Aalto University
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Application of Geographic Information Systems and Multicriteria Decision Analysis in Selecting Suitable Sites for Rural Tourism Development

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Degree Program in Geomatics
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Abstract of master's thesis

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Abstract

In Mexico, there is a high failure rate of most rural tourism activities which has been attributed to inadequate planning and choice of tourism destinations. This study seeks to integrate techniques in Multicriteria Decision Analysis (MCDA) and Geographic Information Systems (GIS) to provide a complete decision support in site selection for rural tourism development. Tourism expert's opinions and literature study were used to select rural tourism factors which includes: Landcover, attractions, cultural elements, facilities and services, population density as well as relief features. These factors were represented in GIS in the form of criterion maps and preferences for criteria were evaluated with the Analytical Hierarchy Process (AHP) technique. A questionnaire for tourism experts were used to decide the importance of criteria in a pairwise comparison. A final Suitability analysis was performed using generated criterion weights from AHP in a GIS environment.

The study yielded a tourism suitability map where areas of High suitability constituted about 7.6% of the study area. Average suitability areas were found to be about 11.6% of the region and 48.5% constituted areas of low suitability. High suitability areas were found to be near urban areas with good accessibility and services which were the most important tourism factors. The result in this study showed the integrated approach of determining suitable sites for rural tourism development can aid decision-making process.

Keywords MCDA, AHP, GIS, Rural Tourism, Weighted Sum, Site Suitability analysis

Foreword

The idea for this thesis was first conceived when I travelled to Mexico as part of a project team in the Sustainable Global Technologies studio course at Aalto University. My project team visited a rural village with so much tourism potential to do feasibility studies for tourism development. During my stay, I met Dr. Kennedy O. Magio, who is a tourism expert and was our project mentor. We had a lot of discussions about rural tourism development in Mexico and the interest in applying Geographic Information Systems in this area was borne.

I will like to first thank my supervisor, Professor Kirsi Virrantaus for her support throughout my studies at Aalto University and giving me the encouragement and materials to pursue this project. I will also like to thank my thesis advisors, Marko Kallio, who gave me immense help, support and ideas in the course of this project and Dr. Kennedy O. Magio, for his wonderful hospitality and brotherly love during and after my stay in Mexico. He has been an integral part of this project by helping me with all the information I needed to complete this project. Finally, I thank my family and loved ones for all the support and encouragement throughout my studies.

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Abbreviations

INEGI	Instituto Nacional de Estadística y Geografía
MCDA	Multicriteria Decision Analysis
GIS	Geographic Information Systems
SECTUR	Secretaría de Turismo
CDI	The National Commission for the Development of Indigenous People
AHP	Analytical Hierarchy Process
CAD	Computer-aided and Design
DATATUR	National System for Statistical Information of the Tourism sector in Mexico
EOEP	Earth Observation Envelope Programme
ESA	European Space Agency
CR	Consistency Ratio

1 Introduction

Across the world, tourism development trends have had an urban centric approach. Alongside, the increased negative environmental and socio-cultural impacts of urban tourism, dwindling income levels and economic opportunities in urban tourist destinations has led to a “counter-urbanization” syndrome and a growing interest in the rural areas. Rural Tourism has been identified in literature (Wilson et. al., 2001; Sharpley, 2002) as one of the few activities which can provide a solution to these problems. Harnessing the unexploited tourism potential of rural areas is particularly important for countries like México, where almost 70% of the population resides in its rural settings (INEGI – Instituto Nacional de Estadística y Geografía, 2015).

But what is Rural Tourism? This seems to be a simple question at a first glance, but a single definition for the concept is inadequate for many purposes (Lane, 1994). The complexities of defining and conceptualizing rural tourism arise because of a number of reasons outlined by the author (Lane 1994:9): 1. Urban or resort-based tourism is not confined to urban areas, but spills out into rural areas. 2. Rural areas themselves are difficult to define, and the criteria used by different nations vary considerably. 3. Not all tourism which takes place in rural areas is strictly 'rural' - it can be 'urban' in form, and merely be located in a rural area. 4. Historically, tourism has been an urban concept; the great majority of tourists live in urban areas. Tourism can be an urbanising influence on rural areas, encouraging cultural and economic change, and new construction. 5. Different forms of rural tourism have developed in different regions. For example, farm-based holidays are important in many parts of rural Germany and Austria but much rarer in rural USA and Canada. 6. Rural areas themselves are in a complex process of change. The impact of global markets, communications and telecommunication have changed market conditions and orientations for traditional products. 7. Rural tourism is a complex multi-faceted activity: it is not just farm-based tourism. It includes farm-based holidays but also comprises special-interest nature holidays and ecotourism, walking, climbing and riding holidays, adventure, sport and health tourism, hunting and angling, educational travel, arts and heritage tourism, and, in some areas, ethnic tourism.

In general terms, Rural tourism has been defined as any form of tourism that showcases the rural life, art, culture and heritage at rural locations, thereby benefiting the local community economically and socially as well as enabling interaction between the tourists and the locals for a more enriching tourism experience. According to Butterfield and Long (1998), it is essentially an activity which takes place in the countryside. It is multi-faceted and may entail farm/agricultural tourism, cultural tourism, nature tourism, adventure tourism, and ecotourism. As opposed to conventional tourism, rural tourism has certain typical characteristics like; it is experience oriented, the locations are sparsely populated, it is predominantly in natural environment (Lane, 2005), it meshes with seasonality and local events and is based on preservation of culture, heritage and traditions (Sharpley & Sharpley, 1997).

