AUTOMATED TRAFFICABILITY MODEL

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ABSTRACT

Trafficability is a global term which refers to the ability of ground to support movement of vehicles through a given region. This project is aimed at developing a software-based system that provides an automated method to determine and forecast the trafficability of selected topographical regions. The system will use a variety of data to perform this analysis such as vector map layers, attributes of the vector data in the form of a database as well as various criteria such as vehicle type, soil type, area information and weather data to be applied for trafficability analysis.

ACKNOWLEDGMENTS

First of all we would like to thank Allah Almighty. Whatever, we have achieved; we owe it to Him, in totality.

We are really grateful to our parents, family and well-wishers for their admirable support not during the course of the project, but also throughout our lives for without them, all this would have never been possible. They have always been behind our every success and are the major stimulating force that facilitates us in achieving what we aspire.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Trafficability is a global term which refers to the ability of ground to support movement of vehicles through a given region. Every army in the world has developed some system to assess trafficability of the ground for movement of military vehicles including tanks and other heavier vehicles. In all cases, the output of a trafficability assessment system is some sort of map for reference by ground forces. Like all other armies, trafficability assessment system also exists in Pakistan army for last many years.

In the existing system, a combination of field survey and data received from various civil departments is used for preparing trafficability maps for the army. Trafficability maps indicate ground profile in five different colours to indicate degree of difficulty for movement of vehicles.

1.2 Problems with Existing System

The existing trafficability maps only indicate trafficability conditions for a particular type of tank and cannot be automatically interpreted for other type of vehicles. The existing maps do not incorporate the weather efficiently. They are for dry or wet weather only. They cannot be automated for different months and weather conditions. The existing maps give no information about the crop, water table, soil and corps deployed in the region. To use the existing system, one must have basic knowledge of the map reading to locate certain area on the map. Automatic selection of an area is not possible in these existing maps. Printing of existing maps is very expensive.

Presence of trafficability model is very important for safe passage of vehicles. The absence of trafficability model may cause trap for the tanks or other heavy military vehicles. Such a situation is explained in the figure 1.1. Where, tank is trapped because of absence of trafficability model.

Figure 1.1: Absence of Trafficability Model

1.3 Purpose

The purpose of the project is to eliminate all the problems present in the existing system. Its purpose is to automatically predict and forecast the trafficability of a certain region. To automatically determine trafficability for all type of vehicles. Since GIS tasks are quite complicated in nature, best utilization of the system can only be made if it is simplified for field military commanders. They keep less knowledge of the computer system.

1.4 Project Scope Statement

The project is aimed at developing a software-based system that provides an automated method to determine and forecast the trafficability of selected topographical regions. The system will use a variety of data to perform this analysis such as vector map layers, attributes of the vector data in the form of a database as well as various criteria such as vehicle type, soil type, area information and weather data to be applied for trafficability analysis.

1.5 Motivation

GIS is an emerging field in Pakistan and it is being used for variety of purposes in a variety of applications. Project would not only be a learning task but also a practical benefit for the Army. In this respect trafficability plans are very important in all kind of movements and operations in service. Trafficability plays a vital role in success of a Military operation. Promote cause of service especially by helping and enhancing the capability of the infantry commanders for terrain analysis and military planning. The project is requirement and an offer by Army Trafficability Survey unit.

1.6 Achievements

This project was done with guidelines from Army Survey Unit, Lahore so that it becomes practically deployable in all formations of Pakistan Army.

It was presented to Commander Survey, Pakistan Army along with other high officials from Army Survey Unit, Lahore. It was also presented to our Assistant Project Supervisor Lt Col ® Nasar-ul-Haq who made all trafficability maps of Pakistan manually. The project was discussed in detail in all its aspects and working operations and was highly appreciated.

1.7 Future

This project can be further extended as a distributed application where the geographical data will be kept at central location and users can access it remotely which will not only make it easier to update the databases involved but also give the user a freedom to carry and use it without much of processing power.

1.8 Organization of Report

This project report has been divided into eight chapters. Chapter 1 gives an introduction to the technology used and project statement and motivation behind under taking the project. Chapter two gives the literature review in detail along with the appropriate references. Chapter 3 is based on the detailed analysis of system requirements. Chapter 4 gives the brief system description along with system constraints. Chapter 5 describes the system design and architecture and explains the way project is organized. Chapter 6 describes the system development with all the details of the system functions and explains the way they have been developed. Testing and validation of the system is explained in chapter 7 and finally chapter 8 describes all the achievements of the project and the forums where it has been presented also including the future work that can be done in the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Trafficability

Trafficability is a term, which is globally used and refers to the ability of ground to support the movement of different types of vehicles. Trafficability maps indicate ground profile in five different colours to indicate degree of difficulty for movement of vehicles. These different colors represent different classes of trafficability. The class 1 represents the best trafficability conditions. Moving towards higher classes, trafficability decreases, making difficult for the movement of vehicles.

2.1.1 Importance of Trafficability

Every military plan or military exercise requires movement of troops, vehicles or even movement of tanks into that area. Before making any military plan or moving troop's into area the trafficability of that area is required to be known. The absence of trafficability model may cause trap for the tanks or other heavy military vehicles.

The existence of trafficability model is very important for the success or failure of a military plan. Knowing the importance of trafficability model, Army Trafficability Survey Unit is formed to deal with the trafficability of Pakistan and areas of India, in which in case of war Army has to move its troops and tanks.

2.1.2 Working of Trafficability Model

The trafficability model is to be used by the Army field commanders for making several plans and to plan exercises. The army field commanders are not expert computer programmers. Instead they have a little knowledge of the system. The GIS based software's are very complex in nature. Best utilization of the system can only be made if it is simplified for field military commanders. Keeping this constraint in mind, the model is designed to be very user friendly.

The automated trafficability model predicts the trafficability of a certain area depending upon the parameters given to it by the user. The user has to enter the vehicle type for which the trafficability is to be calculated. The trafficability of any area differs depending upon the vehicle type. Because the tanks are heavier in weight would move with difficulty and their trafficability would be lesser in comparison with lighter vehicles like Dozer etc. Also the problem with existing system was that they were designed according to one particular tank and could not be automated for various types of vehicles. To cater that issue or requirement, the system is automated for every type of vehicles. Therefore the user selects the vehicle for which the trafficability is to be calculated.

The second parameter which user has to enter is month for which he requires the trafficability. The problem with existing system was that they didn't take weather into account. There were separate maps for dry and wet weather. It was not

automated according to the weather conditions in a particular month. So user selects the month to cater the weather effect.

The final and last parameter to be selected is Corps, Div and Brigade. These values locate the area for which the trafficability is to be calculated. Definitely the trafficability is to be calculated of a certain area. By inserting these values model automatically finds the trafficability of the area in which these Corps, Div and Brigade is deployed.

All these parameters are given in a combo box. He has not to type anything with his hands. By just mouse clicks, he selects the vehicle type, month and area from combo box. On just clicking the “find trafficability” button Trafficability of the particular are is calculated and displayed to the user in the form of map and as well in text form. Making it simpler for the field commanders to use the system.

2.2 Classes of Trafficability

Trafficability is always presented in different five classes. Each class is recognized by a different colour. The details of these classes are as:-

2.2.1 Class 1

It represents the best trafficability conditions. It means a class 1 ground best supports the movement of vehicles. In this class a particular vehicle can make more than forty passes. The color to represent it is green.

2.2.2 Class 2

In this class a particular vehicle can make twenty five to forty passes. The color to represent it is yellow.

2.2.3 Class 3

In this class a particular vehicle can make ten to twenty five passes. The color to represent it is purple.

2.2.4 Class 4

In this class a particular vehicle can make three to ten passes. The color to represent it is pink.

2.2.5 Class 5

This class represents worst trafficability conditions. In this class a particular vehicle can make only maximum three passes. The color to represent it is red.

2.2.6 Class 6

This is an optional class. It is used to represent the mountainous area. Where, movement of vehicles is not possible.

Table 2.1: Trafficability Classes

Trafficability Class	Passes	Color
Class 1	>40	Green
Class 2	25 – 40	Yellow
Class 3	10 – 25	Purple
Class 4	3 – 10	Pink
Class 5	0 – 3	Red

2.3 Pass

Trafficability is calculated in terms of passes. More passes a vehicle can make in an area, better the trafficability is. Army vehicles and tanks move in the form of a queue. A pass means that all the vehicles move exact on the same path. The number of vehicles that can move exactly on the same path calculates the passes. A pass can well be known from the figure 2.1.

Figure 2.1: Pass

2.4 Factors Affecting Trafficability

There are various factors that affect the trafficability of certain area.

2.4.1 Vehicle Type

Different vehicles affect the trafficability differently. Vehicles range from a simple two ton vehicle to Al-Khalid tank. The lighter the vehicle is. The better is the trafficability. Every vehicle type has its affect on the trafficability. That affect depends on the weight of the vehicle. This effect is calculated by calculating a factor known as vehicle factor.

2.4.2 Weather

Weather affects the trafficability significantly. In dry period, the movement of vehicles is easier while in wet and rainy period, the movement becomes difficult. So weather affects the trafficability significantly. This effect is calculated in terms of weather factor.

2.4.3 Soil Type

Different types of soils behave differently to the trafficability. Sand makes it difficult for the vehicles to move whereas plains support the movement of vehicles. Soil also behaves differently in the case of rain. In rain plains make movement of vehicles difficult whereas sand become hard and supports the movements of vehicles. The effect of soil on trafficability is calculated as soil factor.

2.4.4 Crop

Besides knowing the soil type and weather, another factor affects the trafficability. That is what crop is cultivated in that area. If rice is planted in that area, the fields would be full of water because rice requires regular irrigation. Similarly, if wheat is cultivated in that area then the amount of water in the fields would be lesser. This is such a factor, which cannot be calculated exactly. Just information about the crop can be displayed to the field commander. Then based on his experience, he can guess about affect on trafficability.

2.4.5 Water Table

Another factor that affects the trafficability is the water table of that area. If water table is less, it will make the movement difficult and whereas greater water table would support the movement of vehicles. Its factor is not calculated exactly yet. User is just given information about the water table.

2.5 Summary

Trafficability is a term, which is globally used and refers to the ability of ground to support the movement of different types of vehicles. Trafficability maps indicate ground profile in five different colours to indicate degree of difficulty for movement of vehicles. There are various factors that affect the trafficability of any region. Those factors are vehicle type, soil type, weather, crop and water table. Trafficability model is very important for success of any military plan. The

absence of trafficability plan may result into trap for tanks and other heavier vehicles.

CHAPTER 3

REQUIREMENT ANALYSIS

3.1 Introduction

Requirements analysis encompasses those tasks that go into determining the needs or conditions to meet for a new or altered product, taking account of the possibly conflicting requirements of the various stakeholders, such as beneficiaries or users. Systematic requirements analysis is also known as requirements engineering. Requirements analysis of the Automated Trafficability Model is done in this chapter.

3.2 Existing System

The present system used to determine the trafficability of a certain area is collection of typical trafficability maps. These all maps are designed manually.

They are designed according to one standard tank. There are different collections of these maps for dry and wet weather conditions. To access the trafficability of a certain area, the user has to manually locate that area into the map. That area would be colored according to its trafficability class. That represents the trafficability of that area.

3.3 Problems with Existing System

The existing trafficability maps only indicate trafficability conditions for a particular type of tank and cannot be automatically interpreted for other type of vehicles. The existing maps do not incorporate the weather efficiently. They are for dry or wet weather only. They cannot be automated for different months and weather conditions. The existing maps give no information about the crop, water table, soil and corps deployed in the region. To use the existing system, one must have basic knowledge of the map reading to locate certain area on the map. Automatic selection of an area is not possible in these existing maps. Printing of existing maps is very expensive.

3.4 Requirements Consolidated

Based on the problems of the current system and guidelines from the Army Survey Unit, requirements for our project were consolidated. It was desired that system should predict the trafficability of selected region basing upon the vehicle and month selected. It was required that system should automatically determine the trafficability for various types of vehicles. Another critical requirement was to make the system simpler for army field commander. Our system full fills all these requirements. It can automatically predict the trafficability of a certain area and for every type of vehicles. It makes an efficient use of weather. The GUI is made much simpler for the field commanders who have to just make different clicks.

3.5 Functional Requirements

The requirements related to the functionality of the system are functional requirements of the system.

3.5.1 Description

Trafficability refers to the ability of ground to support movement of vehicles through a given region. Whenever troops are moving or for any military plan the trafficability of that area is required. The trafficability model forecast and predicts the trafficability of a selected area. This is used for military planning. The system is required to determine and predict the trafficability of a certain area. The variety of data is involved in this calculation such as weather, soil type, and vehicle type. Also the data from different departments is used. There would be duplication of data. So verification of integrity of database is required for the working of the system.

The entire database is present in Microsoft Access. GeoMedia Professional allows various map view operations that are to be performed. Development of GUI and automation of the system is done in Visual Basic 6.0. These all software's are required to be linked with each other. Microsoft access is to be linked with the GeoMedia for generation of trafficability model. Then GeoMedia is required to be linking with Visual Basic using GeoMedia command wizard. On the front end only Visual Basic would be working rest of the software would be working in the back end. The trafficability model would be used by infantry army officers for making their plans. It may be used by the clerks for analysis of trafficability of certain area. The infantry officers and clerks are having very less knowledge of the computer system. The project is aimed at developing a user friendly interface. So that without any special training the user is able to interact with the system by just entering few inputs such as area, vehicle type.

3.5.2 Criticality

The requirement is very critical. Because without knowing the trafficability of a selected area if forces move there. They may get trapped in the area. So, trafficability is very essentially required before movement of troops or tanks. The verification of data integrity is very essential because system is to be used by the army for military planning. If the data wouldn't be right the trafficability results

would be affected that can affect on whole of the military plan. The system is needed to be user friendly. Because, GIS tasks are quite complicated in nature, best utilization of the system can only be made if it is simplified for field military commanders.

3.6 Interface Requirements

The trafficability model is to be used by the Army field commanders for making several plans and to plan exercises. The army field commanders are not expert computer programmers. Instead they have a little knowledge of the system. The GIS based software's are very complex in nature. Best utilization of the system can only be made if it is simplified for field military commanders. Keeping this constraint in mind, the model is designed to be very user friendly. The user has to select vehicle type, month and Corps. All these parameters are given in the form of combo boxes. By just making various clicks user can find the trafficability of a certain area. The user is also facilitated with an easy toolbar. The GUI is depicted in the figure 3.1.

