of map. Generated map from Geoserver generates will utilize

- Physical Assets Map of distribution network (Physical asset of distribution network can be consumer, pole, transformer etc.)

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- Link Map of physical assets (Showing connectivity among physical asset of distribution network such as consumer to pole, pole to transformer, transformer to feeder etc.)
- Classification Map of physical assets (Presenting classification of distribution network physical Assets based on size/material/type etc.)
- Recommendation Map of physical assets (Displaying recommendation on relocations of physical assets required for performance enhancements)
- Node extension Map (Suggests optimal point for expanding distribution network. Such as determination of best fit pole for new consumer connection)
- Alarm/Notification Map &
- Many more …

for analysis and generate results as GIS Map. These GIS Map help operators in quick grasping issues existed on network. Aid of pictorial representation will simplify process of

- Detecting faulty points
- Maintenances
- Area to isolate for maintenance
- Damage monitoring
- Replacements
- Shifting
- Reasoning optimal viable location of new expansions &
- Many more

V. CONCLUSION

Proposed analytic and visualization model may effectively be used by Electric utility to prepare GIS Mapping & Consumer Indexing. This GIS Mapping & Consumer Indexing will enable Electric utility to mine spatial data for modelling optimal strategic & operational plan laid on real field facts. Thus benefit organizations on

- Streamlining Management, Monitoring & Maintenance activity of the distribution network.
- Better Decision Making.
- Improving functional performance
- Decreasing operational cost.
- Enhancing customer service.
- Increase sales &
- Many others.

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