1.1 The Research Problem

In Mexico, rural tourism is a growing economic activity that occurs without adequate planning or preparation, this explains a high failure rate identified in different studies (Gaxiola & Castro, 2017). Limiting rural tourism to regions with optimal conditions and characteristics will to an extent guarantee success and long-term sustainability. It is important that only some communities suitable for rural tourism are to be developed, this can be achieved by ensuring that rural tourism criteria match with the basic tourism resource characteristics of the area.

Integrating Multicriteria Decision Analysis (MCDA) and Geographic Information Systems (GIS) can provide a complete decision support methodology with powerful visualization and mapping capabilities which in turn facilitates the creation of suitability maps for rural tourism. The present study will yield criteria for potential rural tourism sites using MCDA and GIS applied in the state of Chiapas - Mexico.

1.2 Justification of Study

A number of previous research approaches on rural tourism in Mexico have focused on conventional methods of planning and evaluation but has not incorporated geo-scientific methods which can be a great tool in modelling sustainable rural tourism indicators and expert views to enhance the decision-making process. Therefore, applying a GIS and MCDA approach to rural tourism development in this regard will be significant for decision makers as well as government and non-governmental organizations who are important stakeholders in choosing areas for tourism development.

1.3 Objectives of Study

The aim of this study is to identify rural communities in Chiapas - Mexico which has the highest potential for rural tourism development by integrating Geographic Information Systems (GIS) and Spatial Multicriteria Decision Analysis (MCDA). Through the integration of GIS and MCDA, this study hopes to achieve the following set objectives:

1. Study the concepts, principles and criteria for rural tourism development, multicriteria evaluation and its integration with GIS
2. Identify areas of high suitability for rural tourism to support decision making in tourism development through the integration of GIS and MCDA.

1.4 Scope of Study

This study will focus on evaluating the potential of areas in the state of Chiapas- Mexico for rural tourism development. It will integrate spatial modelling tools in GIS and multi-criteria decision analysis to identify areas that will be optimal for rural tourism and ensure a more sustainable approach to its development in Mexico.

The study will present the spatial distribution of rural tourism in different areas of Chiapas by analysing the whole state with a set of criterion indicators that are most important for sustainable rural tourism development. These indicators will be decided based on literature and tourism experts in Mexico. This will provide a framework for selecting communities for rural tourism development in any part of the state regardless of other inherent issues that are specific to different areas.

1.5 Structure of Thesis

This thesis is organized into five chapters. Chapter one presents an introduction on the subject of rural tourism as well as the research problem and objectives of this study. In Chapter two, background of study area and the context of rural tourism in Mexico are given, followed by the theoretical framework of GIS and its integration with MCDA. The third chapter introduces the materials and methodology used in this study. In the fourth chapter, the results of the analysis are discussed as well as problems and limitations of the study and conclusions are drawn in the fifth chapter.

2 Background and Theory

This chapter begins with some background information about rural tourism in Mexico and an introduction of the study area. Then some rural tourism challenges in the study area are highlighted briefly. In the following sections, theory on the main methodological framework is discussed. First, Geographic Information Systems (GIS) and spatial data is introduced, then the concept of Multicriteria Decision Analysis (MCDA) is discussed briefly and followed by the framework for GIS and MCDA integration.

2.1 Rural Tourism in Mexico

There are several factors which are shifting the trend towards rural tourism in countries like Mexico which boast of large numbers of rural communities. First, the general growing interest in sustainable tourism and environmental consciousness (Magio & Velarde, 2015). Over the last 30 years the concept of sustainable tourism has been developed to counter the threats which unmanaged tourism can bring (Archer et. al, 2005). According to Lane (2005), sustainable tourism sees tourism within destination areas as a triangular relationship between host areas and their habitats, holidaymakers and the tourism industry. In the past, the triangle was dominated by the tourism industry. However, focus has shifted towards reconciling the tensions between the three partners in the triangle, and keep the equilibrium in the long term.

Therefore, “sustainable tourism aims to minimise environmental and cultural damage, optimise visitor satisfaction, and maximise long-term economic growth for the region. It is a way of obtaining a balance between the growth potential of tourism and the conservation needs of the environment” (Lane, 2005:13). The author considers sustainability in rural tourism as a multi-purpose concept that is not based on a narrow pro-nature conservation ethic, it seeks to: 1. Sustain the culture and character of host communities. 2. Sustain landscape and habitats. 3. Sustain the rural economy. 4. Sustain a tourism industry which will be viable in the long term — and this in turn means the promotion of successful and satisfying holiday experiences. 5. Develop sufficient understanding, leadership and vision amongst the decision-makers in an area that they realise the dangers of too much reliance on tourism, and continue to work towards a balanced and diversified rural economy.

A second reason why tourism in rural areas has grown is partly because of market forces, where tourists are continuously seeking new/different kinds of experiences (Park and Yoon, 2009), and partly as a result of government initiatives to counter mass, package-type tourism in destination areas (MacDonald & Jolliffe, 2003). In the Mexican case, this growth phenomenon has been noticeable where the Ministry of Tourism *(Secretaría de Turismo - SECTUR),* and other tourism development agencies have been hard at work promoting new uses for the countryside (*comunidades rurales*), influencing both potential providers of tourism facilities, and the markets for rural tourism through programs like Pueblos Magicos (Magical Villages). In 2001, the Mexican Ministry of Tourism launched the aforementioned program through Gazette Notice DOF: 26/09/2014 to spread the benefits of tourism away from the traditional beach destinations into the hinterland (DOF - *Diario Oficial de la Federación*, 2014).