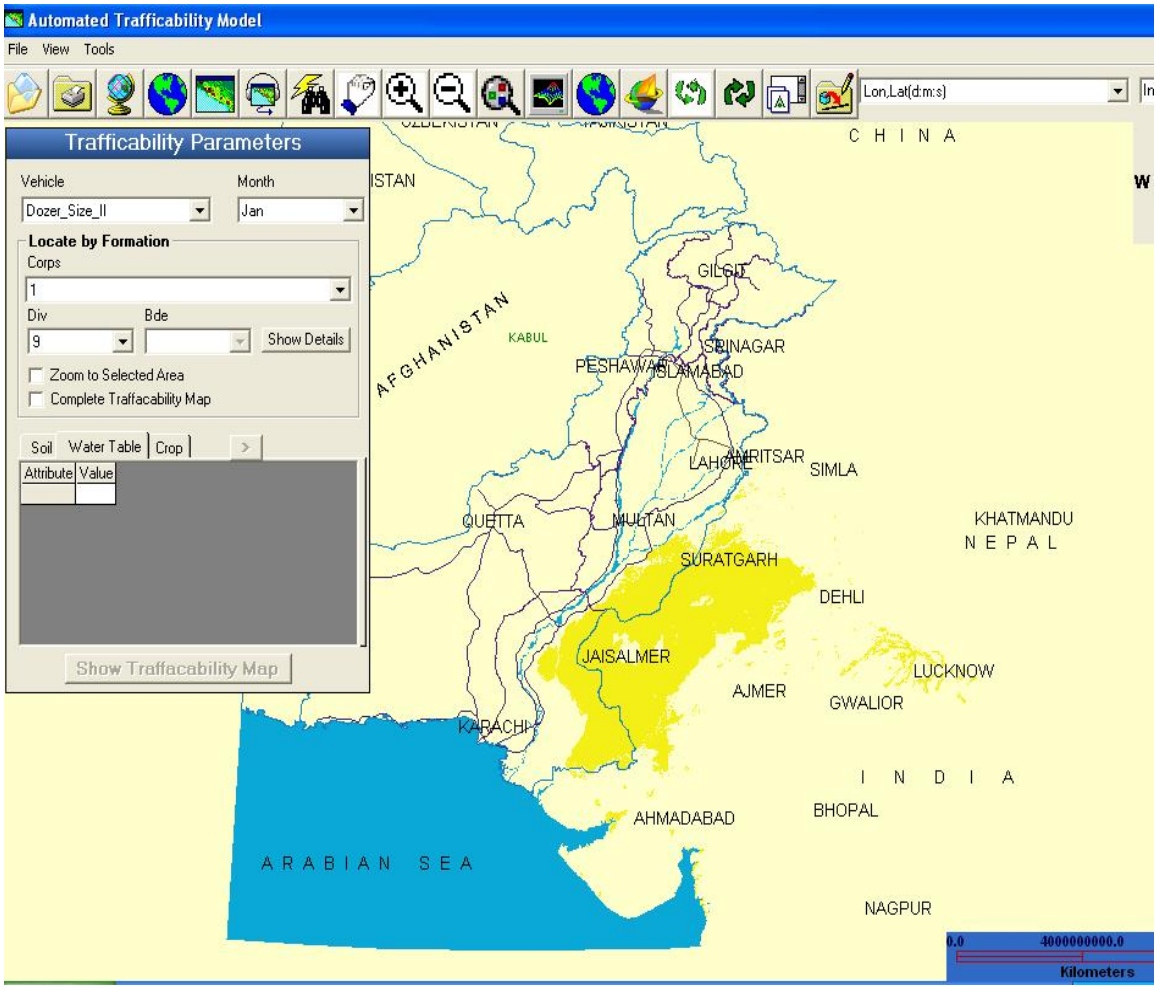


Figure 3.1: GUI

3.7 Performance Requirements

The requirements related to the performance of the system are performance requirements of the system.

3.7.1 Speed

The system is required to perform in real-time environment for military planning. Therefore system should provide the user with quick responses when forecasting trafficability of a selected region. Any delay in calculating results may result into a delay into a real time military operation.

3.7.2 Memory

The system would be using data of whole Pakistan. Moreover, that data is of last thirty years with various types of attributes ranging from geometry data to trafficability data. So, more memory space would be required.

3.8 Non-functional Requirements

A non-functional requirement is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviors. This should be contrasted with functional requirements that define specific behavior or functions.

3.8.1 Security

The system should be secure because the trafficability data used is classified data. The security is also involved in the distribution of system. The data is made secure by applying passwords to the database and making data available only in the trafficability survey unit. The security in the distribution of the system is part of future of the system. In which certain security measures can be taken by applying security keys or distribution keys.

3.8.2 Reliability

The system is to be used by the field commanders for military planning. So the system's reliability is important for working and availability. It should be reliable enough to work well on the user inputs. Its reliability is most important in case of its output. Output is trafficability which is input for all the military plans. Wrong trafficability calculation would result into the failure of a military plan. It is required and expected to be available to the user all the time. Any chances of unavailability and malfunctioning should be minimized. This involves calculation of trafficability.

3.8.3 Maintainability

The trafficability data changes with time. Therefore, the system should be an easy-to-maintain one. System should be able to incorporate any changes in the

data. The system should be maintainable so that in case of any complaints from the users, the system should be modified to meet the new requirements.

3.8.4 Portability

The system need to be portable because it has to be deployed at all army formations.

3.8.5 Compatibility

The system will be made portable enough that any system with Microsoft Windows installed will be able to access the system's features.

3.9 Summary

The Automated Trafficability Model is required to predict and determine the trafficability of any given region. It should automatically predict the trafficability for various types of vehicles and weather condition. Since, GIS tasks are complex in nature; the best utilization can only be made if they are simplified for the army field commanders. So, the model is required to be user friendly for the user's ease to use it.

CHAPTER 4

TRAFFICABILITY MODEL DESCRIPTION

4.1 Introduction

Automated trafficability model determines and predicts the trafficability of a certain region depending upon the trafficability parameters. The trafficability parameters given by the user are vehicle type, month and area in which a particular corps is deployed. Three filters are used to locate a particular area on the map. Those filters are corps, div and brigade. These three filters can be generalized to find an area on the basis of new filters such as province, city and village etc. The soil, crop and water table parameters are taken from the database. The percentages of these details of the area information are also displayed on to the map, to exactly know the area having these details. The database includes two types of data. One is of geometry and maps of Pakistan including various attributes like roads, motorway, province, major city, sea and rivers etc. The second data is trafficability data which includes weather factor, soil factor, vehicle factor and predetermined trafficability of the area. The new trafficability calculated on the basis of the parameters is saved into the database as modified trafficability. The output is trafficability class. That is displayed on the map as a colored layer. Every class has a different color code. The crop, soil type and water table of the selected area are also displayed in the form of a table. The map in different colors of these parameters is also displayed.

Automated trafficability model gets inputs from the user and some parameters from the database. Using values of database and inputs given by the user. It calculates the results. A brief overview of the system is displayed in the figure 4.1.

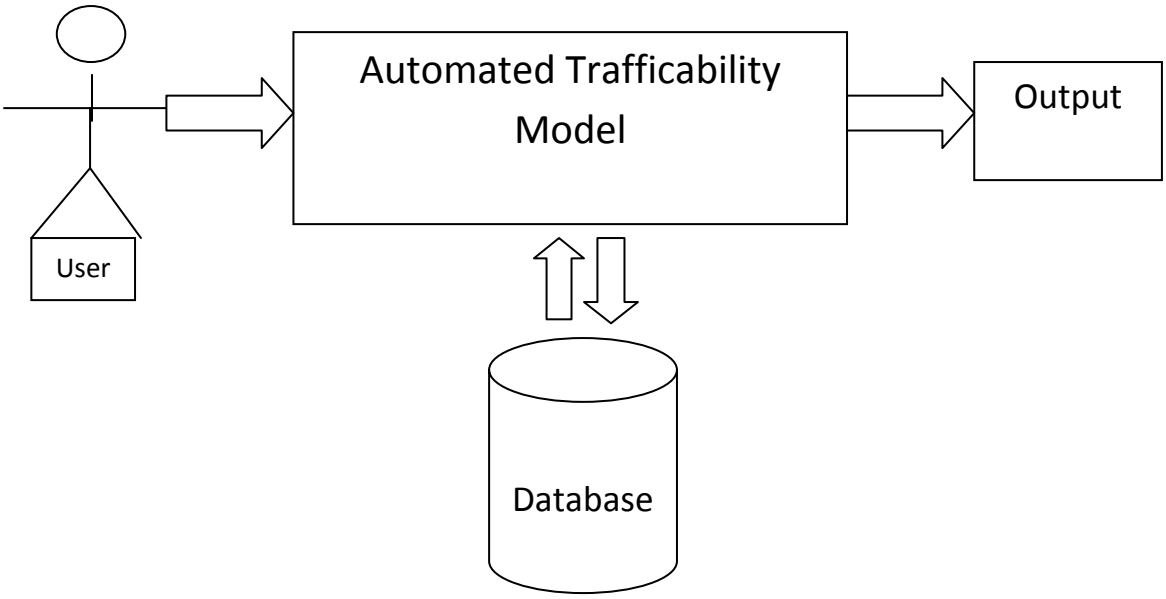


Figure 4.1: System Overview

4.2 Interfaces

The system interacts with the inputs provided by the user. It takes all the geometry shapes, map characteristics from the database. All the trafficability affecting factors are also stored in the database. The database is in Microsoft Access. Therefore certain communication is required between the Visual Basic 6.0 and Microsoft Access. To access the functionality of GeoMedia Professional 5.2 there must be some communication. The user is required to enter the inputs. These inputs are to be given to the user using some interface.

4.2.1 User Interfaces

User provides the trafficability parameters. The trafficability parameters provided by the user are vehicle type, month and corps. Further in a corps the div and the brigade. Basing on these parameters, the trafficability is calculated. These parameters are provided by the user through the user interface. The user interface hides all the expert level details of the system from the user. It presents him with simple combo boxes including all possible values of the parameters and user selects the parameters from that list. The output which is in the form of the

map and with different layers the trafficability class is displayed is also presented on the same user interface. The interface includes the legends. Legends are details about various symbols and shapes.

4.2.2 Hardware Interfaces

The automated trafficability model is entirely software based application and does not involve any sort of the hardware. Therefore no hardware interaction is required and no hardware interfaces are required. If in future, it is required to embed the system on a particular hardware then definitely hardware interface of the system would be required.

4.2.3 Software Interfaces

Automated trafficability model is built using three software. Microsoft Access includes all the data is present including geometrical and trafficability data. Microsoft access is linked with Visual Basic 6.0 using the connection manager of the Visual Basic. GeoMedia is linked with Visual Basic by including GeoMedia references in the Visual Basic. By adding GeoMedia references or components various map related operations are enabled like zoom, span, fit all etc.

4.3 Memory Constraints

The system database is built in Microsoft Access. The database includes geometrical and trafficability data. The raw data is very huge in size. That requires a lot of memory space. Because that is field data Pakistan of last thirty years. It also includes weather data from different departments like MET Department. Basing on that data weather factor, soil factor and vehicle factor have been calculated which is very small in size. The data essential for the functionality of the system imparts no memory constraints. But the field data requires a lot of space.

4.4 System Salient's

The trafficability model is to be used by the Army field commanders for making several plans and to plan exercises. The army field commanders are not expert computer programmers. Instead they have a little knowledge of the system. The GIS based software's are very complex in nature. Best utilization of the system can only be made if it is simplified for field military commanders. Keeping this constraint in mind, the model is designed to be very user friendly.

The aim of the model is to predict the trafficability of a certain area depending upon the parameters given to it by the user. The user has to enter the vehicle type for which the trafficability is to be calculated. The trafficability of any area differs depending upon the vehicle type. Because the tanks are heavier in weight would move with difficulty and their trafficability would be lesser in comparison with lighter vehicles like Dozer etc. Also the problem with existing system was that they were designed according to one particular tank and could not be automated for various types of vehicles. To cater that issue or requirement, the system is automated for every type of vehicles. Therefore the user selects the vehicle for which the trafficability is to be calculated.

The second parameter which user has to enter is month for which he requires the trafficability. The problem with existing system was that they didn't take weather into account. There were separate maps for dry and wet weather. It was not automated according to the weather conditions in a particular month. So user selects the month to cater the weather effect.

The final and last parameter to be selected is Corps, Div and Brigade. These values locate the area for which the trafficability is to be calculated. Definitely the trafficability is to be calculated of a certain area. By inserting these values model automatically finds the trafficability of the area in which these Corps, Div and Brigade is deployed.

All these parameters are given in a combo box. He has not to type anything with his hands. By just mouse clicks, he selects the vehicle type, month and area from combo box. On just clicking the “find trafficability” button Trafficability of the particular are is calculated and displayed to the user in the form of map and as well in text form.

The trafficability is calculated by the following formula:-

Trafficability Class = (Field Factor)*(Weather Factor)*(Soil Factor)*(Vehicle Factor)

4.5 User Characteristics

The trafficability model is to be used by the Army field commanders for making several plans and to plan exercises. The army field commanders are not expert computer programmers. Instead they have a little knowledge of the system. The GIS based software’s are very complex in nature. Best utilization of the system can only be made if it is simplified for field military commanders. Keeping this constraint in mind, the model is designed to be very user friendly.

4.6 System Constraints

The model works using maps that are stored in Microsoft Access as geometrical data and it calculates the trafficability basing on the various factors that affect the trafficability. This all data is stored in the database. The model is developed according to the specific requirement of the Army Survey Unit. It may not work properly if data is not specific and is general. The data included in it was confidential that was a major constraint to understand the working of the system. The system is tested on dummy or raw data.

4.7 Summary

Automated Trafficability Model determines the trafficability of any given region depending upon various trafficability parameters. The trafficability parameters are vehicle type, month and area. The area is recognized by the corps deployed in that area.

CHAPTER 5

SYSTEM DESIGN AND ARCHITECTURE

5.1 Introduction

The software design and architecture of a program or computing system is the structure or structures of the system, which comprise software components or modules, the externally visible properties of those components or modules, and the relationships between them. This chapter covers the layout of our project and its architecture. The components designed and their link with each other is explained here in detail.

5.2 System Architecture

Automated trafficability model is a software based system. The system is divided into various components. Mainly there are three components GUI, trafficability assessment logic and database. The detailed architecture of the system is depicted in the figure 5.1.

