EXECUTIVE SUMMARY

Geographic information systems (GIS) have been under continuous development for several decades. By now, GIS is both well known and widely used, and has become integral elements of information technology applications in a wide variety of domains. In its simplest form, GIS software enables users to address a variety of questions that have two root forms: what are the attributes associated with a place and which places have one or more specified attribute(s)? Such systems are particularly helpful when they are used to obtain results for simple queries or to address structured problems that have a well-defined solution process that can be specified and followed as a sequence of steps. But many problems, particularly those that have a contested public policy component, are neither well structured nor clearly defined. In such cases, consequently, there is no prescriptive process that can be followed to yield a solution. Spatial decision support systems (SDSS) are designed and implemented to address this class of semi structured systems with advanced analytical tools that help people explore a problem, learn about it, and use the information gained to arrive at improved decisions.

This thesis begins with coverage of basic geospatial data handling concepts, methods, and materials. It places the development of SDSS concepts within a historical framework of development and treats important system components with a level of detail that is appropriate for basic understanding. Coverage then moves to give basic understanding about Infrastructure Management, its background and significance. It also illustrates basic knowledge of electrical utility structure of study area together with its distribution network. Coverage then moves on to demonstrate how these components can be assembled into flexible collections that are used to address particular types of applications. It is here, with the illustration of different component assemblages, that the thesis coheres by demonstrating how an SDSS can be implemented in the form of a traditional web-based services or web-based application. As the use of SDSS proliferates, there is a great demand for SDSS based application from an interdisciplinary perspective. The primary goal of this thesis is to provide a thorough overview concerning the current state of the art in SDSS technology and their application from an interdisciplinary perspective for infrastructure management specifically for electrical distribution. The collection in this thesis consists of
four major parts, each addressing different topic areas in SDSS for Infrastructure Management.

**PART 1**, consisting of Chapters 1 and 2, primarily presents an introduction to SDSS, the evolution of SDSS. **CHAPTER 1: INTRODUCTION**, an introductory chapter provides an introduction to the importance of spatial decision making and discusses how SDSS supports the spatial decision-making process, focuses on components of SDSS. It also provides background and significance of infrastructure management, together with brief introduction about electrical utility structure too. It also includes significance of proposed research work and research objectives. **PART 1 CHAPTER 2: APPLICATIONS OF SPATIAL DECISION SUPPORT SYSTEM** highlights the variety of SDSS application examples from a range of disciplines using a variety of techniques developed nationally and internationally with numerous detailed case studies provided. It also includes review of literature available on the topic.

**PART 2** covers details about study area i.e. Jodhpur city in **CHAPTER 3: STUDY AREA AND ITS ELECTRICAL DISTRIBUTION NETWORK**. It briefs about location and boundaries, physical environment & economy, human resources and city infrastructure. It also throws light on Indian power system to provide basic understanding to the user in particularly of Rajasthan Power system and JODHPUR DISCOM covering knowledge about general profile of Jodhpur DISCOM with its transmission and distribution network details.

**PART 3** is the most crucial section of the document, serves as backbone of thesis, which includes details regarding input data and methodology so developed and used for SDSS in **CHAPTER 4: INPUT DATA AND METHODOLOGY FOR SDSS**. It includes details about data and collateral information so collected from different sources. Later section includes interpretation and analysis of DISCOM data. Focuses on creating electrical dataset for SDSS by providing step by step description from identifying the required attributes, network model and shape file creation. It also include details about interpretation and analysis of data from different sources like RRSC & Google earth, together with briefing on creating spatial dataset for SDSS by step by step process of kml to shp conversion for
building network, setting its projection system and customer mapping. The last section is the most crucial one, it investigates techniques and technologies for building new SDSS, focuses on methodology covering its various aspects like detailed study, data collection, data creation, defining objectives, identifying the main components of SDSS, create and publish map service and lastly SDSS development.

PART 4, last section focuses on design, development and implementation of SDSS together with the results. CHAPTER 5: DESIGN, DEVELOPMENT AND IMPLEMENTATION OF SDSS provides an overview of the range of properties of design including the tools and techniques overview, product perspective, technology forecast, user classes and characteristics, operating environment together with details about hardware architecture and software architecture. The section software architecture is detailed one, focusing on briefs about operating system, Geospatial Requirements covering overview of ArcGIS Server and ArcGIS Desktop. It also illustrates details about adobe flex with briefing about MXML, and Action Script with their Coding Standards. The later section includes pictorial view of the flow diagrams with context level, level 1, level 2 and level 3 details. Next section is one among the most crucial parts of the document, which explains system features of developed SDSS. It includes description about map control, various navigation tools, identify and search tools, various tracing tools, various analysis tools, customer details, report generation, chart and printing tools. Tracing tools are the tools which depict the main functionality of developed web application; it includes Trace Full Feeder tool and Trace DT Network tool. These tools basically perform network analysis on the electrical distribution network of the study area. Analysis tools are set of 3 tools i.e. Ward wise substation details tool, DT summary Report and Affected customer tool. These tools basically performs multilayer queries, with various operations like selection, intersection etc to perform analysis.