The program promotes a series of towns (111 in total) around the country that offer visitors a “magical” experience – by reason of their natural beauty, cultural riches, or historical relevance. SECTUR acknowledges that México´s magical element, and not only its sun and beaches, is what keeps many tourists coming back.
Thus, they created the ‘Pueblos Mágicos’ program to recognize places across the country that imbue certain characteristics that make them unique and historically significant. Investment in this program has been growing over the last four years. Since 2013, the federal government has invested a total of 2.5 million pesos in the program, this is about 50 percent of Mexico’s total investment since they began naming them in 2001 (SECTUR - Secretaría de Turismo (2017). In this context, tourism is seen as an agent for rural economic regeneration and as an effective source of income and employment, particularly in peripheral rural areas where traditional agrarian industries have declined.

Despite the substantial encouragement, support and, in some cases, direct financial assistance enjoyed by rural tourism from both the public and private sectors as a result of perceived benefits, authors (Wilson et. al., 2001; Sharpley, 2002) argue that the activity may not always be successful. Secondly, it may not necessarily represent the most suitable development path to solve economic problems in rural areas, because costs and other factors like area suitability may limit the potential economic returns. As argued by Gannon (1994), not all rural areas are equally attractive to rural tourists and simply providing accommodation facilities does not guarantee demand. The total product package (basic and complementary offer) must be sufficient to attract and keep tourists, offering suitable opportunities for spending. Therefore, this increasing dependence and the traditional fallacy that rural tourism is a magic wand that will automatically be successful and speed up economic progress in rural areas must be treated with some caution. Additionally, developing and organising rural tourism depends on factors like accessibility and availability of other public services that may require a significant investment either beyond the means of the business owner or greater than justified by potential returns. In such cases, the government must come in to flex its financial muscle and guarantee the success of tourism.

Wilson et. al. (2001) suggested that success in rural tourism depends on accurate analysis of an area’s social, economic, ecological and cultural needs, tourism assets and the constraints on future tourism development. They outline several components required by rural tourism to be successful: (1) attractions: the natural and manmade features both within and adjacent to a community; (2) promotion: the marketing of a community and its tourism attractions to potential tourists; (3) tourism infrastructure: access facilities (roads, airports, trains, and buses), water and power services, parking, signs, and recreation facilities; (4) services: lodging, restaurants, and the various retail businesses needed to take care of tourists’ needs; and (5) hospitality: how tourists are treated by both community residents and employees in tourism businesses and attractions. There is a need for some criteria that establishes whether a rural community can offer a complete tourism package, in this sense, it has to be a destination rather than a place to stop off. Communities that have been successful at getting tourists to visit, stay, spend money, and come back have developed high-quality tourism attractions and put together successful tourism packages involving the community, its surrounding area, and businesses involved in tourism (Wilson et. al., 2001).

Even if a community has excellent natural or cultural attractions, success is not guaranteed unless complementary services and facilities are put in place, additionally, the above must be tailored into a product or package with all elements necessary to attract and hold tourists. It must be remembered that rural tourists seek unique experiences that are different from traditional tourist needs (Lane 2005). Looking at key features of successful tourism development, and the main characteristics of rural areas, it is possible to argue that rural tourism faces major obstacles. Holland et. al. (2003) list some of the requirements of tourism, and shows how rural areas may be less likely than urban areas to be able to meet most of them.

Table 2.1 The gap between requirements of tourism and characteristics of rural areas

(Source: Holland et. al. 2003)

Common requirements for tourism development	**Common characteristics of rural areas**
• A product, or potential product	• Variable. May have a high-value unique selling point, may be an attractive desired location for travellers from cities, may have little to offer.
• Access – transport infrastructure, limited distance, limited discomfort	• Distant from cities, poor roads, few trains/buses/planes
• Investment in facilities	• Limited access to financial capital, affordable credit and private investment.
• Skills in service, hospitality	• Low skills (skills migrate)
• Regular and quality inputs, e.g. of food and other supplies	• Undeveloped commercial production, distant from markets
• Marketing skills	• Distant from marketing networks
• Clustering of tourism products to create a 'package' holiday	• Lower concentration of tourism products in one place
• Government investment	• Low priority for governments, particularly tourism/trade ministries, particularly in sub Saharan Africa

Despite the numerous challenges and obstacles, it should not be concluded that rural tourism is impossible. Sometimes, the main attraction may be so strong (e.g. mountains, gorillas, well-endowed wildlife areas, stunning wilderness) that the quality of the product can compensate for other problems, and act as an incentive for tourism, after all, it may be the only motive for visiting the rural community. Otherwise, in the absence of a powerful attraction, it is difficult to develop tourism in rural areas even if other obstacles are addressed. Based on the above, success in rural tourism will require a combination of developing an attractive product, and overcoming the other challenges, such as accessibility and availability of skills (Holland et. al., 2003).

Denman (2001) proposed basic preconditions to be checked before implementing community-based ecotourism (a form of rural tourism): 1. Landscapes or flora/fauna which have inherent attractiveness or degree of interest to appeal either to specialists or more general visitors; 2. Ecosystems that are at least able to absorb a managed level of visitation without damage; 3. A local community that is aware of the potential opportunities, risks and changes involved, and is interested in receiving visitors; 4. Existing or potential structures for effective community decision-making; 5. No obvious threats to indigenous culture and traditions; and 6. An initial market assessment suggesting a potential demand and an effective means of accessing it, and that the area is not over supplied with ecotourism offers.

In this respect, evaluating the suitability of a rural community should be regarded as an important tool for sustainable rural tourism development. This judgement task can be made possible using criteria and indicators. Ideally, rural tourism should meet some certain criteria, for example, accessibility, availability of complementary services and facilities, availability of natural and cultural tourist attractions, possibilities of integrating conservation and rural development. Geographic Information Systems (GIS) can be used as a tool in accessing suitable areas and creating resource inventories.