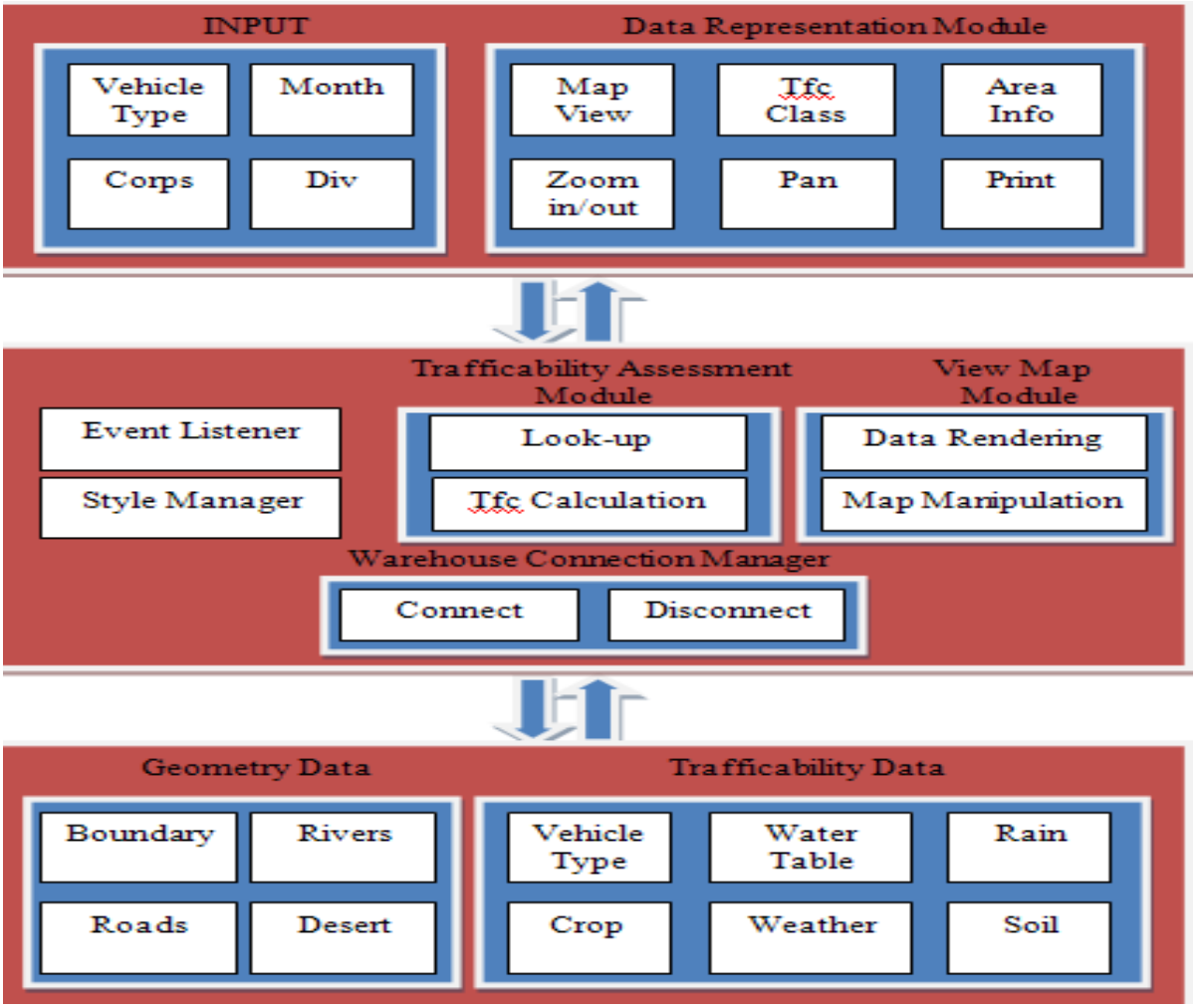


Figure 5.1: Architectural Diagram

5.2.1 Input Module

Input module is the part of the GUI. Using the input module, user provides the trafficability parameters to the system. Basing on those parameters the trafficability of a certain region is determined. The trafficability parameters provided by the user are vehicle type, month and area information that is corps, div and brigade. These all trafficability parameters are directly given to the look-up module.

There are certain operations that are also performed by the user on the map. Those operations include zoom, pan, fit all, view legends, view information etc.

these all inputs are taken from the data representation module, which include the map view. The clicks performed on the map are passed on to the event listener or event control, which perform operation on the map accordingly. Figure 5.2 elaborates the input module.

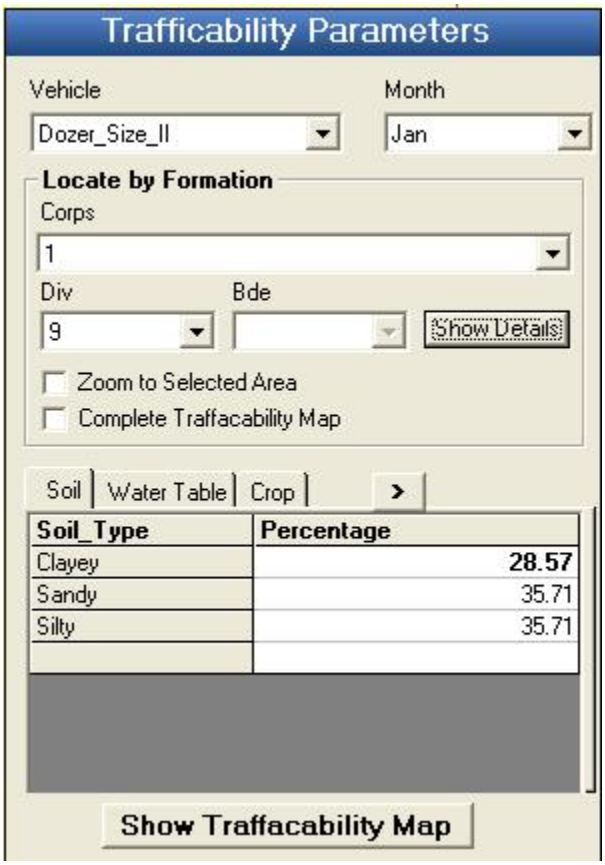


Figure 5.2: Input Module

5.2.2 Data Representation Module

Data Representation module is also part of GUI. Map of Pakistan along with certain attributes such as roads, rivers, cities, provinces, motorway, sea and desert etc are displayed on it. These map view attributes are enabled by map view module. Data representation module enables user to perform certain operation on the map such as zoom, pan, fit-all etc.

The trafficability calculated is displayed by this module in the form a map layer. The area information such as crop, soil and water table is displayed by this

module in the form of table. This module also attaches scale bar and direction bar to the map for ease of the user. Figure 5.3 shows the map view of data representation module.

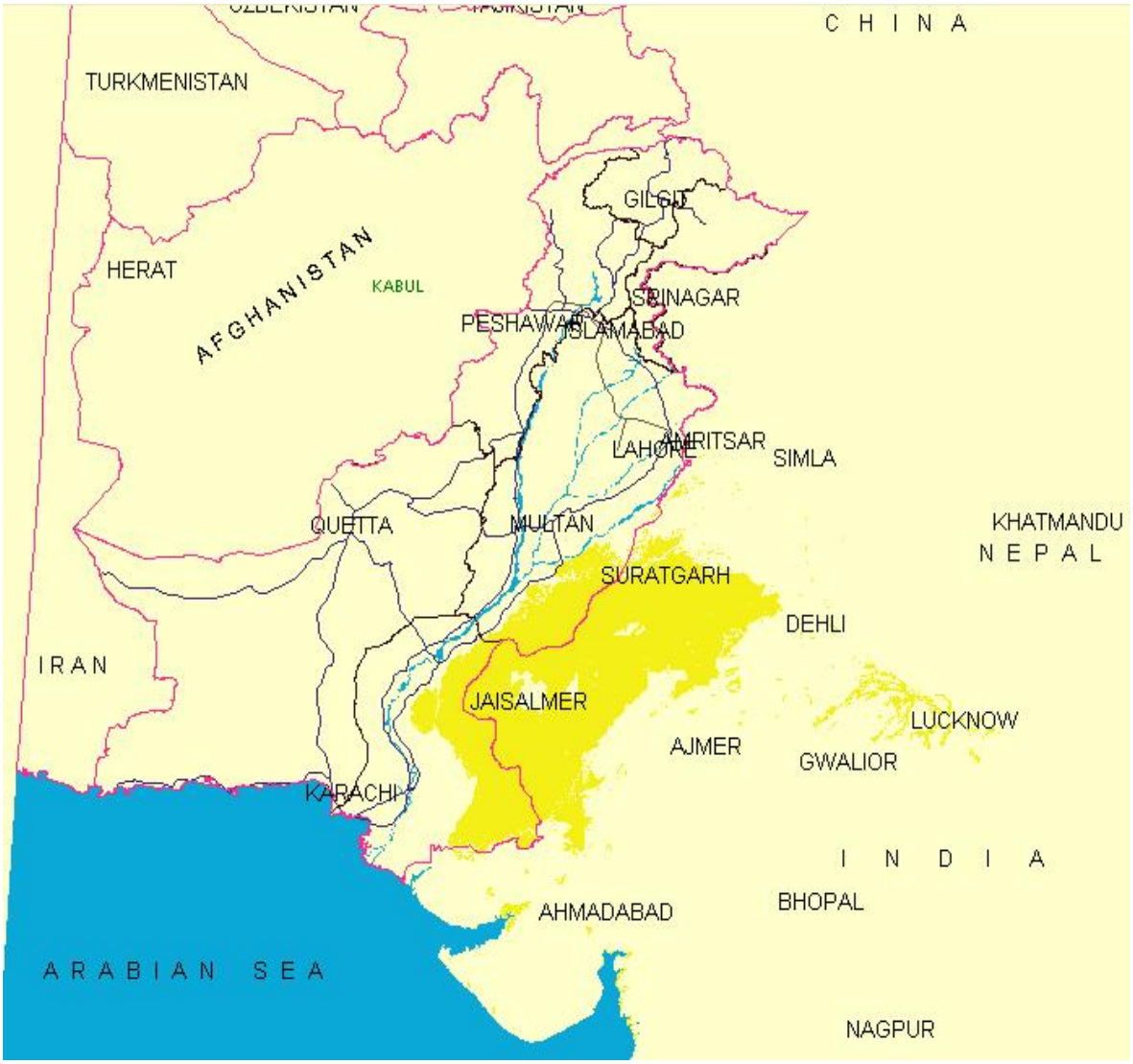


Figure 5.3: Map View

5.2.3 Warehouse Connection Manager

Warehouse connection manager is responsible for establishing all warehouse connections. Warehouse connections are of two types by their access. One is read-only connection. In this connection user cannot not make any change to the database connected. The second types of connection are read and write

connection. In this type of connection user can make changes to the warehouse connected. The read-only type of warehouse connection is used in the system to avoid any unwanted changes made by the user in the warehouse [1].

Warehouse connections are of two types by their connection time. One is static connection. The static connection is established in the initialization of the model. The second is dynamic connection. Dynamic connection is made at the program start-up or any where during the program execution. In trafficability model both types of connections are used. The connection to the warehouse is declared statically. But an option is also given to the user to establish any new connection during the program execution.

Warehouse connection manager allows more than one connection to the warehouse at the same time. Whenever user makes a new connection and wants the previous connection to be terminated. The warehouse connection manager first checks if any connection is already established. If any connection is already established, it first terminates the already built connection. Then it unloads all features of the previous connection. Then it loads the features of the new connected warehouse. The features are needed to be specified earlier. If features are not specified earlier then they have to be specified.

5.2.4 Style Manager

Map of any area include certain features in it. Those all features are stored in the database along with the geometrical data. These features are like road, rivers and canals etc. All these features have different styles to represent them. For example one can represent roads by black lines and rivers by green. Another can represent roads by purple and rivers by blue lines. The style manager manages these different styles for the features. All the styles for the features are managed by style manager.

5.2.5 Event Listener

Event listener serves as a bridge between user actions and the map view. It captures all the user actions clicks performed on the map and forward them to the map view. These actions include zoom, span and fit-all, previous view and rotate etc. These all actions are listened by the event control and forwarded to map view that performs action against all these operations.

5.2.6 Look-up Module

Look-up module interacts with the trafficability data to find various values from it. It receives the inputs from the user and finds the various factors basing on those inputs.

It receives the vehicle type selected by the user and basing on the vehicle type selected it extracts the vehicle factor from the vehicle factor table. Basing on the month selected by the user, it first gets the weather region or weather-ID from the main table and then basing on the month and weather-ID it finds the weather factor from the table weather factor. Then user selects the corps and in that corps the div and brigade. It looks for all the sheets that have that respective corps, div and brigade deployed in them. It passes those sheet numbers to data rendering module. It also finds crop, soil type, soil factor and water table for those sheets. It forwards the sheet numbers and soil factor, vehicle factor, weather factor and trafficability class to the trafficability calculation module.

5.2.7 Trafficability Calculation Module

Trafficability calculation module is responsible for calculating the trafficability of the certain region basing on the vehicle factor, soil factor, field factor and weather factor passed on to it by the look-up module. It saves the trafficability class thus calculated as modified trafficability. It finds the trafficability by the following formula:-

Trafficability Class = (Field Factor)*(Weather Factor)*(Soil Factor)*(Vehicle Factor)

It also finds the percentage of various types of soil present in that area. It also finds the percentage of water table and crop cultivated in that area. These percentages of various types are displayed on the data representation module in the form of table. It forwards these percentages along with the trafficability class calculated to the map manipulation module.

5.2.8 Map Manipulation Module

Map manipulation module as name suggests manipulates the map according to different operations. It has got the sheets numbers for which trafficability was to be calculated. It also receives the trafficability class in that area and percentage of various features like crop, soil type and water table.

It colorizes the sheet numbers according to the trafficability class calculated for those sheet numbers. It colorizes the sheets according to a unique thematic. It assigns one color for one trafficability class.

It is also responsible for any operation performed by the user on the map such as zoom, pan etc. All these operations are listened by event listener who forwards all these actions of the user to map manipulation module and map manipulation module performs all those operations on the map. Any sort of map manipulation is performed by this module.

5.2.9 Data Rendering Module

Data rendering module loads all the map features stored in the database. Which features are to be displayed on the map are specified in this tool.

5.3 Data Design

The system uses two types of data. One is primarily related with the map. That is geometrical data and the other is trafficability data used to calculate the trafficability.

5.3.1 Geometry Data

The geometry data includes all the map features. The geometry data in this case include rivers, roads, sea, international boundary shape, provinces shape, major cities labels, motorway, desert, countries labels and line of control LOC. This all geometry data is given by the Army Trafficability Survey Unit.

5.3.2 Trafficability Data

Trafficability data is used to calculate the trafficability. It includes various tables. The names of the tables are sheet, soil, vehicle and weather table. The sheet table includes the sheet numbers of different areas and it is the main table linked with other tables. The soil, vehicle and weather table includes the soil factor, vehicle factor and weather factor respectively.

All these tables have various relations with each other, which are displayed in the figure 5.4. The table vehicle has no relation with other tables, because only vehicle factor is required from it, which can be independently accessed from it.