The last part of this section is the results, illustrated in CHAPTER 6: RESULTS, which gives a detailed explanation of the result of applied methodology and development of spatial decision support system. The results are presented in snap shot format, so as to provide the user step by step instructions for operating the developed features in SDSS, serving as a user manual for the end user.
PREFACE

Spatial decision support systems (SDSS) are designed to help decision makers solve complex spatially related problems and provide a framework for integrating (a) analytical and spatial modeling capabilities, (b) spatial and non-spatial data management, (c) domain knowledge, (d) spatial display capabilities, and (e) reporting capabilities. They have evolved greatly over the last few decades based on advances in underlying technologies such as computer hardware and software, networking, and communication technologies. The development of SDSS generally followed developments in Geographic Information Systems, with many concepts and techniques of the science taken from decision support systems research and advances. The great advances in networking technology and the use of the Web led to the increased use of Web-based technologies in SDSS architectures in the last decade. With improving efficiency of these systems, the ubiquity in domains like infrastructure management particularly in utility sector, SDSS that operate with multidisciplinary components are becoming feasible.

With reference to utility, Electrification plays a prominent role in maintaining the standard of living. Energy demand has been increasing with burgeoning population coupled with intensive agricultural activities, industrialization and changes in living standard. Details about power systems and their various components are demonstrated in the thesis. A typical Power System consists of Generation, Transmission & Distribution. The total network is a complex grid of interconnected lines. This network has the function of transmitting power from the points of generation to the points of consumption. The distribution system is particularly important to an electrical utility for two reasons: its proximity to the ultimate customer and its high investment cost. But, Distribution is considered the weakest link in the chain of power supply because of high losses (T & D losses). The thesis throws light on some of the areas that shall be looked at to implement distribution reforms to reduce losses and improve energy efficiency. To efficiently manage utility operations separate systems exist and the role of each system is different and unique. The lacuna falls here, in operating process of these unique and different systems, as there is lack of proper flow of information between these systems. With the huge & complex
electrical distribution network consisting of many sources, feeders, alternate feeding points; updating and management of network data is a Herculean task.

The thesis demonstrates the idea that SDSS are built from components found both in decision support systems and geographic information systems. Both DSS and GIS have user interfaces and database management components, while DSS have modeling components, and GIS have spatial data analyses and presentation components. Traditionally, many SDSS were GIS centric as GIS provided the necessary spatial data management and analysis functionality. Disadvantages of GIS-centric SDSS have been that GIS software is expensive and generally requires expertise to use. The development of open source and free GIS software is to some extent overcoming the first problem, while the development of GIS services over the Web and the development of digital spatial analytical and mapping libraries or modules are helping to address both issues. The use of these technologies allows the development of SDSS that only utilize a portion of the functionality available in a full-fledged GIS, and thus limits cost and reduces the level of expertise necessary to use the applications. For the same reason as stated above, major development of the web based SDSS so developed is done in the open source software i.e. flex builder 4.

As stated above a multi disciplinary, multi-attribute, web based open source spatial decision support system can assist in solution of complex problems and provide efficiency gains in operational & non-operational areas of utility business, most importantly will helps utility sector for simple & effective visualization of complex distribution network, together with fast electrical operations and loss calculations. Thus, in the developed SDSS for infrastructure management, GIS (Geographical information system) is used to superimpose the complete electrical network assets from Generation to distribution on top of the land base data. Advanced capabilities such network monitoring, Network tracing, Query shell and Analysis can go far in giving utilities the power to be successful in competitive environment. These various tools, technologies, and systems used in the developed SDSS can play a crucial role in optimal working of power sector. By integrating the key functions from separate systems so used in development of this SDSS i.e. ArcGIS Desktop engine, ArcGIS Server, Open source Flex builder etc., improvement of visualization of all the required information on Network Map with respect to location leads to better management.
ACKNOWLEDGMENTS

Many people have contributed directly or indirectly to the completion of this research and need to be acknowledged and thanked. First, my supervisor Dr. Sarvesh Palria, Professor and Head, Department of Remote Sensing and Geo-Informatics, and Director CDC, Maharshi Dayanand Saraswati University, Ajmer, needs to be thanked. I would like to express my sincere and respectful gratitude to him, for his encouragement, constant support, timely guidance and suggestions.

Secondly, I acknowledge my debt of gratitude to Dr. J.R.Sharma, Chief General Manager, NRSC, ISRO, Hyderabad for his constructive comments and kind support. This thesis has benefited greatly by his valuable content suggestions and feedback on materials. I have learnt much from discussion and debates with him.

I am deeply grateful to Mr. A.K.Gupta, MD Jodhpur DISCOM, for his kind support. I am grateful to Shri. Suresh Chouhan, S.E (DSM-IT & Training) Jodhpur DISCOM, for guiding me on understanding of Jodhpur electrical network and its technical details.

I warmly thank to Mrs. Suman Gujar, RRSC, Jodhpur for assistance in my research work. On a special note I would like to thank the Library staff of MDS University, Ajmer and RRSC, Jodhpur for providing books, reports and journals. I humbly acknowledge the assistance of the entire staff of the Department of Remote Sensing and Geo-Informatics, Maharshi Dayanand Saraswati University, Ajmer and M.Sc. students. My sincere thanks to Mrs. Pushplata Palria, for her help and support.

Finally, special thanks to my husband Mr.Rajesh Kumar Swami, for his unconditional support and patience all through and my little angles Akshita and Rajveer for providing joy at home. I would express my heartfelt thanks to all at home for motivation, inspiration and blessings to complete this work. Last but not the least, I would like to pay my obeisance to the omnipresent God without whose blessings this work could have been successfully completed.

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