2.2 The Study Area

Chiapas is one of the 32 federal states of Mexico located in the south-eastern part of the country. It is bordered by Guatemala on the southeast, the Pacific on the southwest, and the states of Oaxaca, Veracruz, Tabasco, and Yucatan from west to northeast (INEGI, 2017). It is divided into 118 municipalities with Tuxtla Gutiérrez as the capital city. Chiapas has a total land area of about 73,311 km^2 which has different ecosystems ranging from the rich tropical rain forests and jungles to the natural beauty of rivers, waterfalls and beaches. It has a subtropical climate with average temperatures between 20 and 29^o C. It has a population of over 5.2 million people and even though most indigenes are of Mayan heritage, it also ranks among the highest in terms of ethnic diversity in Mexico. In addition to the beautiful *Flora* (mangroves, pastures, rainforest, pine trees etc) and *Fauna* (porcupines, jaguars, monkeys, anteaters, crocodiles, turtles, birds etc.) which is in abundance, the state of Chiapas is also characterized by high volcanic mountain ranges, important archaeological sites as well as historic Mayan ruins. This topography makes Chiapas an attractive location for travellers who wants to explore nature and cultures.

Figure 2.1 Location of Study Area

2.3 Rural Tourism Issues in Chiapas

Tourism has always been an important part of the development plans of Chiapas governments and since the early 2000s, it has essentially become a strategic area of development for the state. According to author Velázquez (2013), The National Commission for the Development of Indigenous People (CDI) and the state government, through the Offices of Tourism and Economic Development, with funding from the Project for Integrated and Sustainable Social Development in the Lacandón Jungle (*also called Prodesis*), joined forces to support the development of tourism. In a project called *"Chiapas Vision 2020",* which had been in operation since 1998, plans for tourism development in the state are outlined, which includes infrastructure development to attract more tourist. The plan states that "its mission is to identify, develop and promote projects and/or strategic actions that contribute to the development of regional competitiveness, with the effective collaboration of the principal authors, actors and beneficiaries of development, based on the values of common good, subsidiarity and solidarity." As a result, many so-called ecotourism centres emerged, which on paper have the purpose of supporting indigenous and peasant communities that have natural resources with the possibility of being exploited for this purpose. Places with waters and forests were chosen for these projects and the communities themselves organized to offer the tourism services. They are offered support for the construction of infrastructure such as roads, cabins, hotels, etc., while being promoted in the world as ecotourism centres. This attracts visitors who seek adventure and alternative to mass tourism. The *"Chiapas Vision 2020"* project was revised in 2012, with the participation of the state and federal governments, hoteliers and travel agencies but there was limited involvement of the local people. There were plans to create sustainable ecotourism centres to boost rural tourism, but these concepts were not defined to clearly understand their particularities. There have been several inherent issues that has plighted the development of rural tourism in the state which includes exclusion of communities, exploitation of indigenes by middle men and in some cases insufficient flow of tourist to tourism centres. The focus of the projects has been rural areas in an attempt to tackle poverty but some of these projects has led to intra- community conflicts due to exploitation of the natural resources. Most locations selected for these projects has been areas with forest and water. Even though the landscape of Chiapas is predominantly forest areas, including other essential tourism indicators when choosing areas for rural tourism development will ensure communities involved are able to provide a full tourism package for visitors and reduce the exploitation of the natural environment.

2.4 GIS in Tourism Planning

The application of GIS in environmental and resource management has inherently extended to tourism development where there are major issues of concern relating to the sustainability of natural ecosystems as a result of mass tourism activities which threaten the environment. There have been increasing need to plan tourism developments in such a way to protect the biodiversity of destinations and ensure its sustainability is not at the expense of its profitability. There have been several studies on the applications of GIS in tourism development (particularly in rural tourism) where there has been focus on site suitability.
Mehdi Ahmadi et al (2015), applied GIS and Multicriteria decision making techniques to identify site attractions for ecotourism development in Ilam Province, Iran. Their studies focused on using GIS to identify vulnerable zones and ecotourism status in the province and GIS proved to be a capable approach for the site suitability analysis. Similarly, Kedir Nino et al (2016) also demonstrated the applications of GIS where their study aimed at assessing ecotourism potential in Ethiopia. They used tourism suitability development factors such as landcover types, wild animal zone, unique features, topography and distance to roads as input data layers to create a final suitability map for ecotourism.

In another study, Bunruamkaew and Murayama (2011), used the integration of GIS and Analytical Hierarchy Process (AHP) to evaluate site suitability in ecotourism in the Thani Province of Thailand. The objective of the was to identify and prioritize the potential ecotourism sites in the province. The identified landscape/naturalness, wildlife, topography, accessibility and community characteristics as the important suitability factors after which they chose visibility, land use/cover, reservation/protection, species diversity, elevation, slope, proximity to cultural sites, distance from roads and settlement size as the criterion indicators for the suitability factors. The study used AHP to assign criterion weights and overlay analysis in GIS to create a final suitability map. These are but a few of the examples of the growing GIS applications in tourism development and planning. Several studies on GIS applications in tourism development are somewhat limited to site suitability analysis, tourism resource management, impact assessment among a few others. This can be attributed to the lack of reliable tourism databases and inconsistencies in available data. Nevertheless, the potential of GIS in tourism development is tremendous and cannot be understated.

2.5 Theory

This section introduces Geographic Information Systems (GIS) and its integration with Multicriteria Decision Analysis (MCDA).