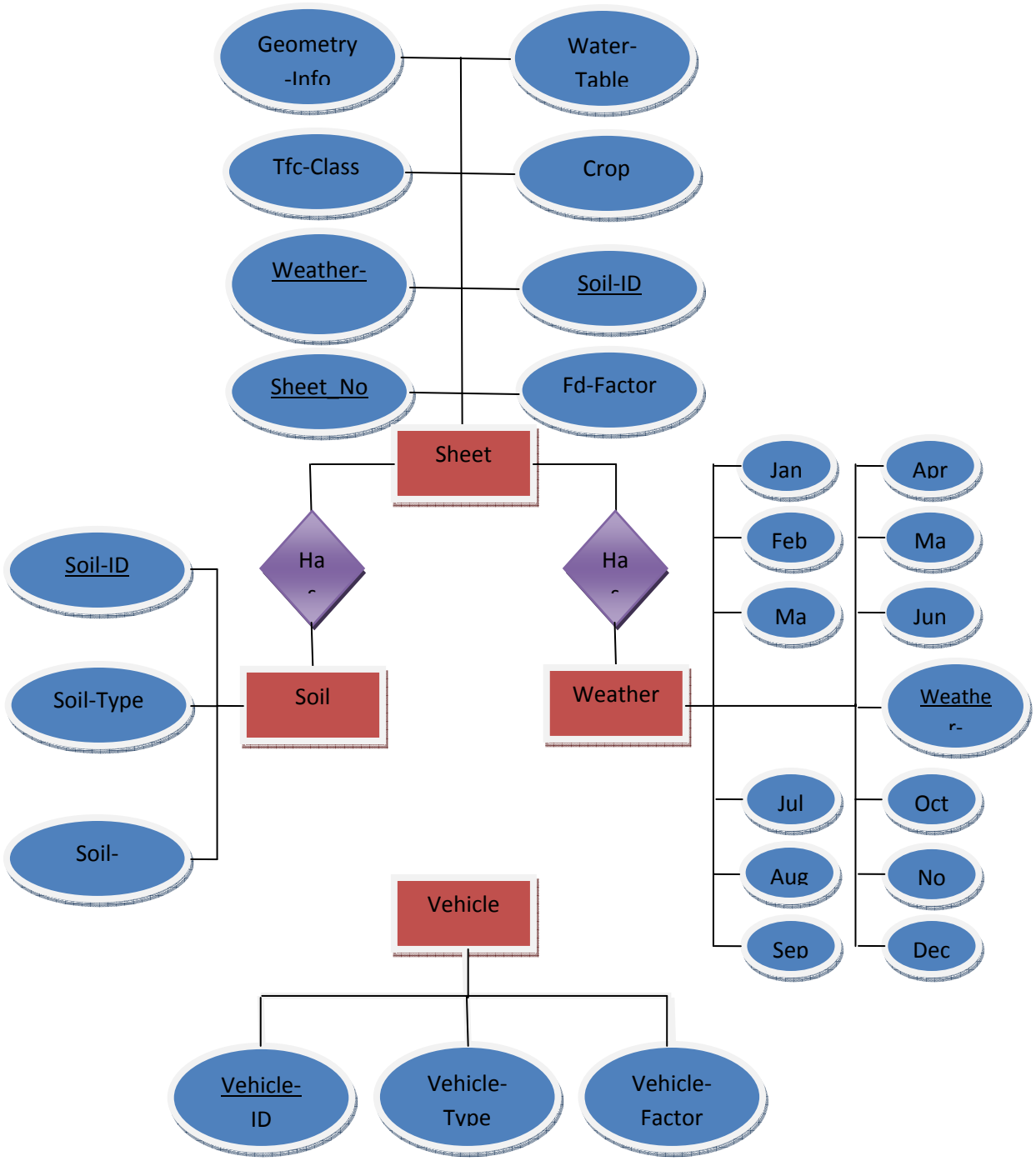


Figure 5.4: ER Diagram

5.4 UML Design

Modeling has been an essential part of engineering, art and construction for centuries. Complex software designs that are difficult to describe textually can readily be conveyed through diagrams. Modeling provides three key benefits: visualization, complexity management and clear communication [2]. UML, the Unified Modeling Language, is a visual language for specifying, constructing, and documenting the artifacts of systems. UML was approved by the OMG as a standard in 1997. Over the past few years there have been minor modifications made to the language.

The Unified Modified Language (UML) is a standard language for specifying, visualizing, constructing and documenting the artifacts of software systems as for business modeling and other non-software systems. The UML mostly uses graphical notations to express the design of software projects. Using the UML helps project teams communicate, explore potential designs and validate the architectural design of the software [3].

Using the UML modeling, the use case diagram of the system is developed. Figure 5.5 depicts the use case diagram of automated trafficability model.

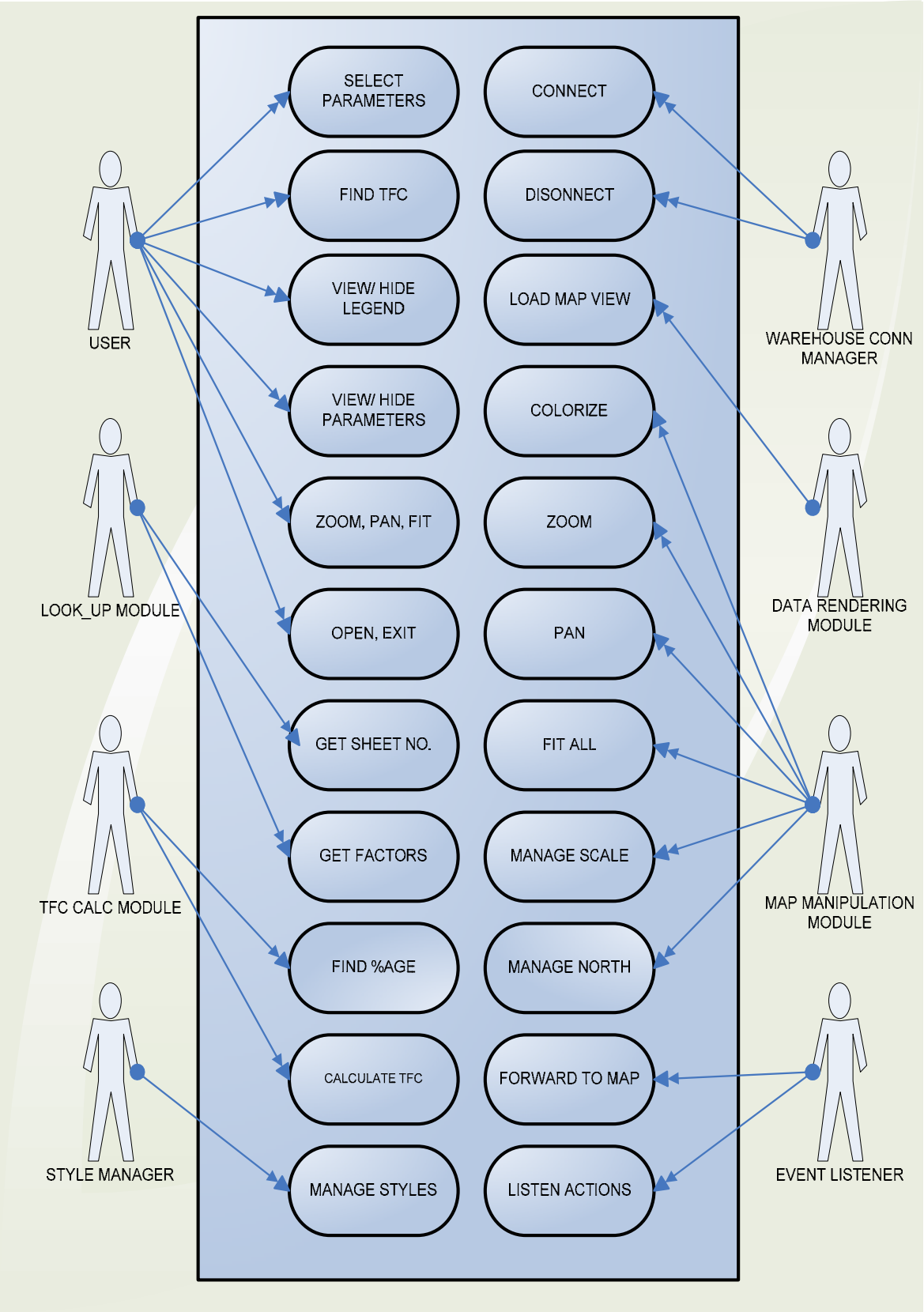


Figure 5.5: Use Case Diagram

5.5 Interface Design

The trafficability model is to be used by the Army field commanders for making several plans and to plan exercises. The army field commanders are not expert computer programmers. Instead they have a little knowledge of the system. The GIS based software's are very complex in nature. Best utilization of the system can only be made if it is simplified for field military commanders. Keeping this constraint in mind, the model is designed to be very user friendly.

User provides the trafficability parameters. The trafficability parameters provided by the user are vehicle type, month and corps. Further in a corps the div and the brigade. Basing on these parameters, the trafficability is calculated. These parameters are provided by the user through the user interface. The user interface hides all the expert level details of the system from the user. It presents him with simple combo boxes including all possible values of the parameters and user selects the parameters from that list. The output which is in the form of the map and with different layers the trafficability class is displayed is also presented on the same user interface. The interface includes the legends. Legends are details about various symbols and shapes. User interface of the system is shown in the figure 5.6.

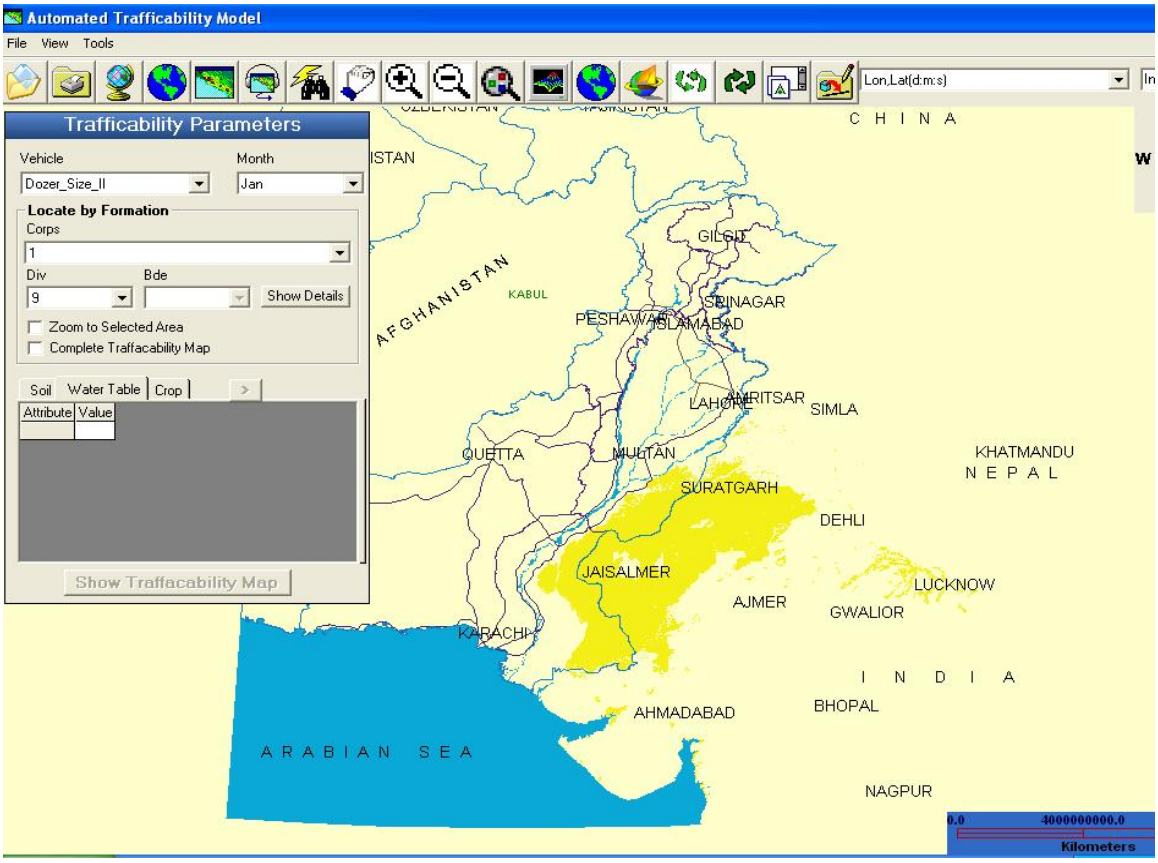


Figure 5.6: User Interface

5.6 Summary

Automated Trafficability Model has various modules to perform its functionality. The input and data representation modules are part of GUI. The trafficability assessment module calculates the trafficability on the basis of parameters and map view module manages all the manipulation made on the map. Warehouse connection manager makes connection with the database. The database contains trafficability and geometry data.

CHAPTER 6

SYSTEM IMPLEMENTATION

6.1 Introduction

This chapter gives a closer look at the detailed aspects of system implementation. It specifies all the software tools and techniques used to build the system. Module and system development is explained in detail.

6.2 Languages and Tools Used

The system is developed using Microsoft Access, GeoMedia Professional 5.2 and Visual Basic 6.0

The entire database is stored and organized in Microsoft Access. GeoMedia Professional controls and functions are used for various map manipulation functions. The system is developed in Visual Basic 6.0.

6.3 Implementation of GUI

The GUI is developed in Visual Basic 6.0 using different GeoMedia Professional 5.2 graphical controls for displaying and manipulation of map. The GUI includes two modules that are input module and data representation module. Input module for taking inputs and the data representation module for displaying the outputs. The data representation module displays map and area information including crop, soil and water table.

GeoMedia Professional 5.2 controls that are used for building the GUI are Intergraph GeoMedia Controls 5.2, Intergraph GeoMedia Event Control 5.2, Intergraph GeoMedia Map View Control 5.2, Intergraph GeoMedia North Arrow Control 5.2 and Intergraph GeoMedia Scale Bar Control 5.2 [4].

These all controls allow addition of various GeoMedia graphical controls into the Visual Basic 6.0, which are not present in the default settings. By adding these

controls, GeoMedia interface functionality can be achieved. That is explained in detail.

6.3.1 Intergraph GeoMedia Controls 5.2

These controls allow using GeoMedia graphical controls on the GUI. When these controls are added in the Visual Basic 6.0 they appear in the graphical box of the Visual Basic 6.0.

6.3.2 Intergraph GeoMedia Event Control 5.2

It allows working of event listener. Which listens all the actions performed by the user on the map and forwards them to the map manipulation module to take actions against them.

6.3.3 Intergraph GeoMedia Map View Control 5.2

Visual Basic 6.0 doesn't support display of the map. These controls allow including map view controls on the GUI. It also allows implementation of various map manipulation functions like zoom, pan, fit, rotate and previous view etc.

6.3.4 Intergraph GeoMedia North Arrow Control 5.2

North Arrow is also displayed on the map. This changes its position according to any change in the direction of the map. North Arrow control allows accurate working of north direction on the map. The north arrow is shown in the figure 6.1.

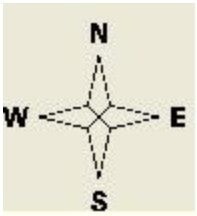


Figure 6.1: North Arrow

6.3.5 Intergraph GeoMedia Scale Bar Control 5.2

Scale bar represents the scale on the map. Scale represents the distance on the map to its actual distance on the ground. Scale changes as user zoom in or out a certain area. The scale bar tool is enabled by adding these controls into Visual Basic 6.0. The scale bar of the system is depicted in the figure 6.2.

Figure 6.2: Scale Bar

Other then GeoMedia controls, certain Visual Basic controls are also used to develop the GUI. Those are Microsoft Common Dialog Control 6.0, Microsoft FlexGrid Control 6.0, Microsoft Tabbed Dialog Control 6.0, Microsoft Common Controls 5.0 and Microsoft Common Controls 6.0.

These all controls allow addition of various graphical interface functions, which are not there in the default settings and appear in the Visual Basic graphical control options.

6.3.6 Microsoft Common Dialog Control 6.0

This control enables the addition of file option in the menu. This allows opening or exiting a connection or opening of a file.

6.3.7 Microsoft FlexGrid Control 6.0

The input module is developed using these controls. This allows making the complete form as a form of a picture.

6.3.8 Microsoft Tabbed Dialog Control 6.0

The percentage of crop, water table and soil in any selected area is given in the form of a table. That table addition is done by using these controls. The use of tabbed dialog is shown in the figure 6.3.

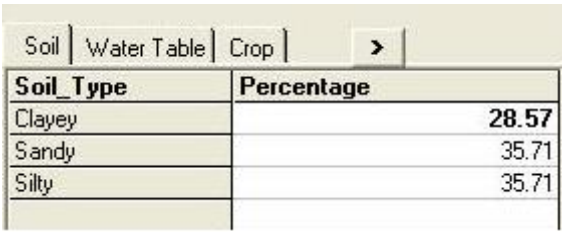


Figure 6.3: Tabbed Dialog

6.3.9 Microsoft Common Controls 5.0 and 6.0

These controls allow working of combo and radio boxes and these controls are added in the default settings of Visual Basic 6.0.

6.4 Implementation of Warehouse Connection Manager

Warehouse connection manager is responsible for establishing all warehouse connections. Warehouse connections are of two types by their access. One is read-only connection. In this connection user cannot not make any change to the database connected. The second types of connection are read and write connection. In this type of connection user can make changes to the warehouse connected. The read-only type of warehouse connection is used in the system to avoid any unwanted changes made by the user in the warehouse.

Warehouse connections are of two types by their connection time. One is static connection. The static connection is established in the initialization of the model. The second is dynamic connection. Dynamic connection is made at the program start-up or any where during the program execution. In trafficability model both types of connections are used. The connection to the warehouse is declared statically. But an option is also given to the user to establish any new connection during the program execution.

Both types of connection are made by declaring an object of Conn type. It first checks if any already established connection exists. If any connection exists, it first disconnects that connection and unloads all its features. Then it establishes the new connection as specified and loads it’s all the features those are

specified. The features loaded in this case are desert, roads, sea, motorway, line of control, provinces boundary, country labels, major cities labels and international boundary shape.

These features are declared, further features can also be selected from select feature tool. This tool is GeoMedia control and is added into the Visual Basic. It displays the list of all features present in the database and user can select any of those according to his interest.

6.5 Implementation of Style Manager

Map of any area include certain features in it. Those all features are stored in the database along with the geometrical data. These features are like road, rivers and canals etc. All these features have different styles to represent them. For example one can represent roads by black lines and rivers by green. Another can represent roads by purple and rivers by blue lines. The style manager manages these different styles for the features. All the styles for the features are managed by style manager.

It sets style for sea, rivers, roads, motorway, desert and district. It gives random color to any other feature that is not set here. Sea and rivers are given blue color. The roads are specified by black lines and desert by yellow color.

6.6 Implementation of Event Listener

Event listener serves as a bridge between user actions and the map view. It captures all the user actions clicks performed on the map and forward them to the map view. These actions include zoom, span and fit-all, previous view and rotate etc. These all actions are listened by the event control and forwarded to map view that performs action against all these operations.

It is implemented by adding Intergraph GeoMedia Event Control 5.2 on the GUI. It automatically captures all the clicks of the user and passes them to the map manipulation module to take respective action against them.

6.7 Implementation of Look-up Module

Look-up module interacts with the trafficability data to find various values from it. It receives the inputs from the user and finds the various factors basing on those inputs.

It receives the vehicle type selected by the user and basing on the vehicle type selected it extracts the vehicle factor from the vehicle factor table. The vehicle factor table is shown in the figure 6.4.

Veh_ID	Veh_Type	Veh_Factor
1	Dozer_Size_II	0.76
2	Dozer_Size_IV	0.68
3	Tk_T85IIAP	0.93
4	Tk_T80UD	1.01
5	Tk_T69IIAP	0.87
6	Tk_AlKhalid	1
7	Tk_AlZarrar	0.92
8	ARV_W653	0.88
9	APC_M113P	0.61
10	Tk_M47	1
11	Trk1/4Ton	0.46
12	Trk3/4Ton	0.48
13	Trk21/2Ton	0.66
14	Trk3Ton	0.67
15	MotorGrader	0.7

Figure 6.4: Table Vehicle Factor

Basing on the month selected by the user, it first gets the weather-Region from the main table and then basing on the month and weather-Region it finds the weather factor from the table weather factor. The Pakistan has been divided into twenty different regions basing on the similarity in the weather conditions. These weather regions are used to find the weather factor in any area. The table weather factor is shown in the figure 6.5.

Weather_Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	1	1	1	1.25	1.25	1.25	1.25	1.1	1.1	1.1	1.1
2	1.2	1.2	1.2	1.3	1.4	1.5	1.3	1.2	1.1	1.2	1.3	1.3
3	1	1	1	1	1	1	1	1.2	1	1	1	1
4	1	1	1	1	1	1.1	1	1	1.1	1	1	1
5	1.1	1	1.2	1.1	1.1	1	1.2	1.2	1.1	1	1	1.1
6	1.2	1.2	1.1	1.2	1.2	1.3	1.3	1.3	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1
8	0.8	0.8	0.6	0.6	0.7	0.9	0.7	0.7	1	0.6	0.6	0.5
9	1	1	1	1	1.25	1.25	1.25	1.25	1.1	1.1	1.1	1.1
10	1.2	1.2	1.2	1.3	1.4	1.5	1.3	1.2	1.1	1.2	1.2	1.2
11	1	1	1	1	1	1	1	1.2	1	1	1	1
12	1.2	1	1	1.2	1	1.1	1	1	1.1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	0.8	1	1	1	1	1	0.8	1	1	1
15	1	0.8	0.8	1	1	1	1	1	1	1	0.8	1
16	0.8	0.8	1	0.9	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1
18	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
19	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1
(New)	0	0	0	0	0	0	0	0	0	0	0	0

Figure 6.5: Table Weather Factor

Then user selects the corps and in that corps the div and brigade to locate an area on the map. These are three filters to locate an area on the map. Basing on these filters the complete area of Pakistan is filtered to finally reach to the required area requested by the user. The figure 6.6 shows complete areas where army is deployed.

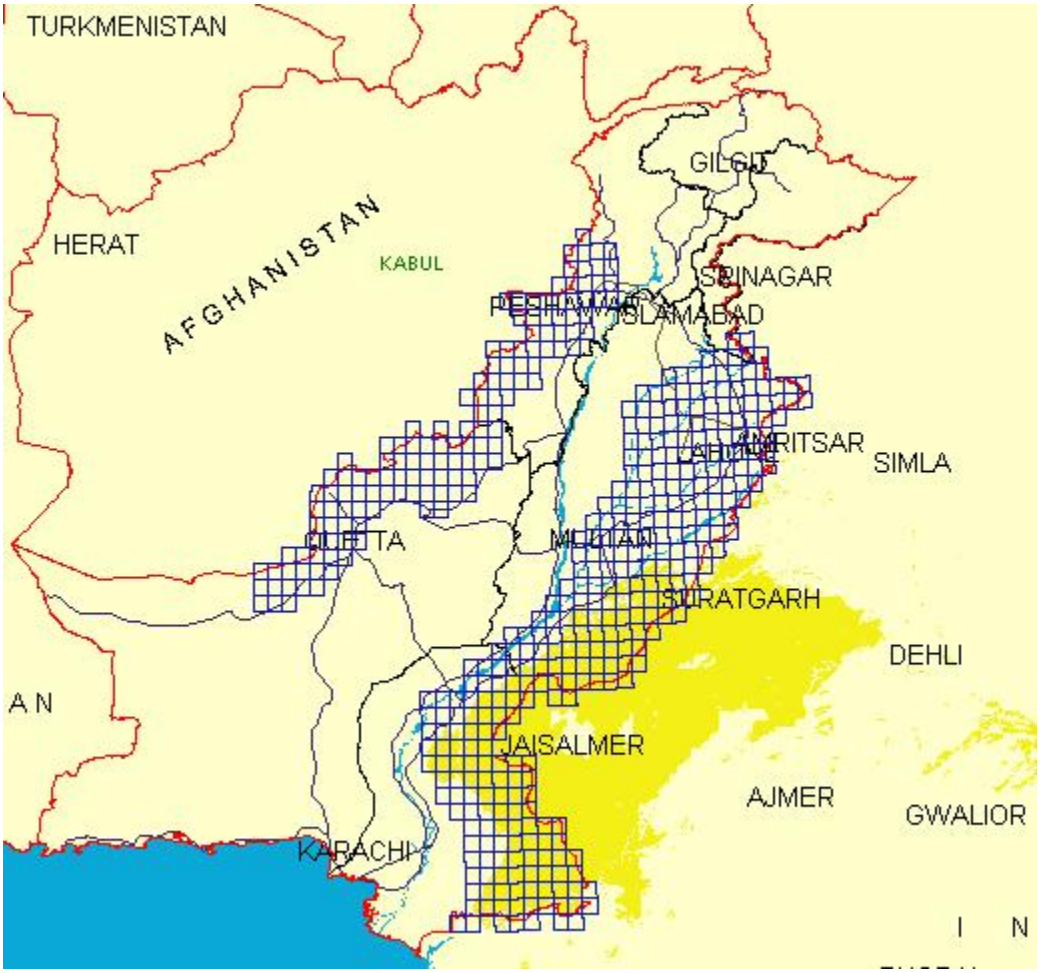


Figure 6.6: Complete Area for Trafficability

The first filter is for corps and second is for the div in that corps. It filters the area according to corps and div. this is shown in figure 6.7. The red area depicts deployment of 5 corps.

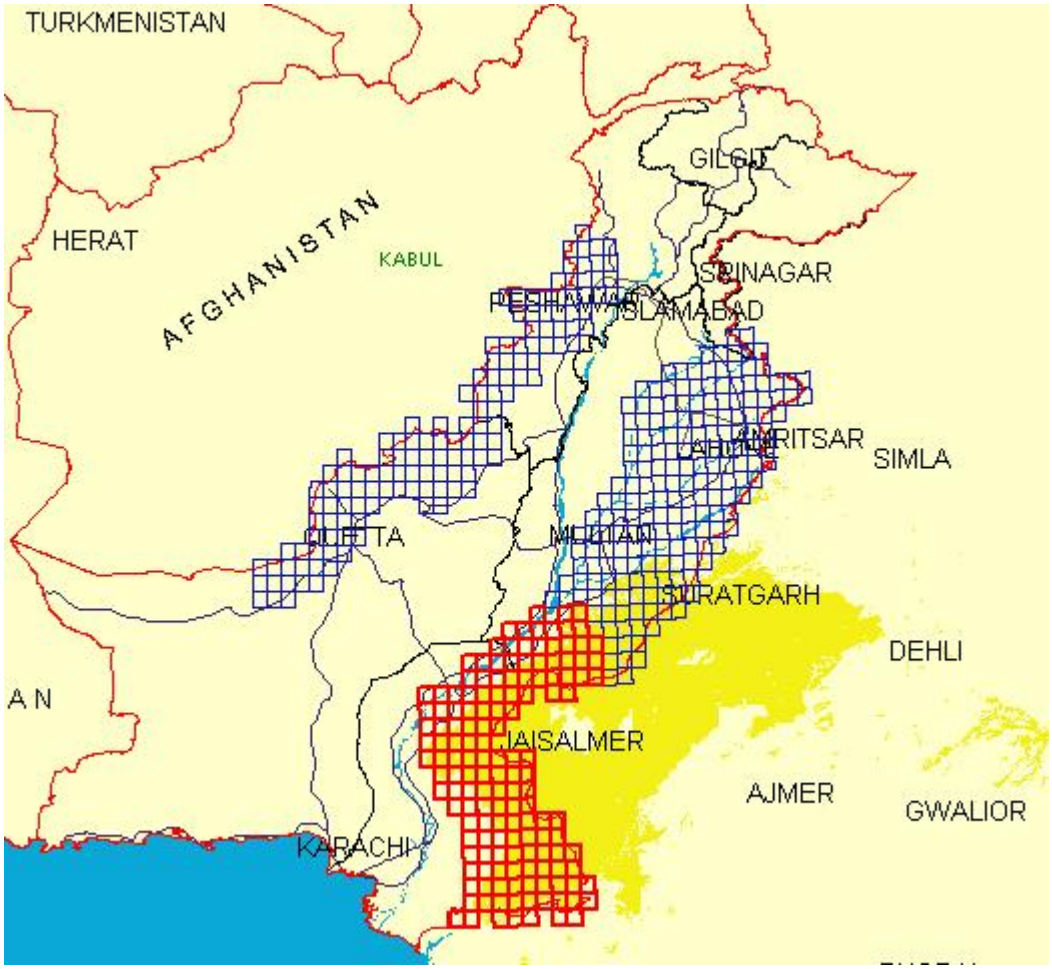


Figure 6.7: Application of Corps Filter

After applying, filters for corps and division. The third filter is applied for brigade that further filters the area of selected corps. The figure 6.8 shows the area of 5 corps after applying brigade filter. The purple area shows 5th brigade in 5 corps.