2.5.1 Geospatial Data and Geographic Information Systems

Geospatial data refers to data entities that represent information about features or phenomenon that can be tied to a geographic location on or near the surface of the earth. The set of tools that allows for the input, storage and retrieval, manipulation and analysis, and output of geospatial data is known as a Geographic Information Systems (Malczewski, 1999). GIS has proven to be a powerful decision support system with capabilities to visualize, analyze and predict trends and patterns in spatial data to aid in decision making by data owners. GIS also provides an integrated environment where other geospatial technologies like Remote Sensing and Photogrammetry, computer-aided and design (CAD), Global Positioning Systems etc. can be incorporated to enhance analysis of geospatial data and improve decision making process. These functionalities distinguish GIS from other information management systems and sets it apart as a decision support system capable of integrating georeferenced data in a problem-solving environment (Malczewski, 1999). The integrated capabilities of GIS have extended its applicability to diverse disciplines including, environmental management, forestry, urban planning, tourism development, business management etc. Indeed, having the ability to incorporate varieties of information from different disciplines to meet user needs it’s a major attribute of GIS.

2.5.2 Spatial Data Types in GIS

Information about real world entities are collected, stored and analyzed in GIS as spatial data. Spatial data sets are categorized into two main data models called *objects* and *fields*. The object-based data model is used to represent real world features that are discrete, can be identified and touched and is often confined to a limited space. Object-based data models are represented in a GIS as *vector* data i.e. points, lines and polygons. Points are used to represent spatial objects in which only the locations are important and not its extent. An example is a large-scale map where cities can be represented as points, location of tourism sites, hotels etc. are all entities that can be represented as points in a GIS. Lines and Polygons on the other hand, are used to represent spatial objects that move through space (e.g. rivers, electricity, roads etc.) and objects that have extent (e.g. cities, countries etc.) respectively. Field data models represent phenomenon that varies across space such as temperature, altitude, rainfall etc. Field-based data models are recorded in GIS as *raster* layers where the geographic variations of the field are represented in pixels with assigned cell values (O’Sullivan and Unwin, 2010). It must be noted however, that the representation of spatial data objects and fields is not limited to just vectors and rasters respectively. Field-based data models can also be represented as Triangular Irregular Networks (TINS), polygon networks, point sets or level contours and similarly cells of a grid can be considered as objects. The variations in the implementation of the data models is dependent on the needs of application and the way of modelling that is required.

In order to be able to perform any analysis, visualizations etc. on spatial data objects, there is the need to also record information about the data entity called attributes. Attributes are the information that is characteristic of the spatial entity e.g. a hotel entity will have attributes such as, number of rooms, year built, ownership, rental prices etc. An illustration of the different spatial data types and measurements of their attributes is shown in figure 2.2.

There are several spatial manipulations and analysis that can be performed on spatial data in a GIS that involves transformations between spatial data types. One example of such analysis which is utilized in this project is the overlay of maps. Map overlay operations are the most typical and popular GIS analysis method because it has a clear link to multicriteria analysis where a number of different input map layers with the same geographical reference is combined to produce an output composite map formed from the intersections of the input data layers. The output composite map contains values that corresponds to the attributes of the input map layers and is normally a result of a suitability analysis.

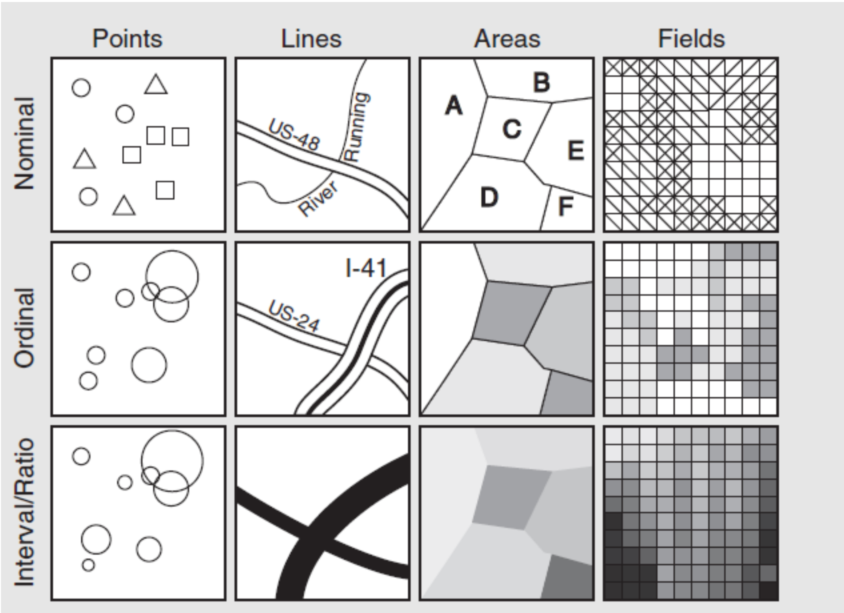

Figure 2.2 Spatial data types (O'Sullivan and Unwin, 2010)

2.6 Multicriteria Decision Analysis

Decision making in tourism development and indeed many other domains often requires a consideration of many factors that ranges from socio-political, economic, environmental etc. among which various stakeholders and decision makers have divergent views which makes the decision-making process difficult. The planning and management of rural tourism in particular are inherently difficult because of the many attributes that have to be considered in order for a tourism project to be successful. Often times, stakeholders have conflicting interests and attribute preference that makes the decision-making process even more complex thereby presenting the need for methods that can be used to evaluate and identify alternatives that can maximize all criteria in the decision-making space.

The term Multicriteria Decision Models (MCDM) or Multicriteria Decision Analysis (MCDA) as used interchangeably, present a scientific way to aid decision making where decision makers have the need to choose from a set of options (alternatives) based on a set of criterion factors. It has been generally defined as a decision-aid and a mathematical tool allowing the comparison of different alternatives or scenarios according to many criteria, often conflicting, in order to guide the decision maker towards a judicious choice (Chakhar and Mousseau, 2008). According to Jankowski (1995), the challenge faced by individuals, organizations etc. when dealing with Multicriteria evaluation problems in decision making comes in two folds; 1. The problem of identifying all choice options that incorporates the objectives and interest of stakeholders in the decision-making process and 2. How to identify within the feasible options the most preferred alternatives. MCDA is often used to discover and quantify considerations that a decision maker or stakeholder needs to make about a problem in order to compare alternative courses of action. The concept of MCDA has developed very well over the years and continuous to be applied successfully in different domains. MCDA methods are commonly categorized as *Multi-Attribute Decision Making* (MADM) and *Multi-Objective Decision Making* (MODM) (Malczewski, 1999). MADM problems are assumed to have a predetermined, limited number of alternatives hence, solving an MADM problem is more of a selection process, as opposed to a design process. The MODM problem is continuous in the sense that the best solution may be found anywhere within the region of feasible solutions (Malczewski, 1999). The objective of this project means MADM approach will be utilized in the decision-making process.