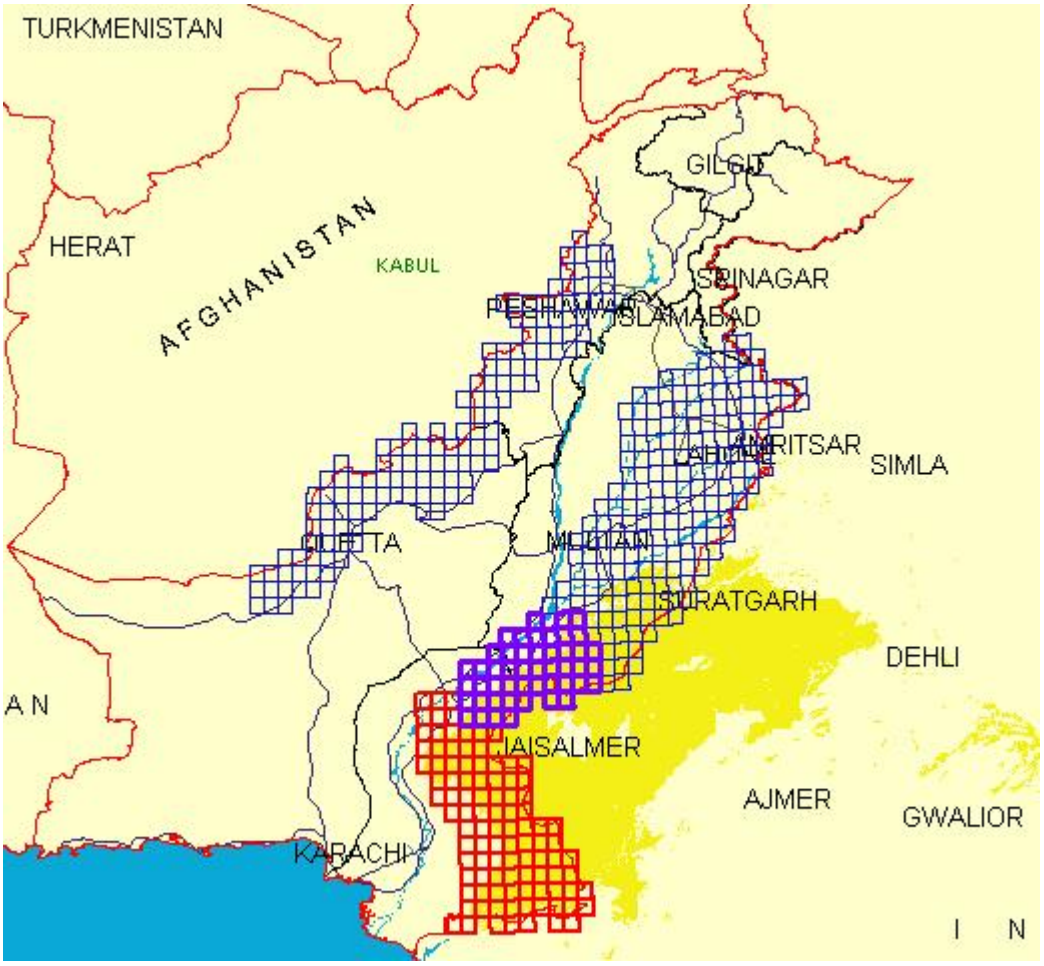


Figure 6.8: Application of Brigade Filter

The area is selected by three types of filters those are corps, div and brigade. It can be generalized for any other type of filters such province, district and city. Basing on the area selected by the user, it first gets the soil type from the main table and then basing on the soil type it finds the soil factor from the table soil factor. The table soil factor is shown in the figure 6.9.

Soil_ID	Soil_Type	Soil_Factor
1	Sand	1
2	Silt	0.5
3	Clay	0.25
4	Sandy Clay	0.65
5	Silty Clay	0.35
6	Loam	0.55
7	Sandy Loam	0.65
8	Silt Loam	0.55
9	Clay Loam	0.65
10	Silty Clay Loam	0.45
11	Sandy Clay Loam	0.65
12	Loamy Sand	0.75
13	Gravel	1
(New)		0

Figure 6.9: Table Soil Factor

It looks for all the sheets that have that respective corps, div and brigade deployed in them. It passes those sheet numbers to data rendering module. It also finds crop, soil type, soil factor and water table for those sheets. It forwards the sheet numbers and soil factor, vehicle factor, weather factor and trafficability class to the trafficability calculation module.

6.8 Implementation of Trafficability Calculation Module

Trafficability calculation module is responsible for calculating the trafficability of the certain region basing on the vehicle factor, soil factor, field factor and weather factor passed on to it by the look-up module. It saves the trafficability class thus calculated as modified trafficability. It finds the trafficability by the following formula:-

Trafficability Class = (Field Factor)*(Weather Factor)*(Soil Factor)*(Vehicle Factor)

It also finds the percentage of various types of soil present in that area. It also finds the percentage of water table and crop cultivated in that area. These percentages of various types are displayed on the data representation module in

the form of table. It forwards these percentages along with the trafficability class calculated to the map manipulation module.

The trafficability is simply calculated by the above formula and saved into the table tfc_sheets in the column modified trafficability. The percentage of any type whether that is of soil, water table or crop is calculated by calculating all the rows of the database first. Then calculating the value for which percentage is to be calculated in that area. The process is repeated for each value of soil type, water table and crop available in that area. If X represents the value, for which percentage is to be calculated and N represents the total number of rows of that area. Then percentage of that value is calculated by the formula:-

Percentage of X= (X/N) * 100%

For example if an area have three types of soil. Then first the rows of that area are calculated and then those fields of that area which has soil of first type are calculated and simply percentage is calculated then this process is repeated for all the three types of soil. The figure 6.10 shows percentage calculated for different soil types.

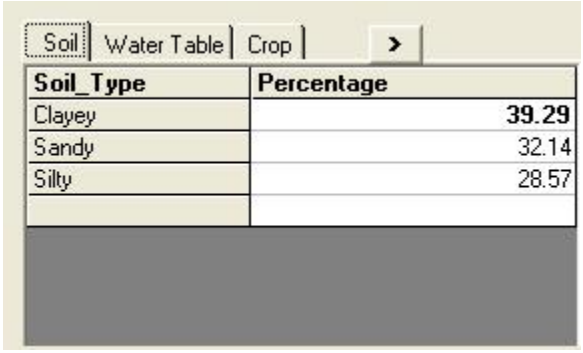


Figure 6.10: Soil Percentage

6.9 Implementation of Map manipulation Module

Map manipulation module as name suggests manipulates the map according to different operations. It has got the sheets numbers for which trafficability was to

be calculated. It also receives the trafficability class in that area and percentage of various features like crop, soil type and water table.

It colorizes the sheet numbers according to the trafficability class calculated for those sheet numbers. It colorizes the sheets according to a unique thematic. It assigns one color for one trafficability class. It generates maps for both trafficability and as well for showing percentage of crop, soil and water table. Figure 6.11 shows the map according to percentage of soil in the area.

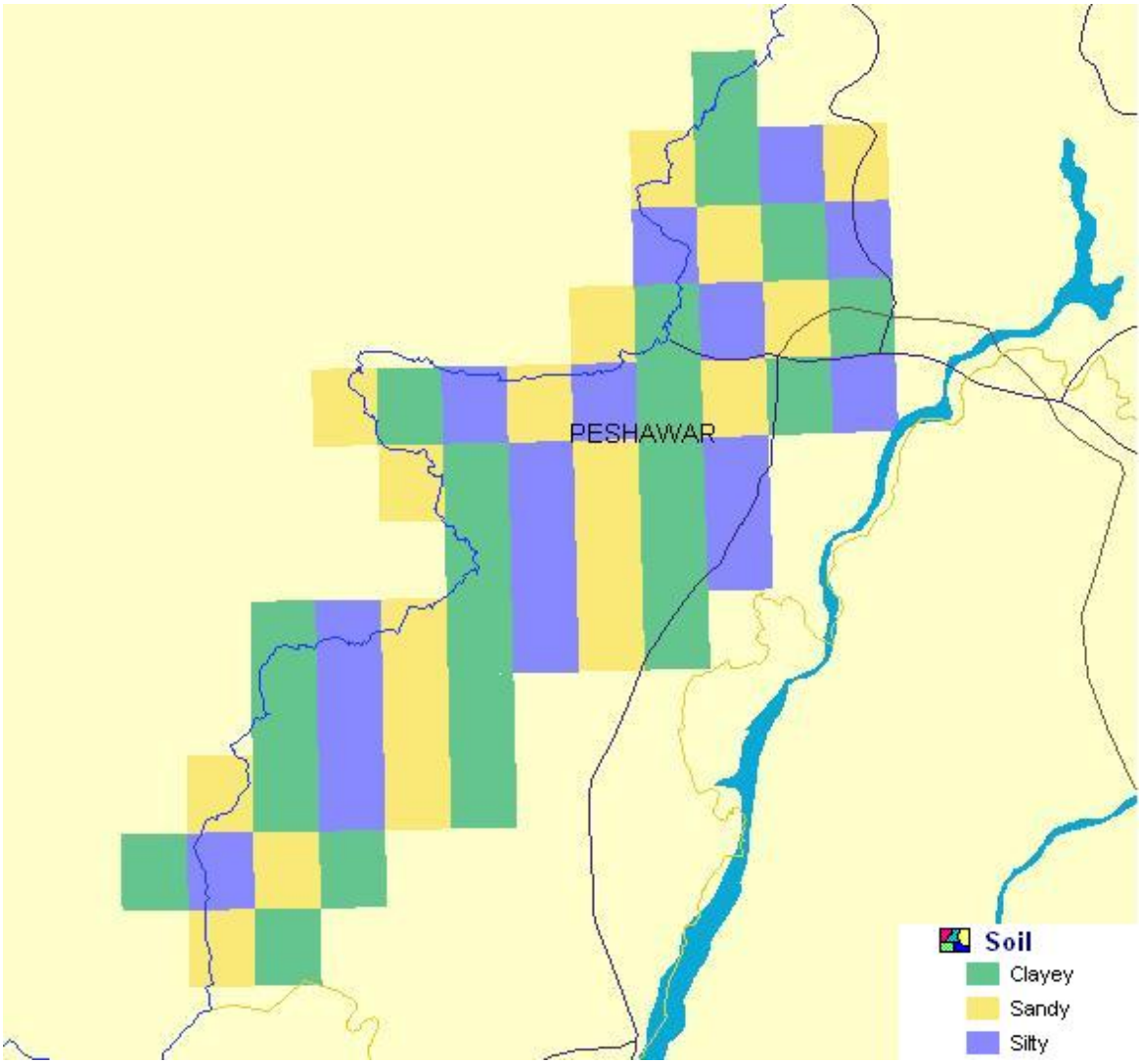


Figure 6.11: Soil Percentage Map

The figure 6.12 shows the trafficability calculated and then displayed on the map. The map manipulation module manages any number of classes found in a particular area.

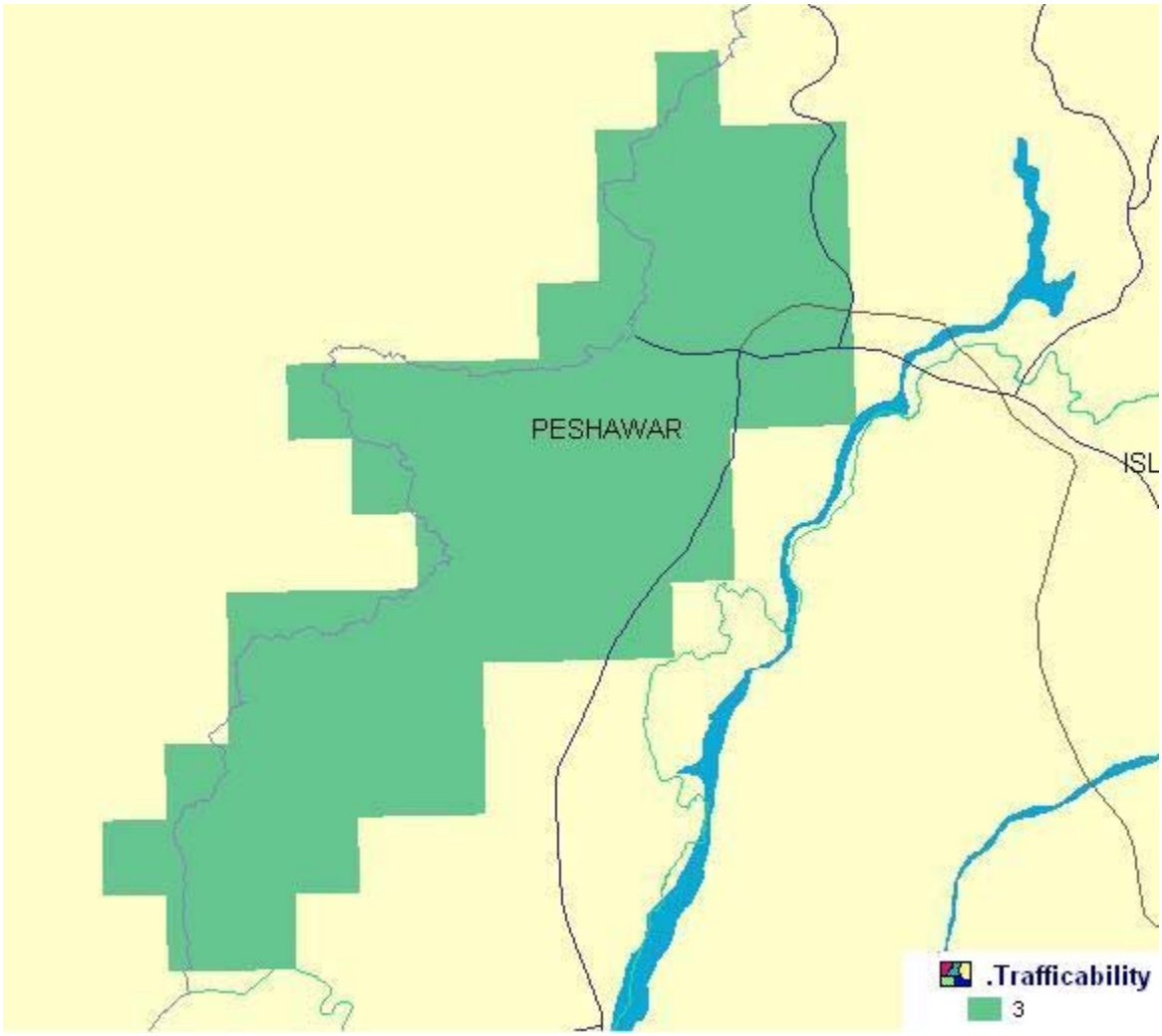


Figure 6.12: Trafficability Map

The map manipulation tool is responsible for applying all the manipulations on the map. Those manipulations are zooming, fit, pan, rotate etc. Whenever user clicks for any of these operations, the event listener inform amp manipulation module about that action to provide. The map manipulation module takes action against those requests. Event listener serves as a bridge between the user actions and the map. Without event listener the map is just a picture and cannot be manipulated.

6.10 Implementation of Data Rendering Module

Data rendering module loads all the map features stored in the database. Which features are to be displayed on the map are specified in this tool. The initial features to load are specified in the ini file. Which data rendering module loads on the program initialization. Those features are roads, rivers, sea, desert, international boundary shape, districts, city labels, and motorway. It can include a list of features to load. It all depends upon the user which features he wants to load.

If any of the features specified are not present in the database. It reports an error message mentioning about all the missing features in the database. Figure 6.13 shows the features that are in the database and can be loaded any time by data rendering module on user's request.

Figure 6.13: Map Features

6.12 Summary

The Automated Trafficability Model is implemented using different software. The database is developed in Microsoft Access. The GUI and trafficability assessment module are developed in Visual Basic 6.0. The functionality of map viewing tools and manipulation on them is integrated from GeoMedia Professional by adding different controls and libraries of GeoMedia into Visual Basic 6.0. The Visual Basic runs in the front end where GeoMedia remains at the back end.