There are several techniques that have been developed to solve MCDA problems and most of them are based on a general framework model represented in Figure 2.3. The general procedure involves first deriving a set of alternatives and a set of criteria. The importance of each alternative on the various criterion is then estimated to get the criterion scores which will result in a performance table. The next step is to specify the decision maker’s preferences by assigning criterion weights to the different criteria and then aggregating the criterion scores in the performance table in order to rank the alternatives. The aggregation of criteria scores permits the decision maker to make a comparison between the different alternatives on the basis of these scores (Chakhar and Mousseau, 2008). Sensitivity analysis is then performed to deal with uncertainties and inaccuracies in the results. Then a final recommendation of the results is determined.

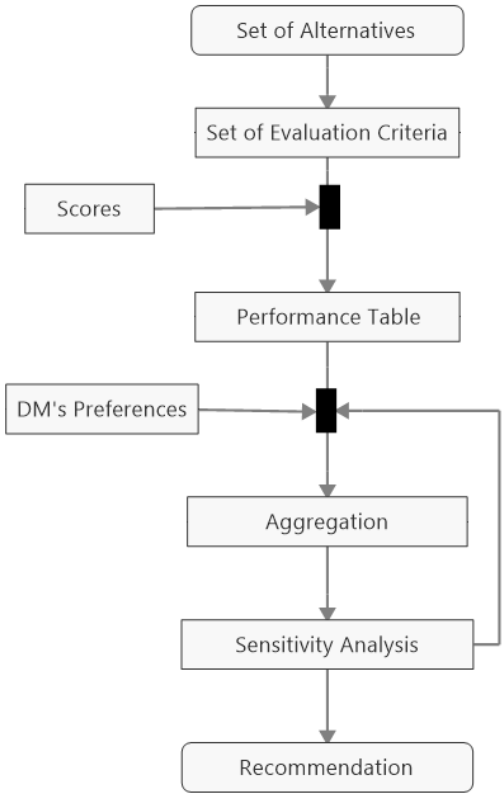

Figure 2.3 General Model of MCDA (after Chakhar and Mousseau, 2008)

2.7 Spatial Multicriteria Decision Analysis

In the previous sections, the concept of GIS and spatial data as well as MCDA were briefly discussed. The integration of GIS and MCDA present a framework where decision alternatives and associated evaluation criteria are represented in spatial data forms and analyzed with GIS and MCDA techniques to further enhance results of the decision-making process. In conventional MCDA methods, evaluation criteria are treated as being spatially homogeneous across the study area but in practice this is unrealistic because there are always variations in the evaluation criteria across space. Spatial multicriteria analysis represent an extension of the conventional MCDA because it incorporates the geographic locations and characteristics of the evaluation criteria entities as well as the set of alternatives. This means that the spatial heterogeneity that exist in the evaluation criteria across the study area is accounted for in the analysis. In practice spatial multicriteria evaluation process requires geographical data input (i.e. spatial data of criteria and alternatives), preferences of the decision maker, application of GIS analysis and MCDA techniques on the input data to produce a decision output.

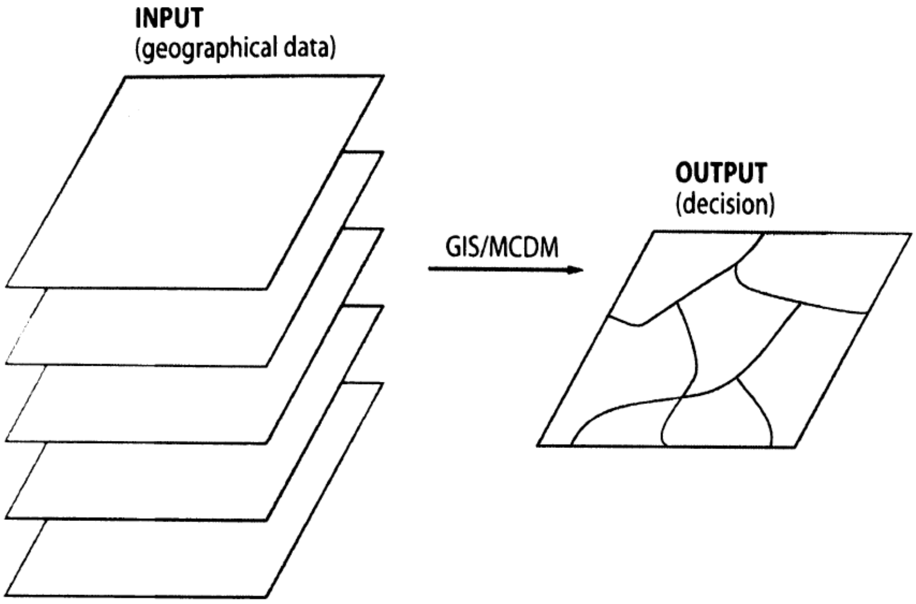

Figure 2.4 Illustration of Spatial Multicriteria analysis (Source: Malczewski, 1999)

2.7.1 Framework for Spatial Multicriteria Decision Analysis

Malczewski (1999) presents a framework which describes the various steps in the procedure for solving spatial multicriteria evaluation problems. In every system, decision makers want to see the system operating at a certain state that they desire with respect to the existing state. Recognizing and identifying the problems in the existing state of the system will help in the decision-making process to achieve the desired state. An example is in rural tourism development where decision-makers wants to identify tourism destinations that will be profitable and sustainable to develop whiles addressing the needs and interest of all stakeholders in contrast to existing system where many rural tourism projects are failing to succeed. In such a decision-making environment there is the need to first identify and recognize the prevailing problems that exist in the system and define the problem in order to ascertain the data, evaluation criteria and appropriate techniques to aid in the decision-making process to achieve a desired state. The framework is shown in figure 3.3 and the various steps are discussed in the proceeding text.