CHAPTER 7

SYSTEM TESTING AND VALIDATION

7.1 Introduction

Software testing is one of the most crucial phases of software development life-cycle. This can be termed as an element of a broader topic that is referred to as 'Verification and Validation' (V&V). Verification refers to the set of activities that ensure that software correctly implements a specific function. Validation refers to the different set of activities that ensures that the software that has been built is traceable to customer requirements [5].

7.2 Validation and Verification

Validation and verification is intended to be a systematic and technical evaluation of the system and its processes. To effectively deal with the increased complexity and functionality, systems need practical techniques that can help improve software quality using the validation and verification process.

Automated Trafficability Model was tested for validation by giving it different inputs and getting the desired outputs. User cannot provide uncertain inputs because all the options for vehicle type, month, corps, div and brigade are given in the combo boxes in the form of lists. In verification testing it was assured that software meets all functional, behavioral, and performance requirements.

7.3 Unit Testing

In computer programming, unit testing is a procedure to validate that individual units of source code are working properly. A unit is the smallest testable part of an application. Unit testing concentrates on each unit of the software as implemented in source code. The goal of unit testing is to isolate each part of the program and show that the individual parts are correct. In our system each module as developed is individually tested. The each function performed on the

map is tested such as zoom, fit, pan, view legend, view info etc. Each operation and function is individually tested so as to check for possible errors that could occur.

7.4 Integration Testing

Integration testing is the phase of software testing in which individual software modules are combined and tested as a group. It follows unit testing and precedes system testing. In integration testing focus is on design and the construction of software architecture. All the modules have been combined and tested to ensure that they work according to the user requirements.

7.5 Black Box Testing

Black box testing takes an external perspective of the test object. These tests can be functional or non-functional, through usually functional. The test designer selects the valid and invalid input and determines the correct output. There is no knowledge of the test object’s internal structure. The requirements established as part of software requirements analysis, are validated against the software that has been constructed.

Automated Trafficability Model has been fully validated as per meeting user requirement. It provides final assurance that the software meets all functional, behavioural, and performance requirements.

7.6 System Testing

In software testing phase overall system is tested as a whole. System testing of software or hardware is testing conducted on a complete, integrated system to evaluate the system's compliance with its specified requirements. The purpose of integration testing is to detect any inconsistencies between the software units that are integrated together. System testing is a more limiting type of testing; it seeks to detect defects within the system as a whole.

In Automated Trafficability Model user has to select the trafficability parameters from a list. So there is no chance of selecting wrong input. He can only select a wrong database at that time an error message would be given that the database doesn't include the required features.

7.7 Summary

The system is tested thoroughly. It behaves according to the user requirement. The user is not allowed to specify any wrong inputs. On entering the required inputs system behaves according to the user requirement and presents the desired results to the user.

CHAPTER 8

CONCLUSION AND FUTURE WORK

8.1 Achievements

Our project was initiated with the aim of enhancing the capability of Army Trafficability Survey Unit. The Unit is presently using the manual trafficability maps which are designed according to one particular tank and weather and cannot be automated to different types of vehicles and weather conditions. Our project increased their capability significantly by allowing them to automate the system for any type of vehicle and weather condition. Our project will facilitate the military field commanders in making their military plans.

Working with growing organization Army Trafficability Survey Unit was a great learning experience for us. This helped us to learn GIS based software GeoMedia Professional that is being using throughout the world.

Our project has been presented to higher officials of Engineering Corps including Commander Survey, who appreciated our work and approve the deployment of Automated Trafficability Model at Army Trafficability Survey Unit, Lahore.

8.2 Conclusion

Knowledge is shared through many abstract forms. Attempts to eloquent and explain human experience and understanding use these abstractions which are summaries of a larger body of knowledge. Abstractions such as text, language, mathematics and statistics, music and art, drawing, images and maps are used to record and communicate experiences, culture and history from generation to generation.

Automated Trafficability Model full filled the requirement of Pakistan Army to meet with upcoming technological growth to remain in pace with the world. Pakistan Army abandoned previous manual systems and took advantage of development in the field of GIS.

8.3 Industrial and Commercial Use

This project can be used for finding the trafficability of commercial heavier vehicles. Those also get stuck in the different areas. The project gives detail of each selected area. The details include crop, water table and soil percentages of that area also along with map depicting the area. This can be used for maintaining the record of complete Pakistan for agriculture and industrial use. The project applies three types of filters to locate an area those are corps, div and brigade. This can be automated for finding an area by district, city and village information of that area.

8.4 Future Work

This project can be further extended as a distributed application where the geographical data will be kept at central location and users can access it remotely which will not only make it easier to update the databases involved but also give the user a freedom to carry and use it without much of processing power.

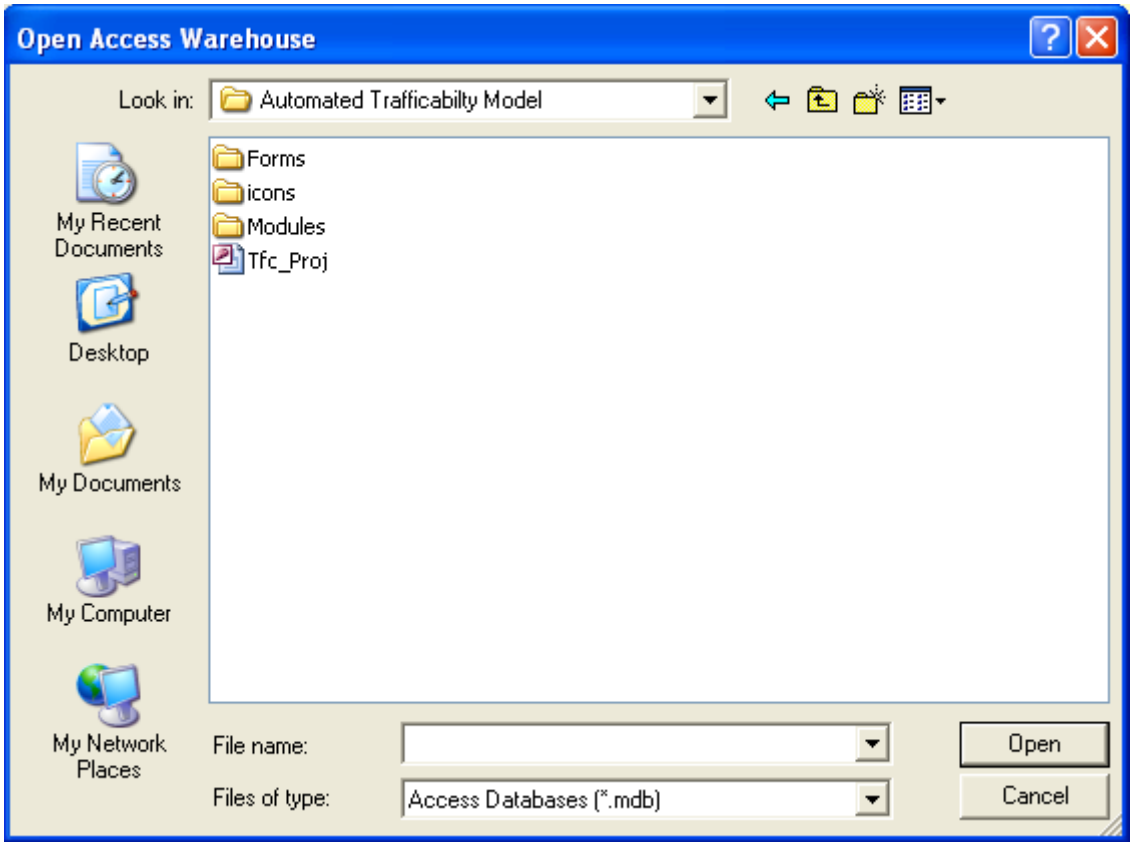
APPENDIX A

USER MANUAL

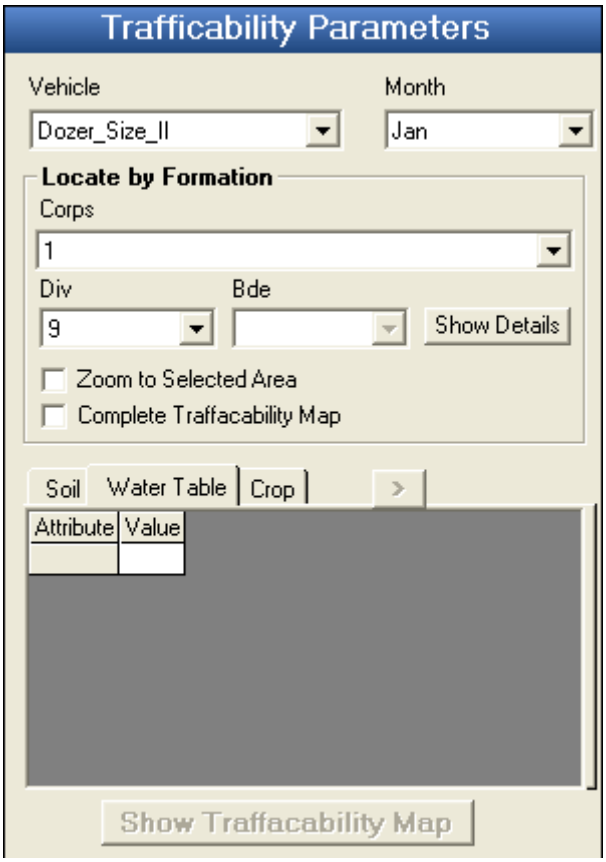
Automated Trafficability Model is very easier and user friendly system, which is developed for military field commanders who have very less knowledge of the computer system.

Steps to be followed

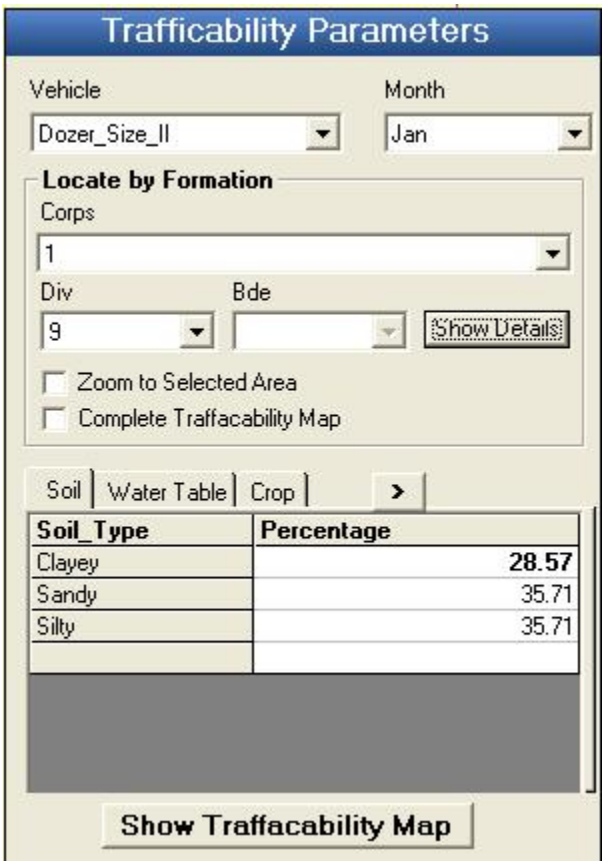
1. Firstly database is to be selected. Although the database connection is declared already but a new connection can also be established.



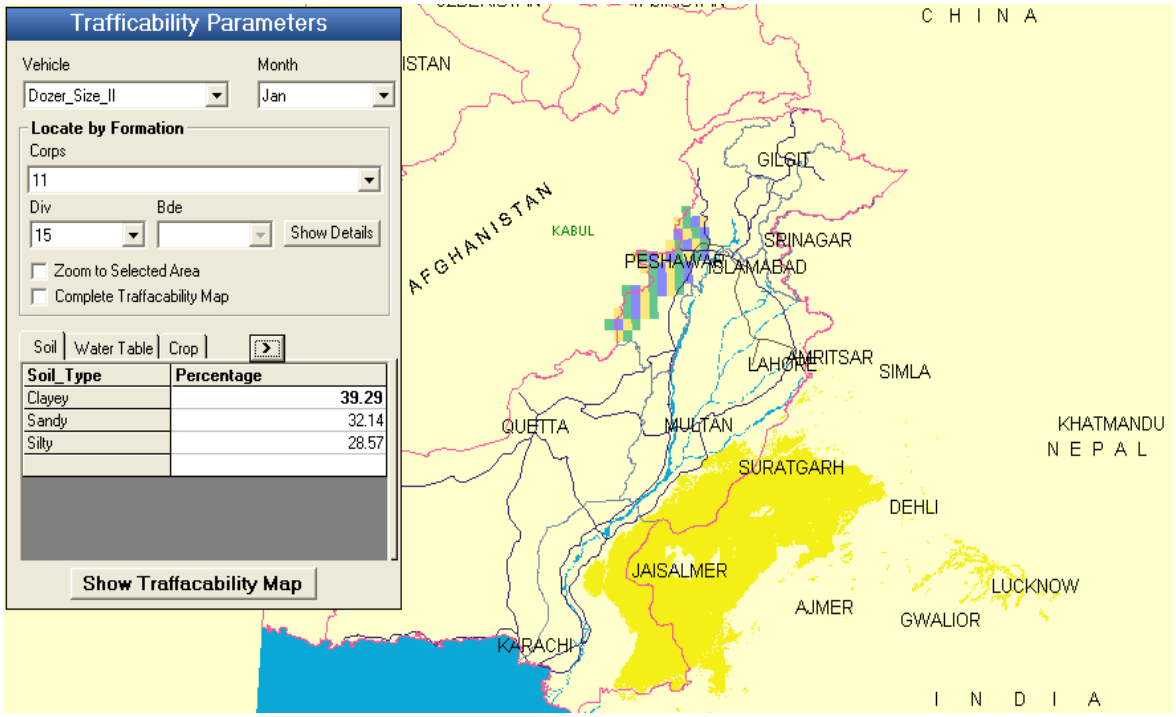
2. Now user has to select the trafficability parameters.