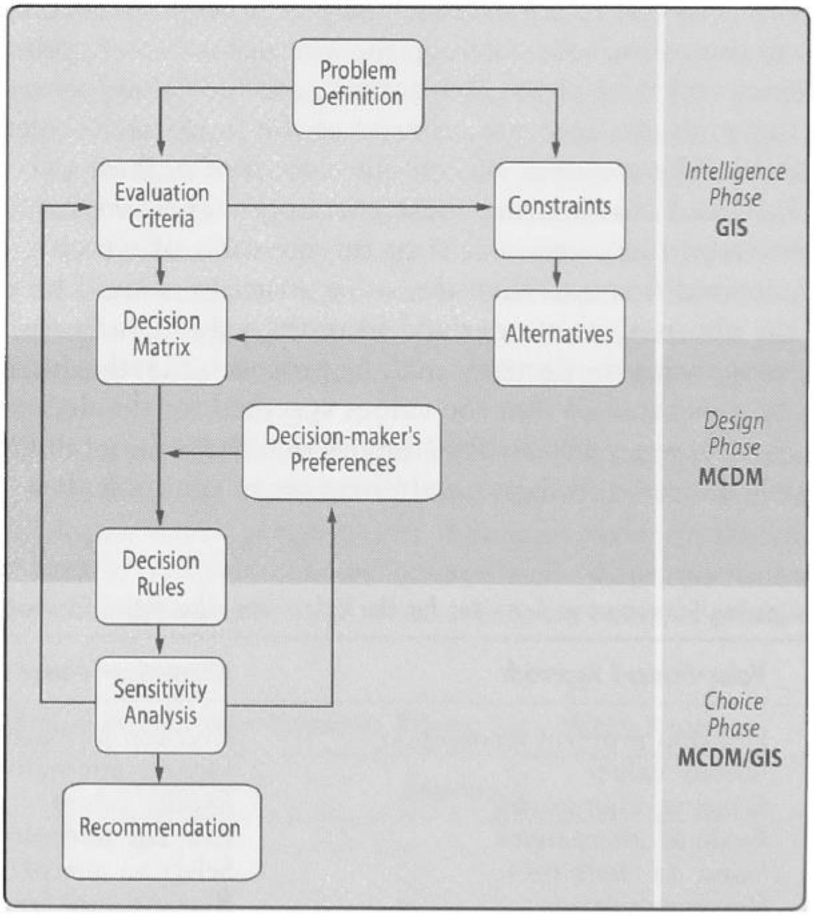

Figure 2.5 Framework of Spatial Multicriteria Evaluation (Source: Malczewski, 1999)

2.7.2 Evaluation Criteria

After defining the problem in the decision-making process, the next important step is to identify the evaluation criteria that are necessary in the decision environment. The set of evaluation criteria to be identified constitute the attributes and objective of the decision problem. The specified objective must reflect the desirable state of the system with associated measures (attributes) necessary to achieve them. Achieving the objectives with the specified attribute measurement is the basis for deciding on the alternatives in the decision problem. The evaluation criteria entities can be tied to a location and therefore can be represented in spatial data form in GIS as data layers. There are a number of factors to consider for the attributes in the evaluation criteria. The attributes should be a measurable entity so that values can be assigned and used to ascertain its measure with respect to the set objective. The set of attributes should be comprehensive and clear to understand so that the decision maker can recognize the relationships in the attributes and be able to ascertain the degree to which each alternative achieves the set objective. The set of attributes should allow for reduction to smaller feasible options to enhance the decision-making process. The procedure for selecting a set of evaluation criteria is usually dependent on the related decision problem. However, there are procedures for selecting evaluation criteria that are common, and this include studying of available literature relating to the decision problem, analytical studies as well as opinion survey. Literature from research agencies, scholars and publications from government and non-governmental agencies pertaining to the spatial decision problem are good sources of selecting appropriate evaluation criteria. Opinion surveys from experts and people in the study area who can be affected by decisions are also good sources for proper evaluation criteria. In some cases, there is the challenge of data availability regarding the evaluation criteria. This means that even though a good sets of evaluation criteria may be identified for a decision problem, challenges in data availability might limit the feasible attributes to a few with respect to the decision objective.

2.7.3 GIS and Criterion Maps

The next step after identifying all evaluation criteria for the decision problem is to generate criterion maps. Criterion maps are the representation of all attributes in the evaluation criteria in geographic data layers in GIS. The spatial data representing each attribute is imported into GIS where various data manipulations and analysis (e.g. georeferencing, data conversions, vector and raster analysis etc.) are performed to generate a criterion map for each attribute.

The next step after generating the criterion maps is to transform them into a standard scale of measurement. This is because MCDA techniques require the evaluation criteria to be in standardized comparable units and since each criterion map contains raw values there is the need to transform all criteria maps into a standard scale. There are a number of methods that are used in GIS for data standardization. The score range method is the most used procedure in GIS (Malczewski and Rinner, 2015). The score range procedure is a special case of the single value function method which incorporate the decision makers preferences in a mathematical function (Malczewski and Rinner, 2015). The resulting standardized sores range from 0 to1 where 0 is the least score and 1 is the best score.