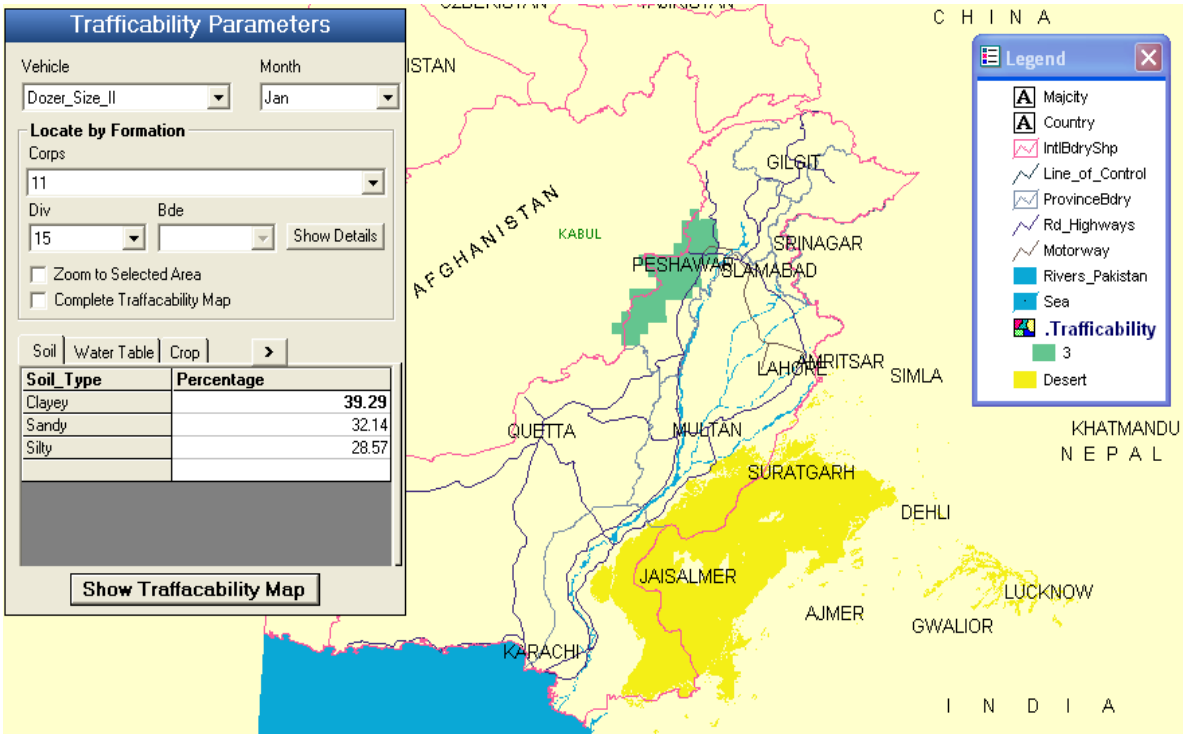
3. After selecting the trafficability parameters user has to click the show details button. This displays the information of that area.



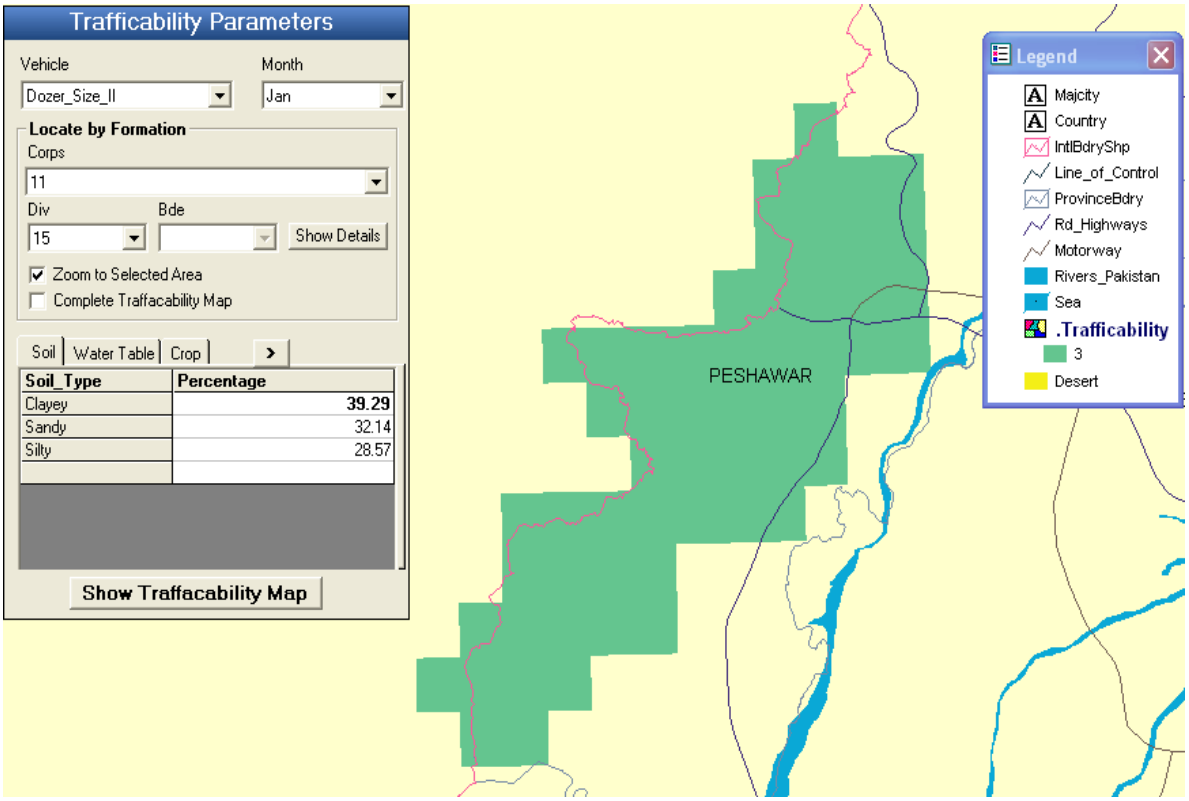
4. If user want to view the area according to soil, water table or crop. He has to press the > button.



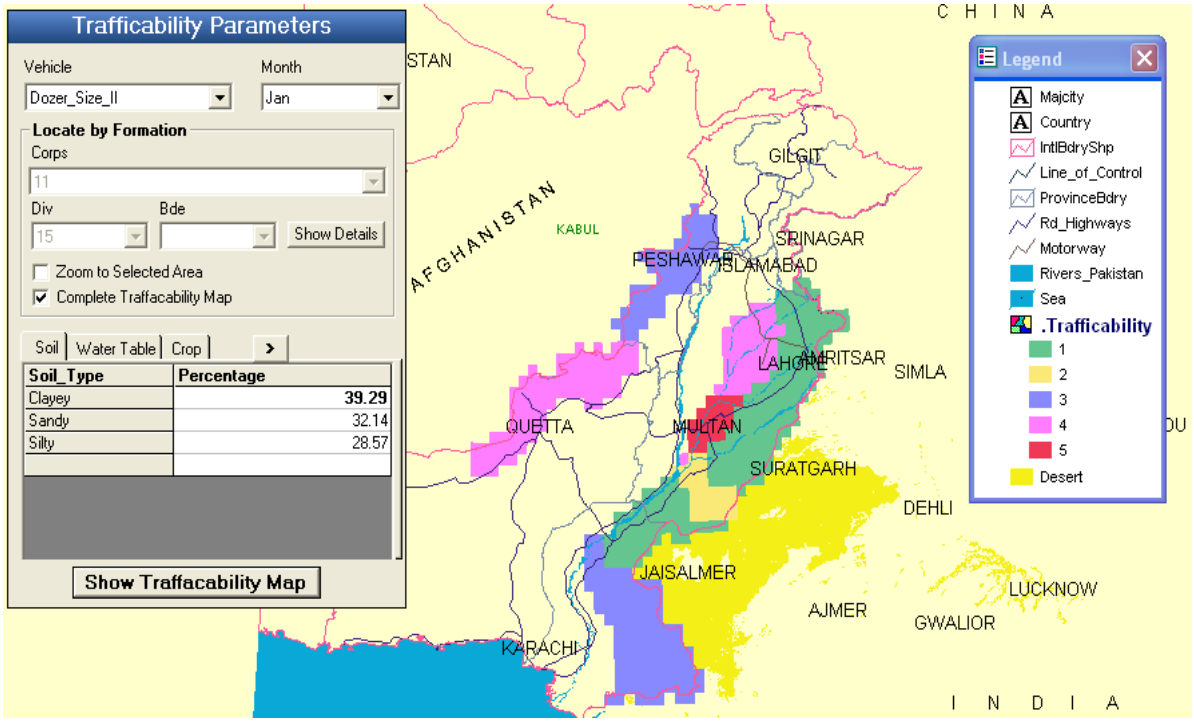
5. If user want to see the trafficability of that area. He has to press the show trafficability button.



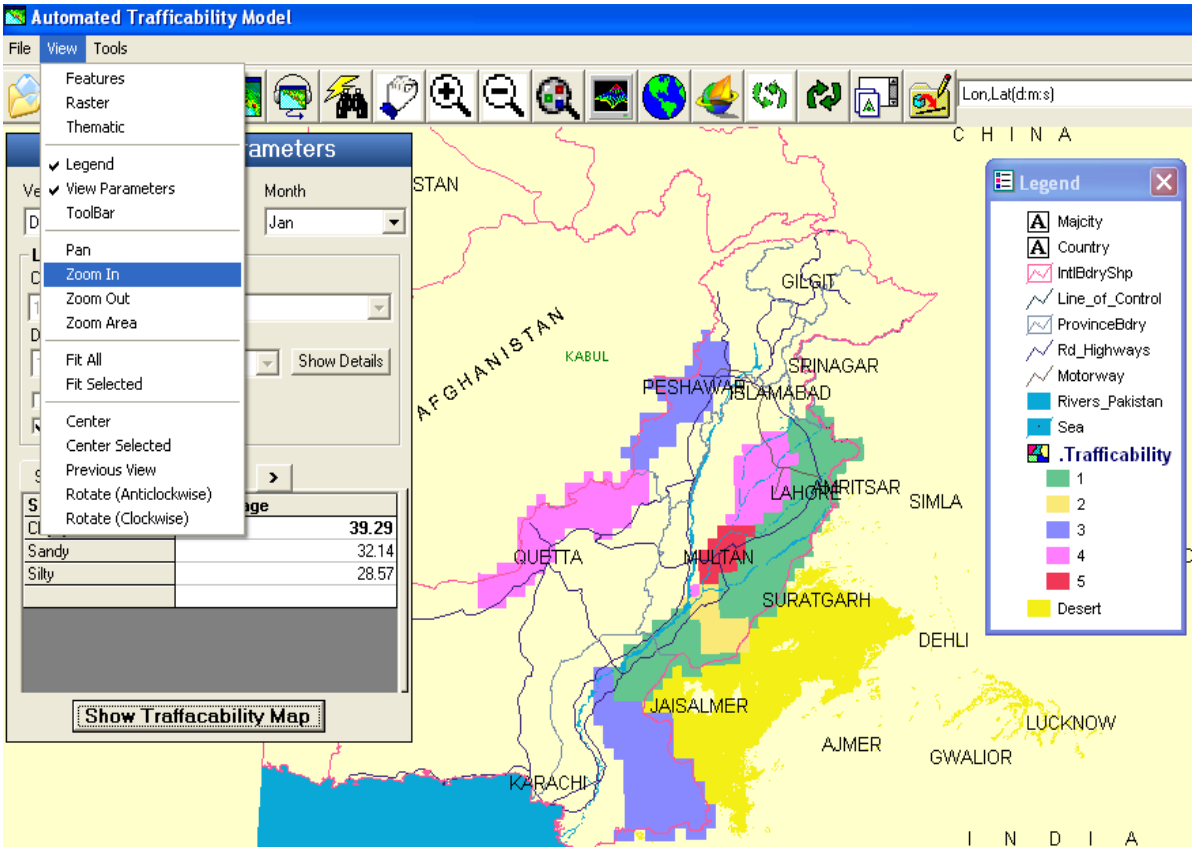
6. To zoom to that particular area, user first has to check zoom to selected area and then click on the show trafficability map.



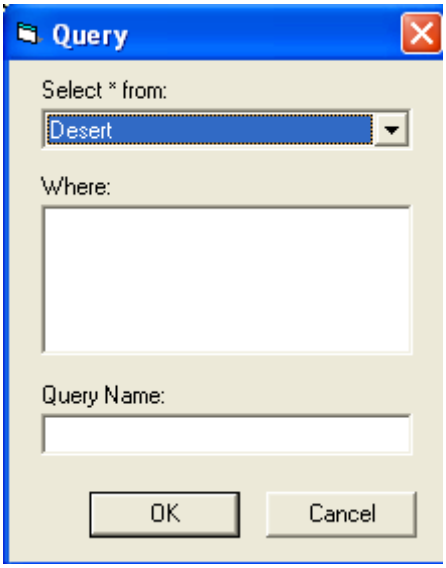
7. To view the trafficability of complete Pakistan, user has to check complete trafficability map and then click on the show trafficability map.

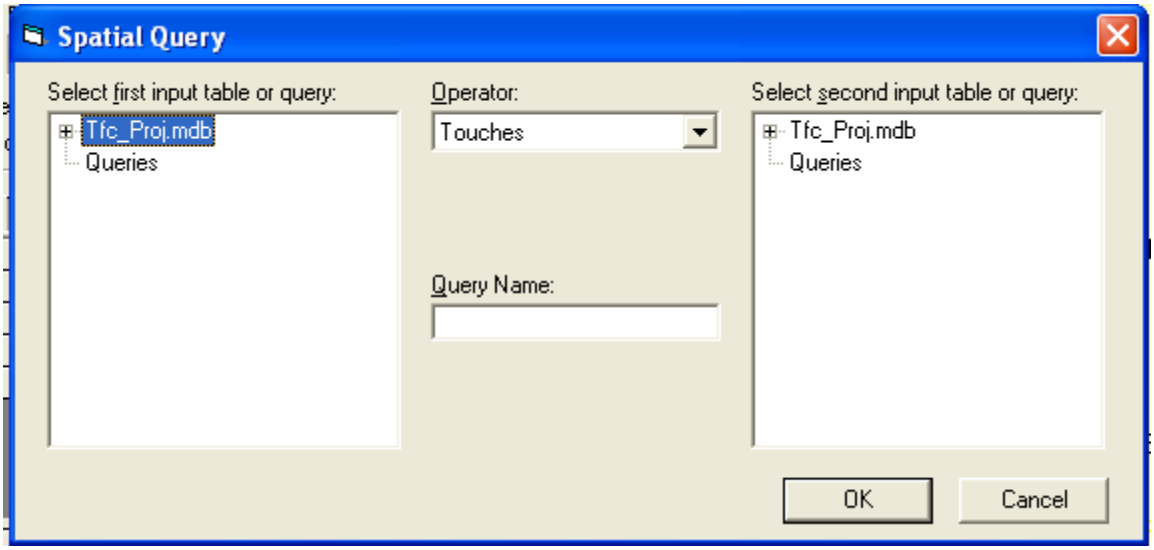


8. To perform any other operation like zoom, pan, fit, show legend, view info, view thematic. User can select from the menu or from the tool bar.

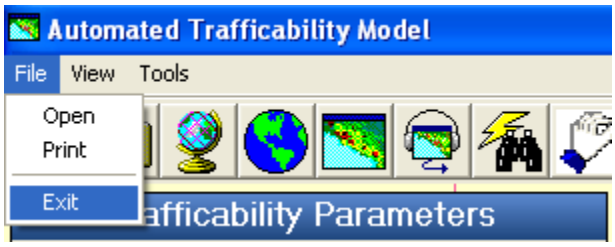


9. To apply any query on the map, user can select from the tool bar or menu and then tools.





10. To exit the system, user can cancel or exit from the menu.



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