2.7.4 Criterion Weighting

The next step in the spatial multicriteria evaluation after criterion standardization is to assign weights to each criterion. Criteria weights indicate the importance of each criteria with respect to the other criteria under consideration. There are couple of methods that are used for assigning weights in spatial multicriteria evaluation. These methods are categorized as global and local methods. The global methods treat the decision maker’s preferences as being spatially uniform across the study area therefore the criteria are assigned single weight values. The global methods include ranking, rating, pairwise comparison, and entropy (Malczewski and Rinner, 2015). Even though these methods use different procedures in assigning weights, there are some properties of weighting that are common to all.

The criterion weights should fulfil this condition:

For W_1 , $W_2 \ldots\ldots\ldots W_h$

$$0 \leq W_h \leq 1 \text{ and } \sum_{h=1}^{n} = 1 \qquad (1)$$

The equation in (1) implies a normalization of the weights where higher weights means the criterion is more important with respect to other criteria and the sum of all weights must be equal to 1. All the global methods of weighting incorporate the subjective preferences of the decision maker with respect to the relative importance of decision criteria. The ranking method present the simplest form of weighting. Weights are assigned to criteria from most important to least important according to the decision maker's preferences. When the criteria ranks are decided, the weights are calculated according to this equation:

$$Wk = \frac{n - P\mathrm{k} + 1}{\sum_{k=1}^{n}(n - P\mathrm{k} + 1)}$$

where w_k is the *k-th* criterion weight, n is the number of criteria under consideration (k = 1, 2, …, n), and p_k is the rank position of the criterion (Malczewski and Rinner, 2015). Even though the ranking method is an effective tool for weighting criteria in Spatial multicriteria evaluation it is sometimes criticized for its lack of theoretical foundations (Malczewski, 1999). The *ratings* method of weighting allows the decision maker to assign weighting vales on a predetermined scale of 0-100. More important criterion is assigned higher values whiles less important ones are given less values relatively. The weights are then normalized by dividing each criterion weight by the sum of all assigned weights. Similarly, to ranking methods, rating methods lack theoretical and formal foundations, thus the generated weights might not be appropriate (Malczewski and Rinner, 2015).

The Analytical Hierarchy Process (AHP) which utilizes the pairwise comparison method is the last weighting method to be discussed. The AHP was introduced by Thomas Saaty for criterion weighting in decision problems. The AHP works by first constructing a comparison matrix for all the evaluation criteria. Each criterion is then compared against all criteria by assigning scores to indicate the criterion importance. The scoring is than on a 1-9 scale, where a score of 1 indicate least importance and 9 indicates most important. When a criterion is compared to itself, it carries the same importance and is assigned a score of 1 across the diagonal of the comparison matrix. The comparison matrix is reciprocal, example, criterion *x* with a score of 9 against criterion *y* will have a reciprocal score of 1/9 when *y* is compared to *x*. Once the comparison matrix is completed with scores, the next step is to calculate the criterion weights. The summation of score values in each column of the matrix is taken and then the matrix is normalized by dividing each element in the matrix the sum in the respective column. The final step is to calculate the averages of each row in the normalized matrix to obtain the criterion weights. Because decision maker's criterion preferences always inconsistencies in judgment, the AHP incorporates a consistency ratio which values must be ≤ 1 to check consistency in the criterion comparisons.

3 Materials and Methods

This chapter describes the rural tourism criteria selected for this project and the associated data and their sources. The methodology for the data analysis employed in this project as well as the tools used in its implementation are also be described.

3.1 Methodology for Analysis

The main purpose of this study is to investigate the applicability of GIS and MCDA in prioritizing locations for rural tourism development in Chiapas and perform a suitability analysis to achieve the study objective. In view of this, the most suitable criteria for rural tourism development will be identified from literature and tourism experts. The data for the criteria will be mainly secondary data and collected from a variety of sources. The spatial and statistical data that will be used for this project will be processed using MCDA methods and GIS tools. A set of evaluation criteria will be determined and indicators that are suitable for each criterion will be selected for measurement. The related factors and criteria will be presented in spatial data layers and evaluated using different GIS analysis functionalities (reclassification, conversion tools, raster analysis, weighted overlay etc.) in ArcGIS 10.5 suite. The weighted layers will then be summed up in a final suitability analysis.

In order to weight the input layers in a scientific way, the Analytical Hierarchy Process (AHP), which is one of the most extended Multi-Criteria Decision Analysis (MCDA) techniques will be utilized in this project. The AHP will be utilized in this project mainly because of its ability to give pair-wise comparison to all criteria. This method provides a structural basis for quantifying the comparison of decision elements thereby allowing the decision maker to cognitively compare individual criterion against each other with the objective in mind. The pair wise comparison will be developed using the AHP toolkit in ArcGIS 10.5.

3.1.1 Determination of Evaluation Criteria

Defining the criteria for rural tourism development in Chiapas is important because it is the standard of judgement based on which a particular area will be assessed as being suitable or not for development. The evaluation criteria selected for this project was based on extensive literature study on proven factors which are known to influence tourism development as well as views from tourism experts who have extensive knowledge of tourism in the study area. The evaluation criteria for this study includes; Landcover, Tourist Attractions, Cultural Elements, Accessibility, Facilities and Services, Population Density and Relief. There are several other factors which contribute to the general success of a rural tourism project, but these selected criteria show the different needs for rural tourism development in Chiapas and in part were chosen also due to the availability of data to be represented in the form of criterion maps/ data layers for further analysis in GIS. The selected criteria are explained in the proceeding texts.

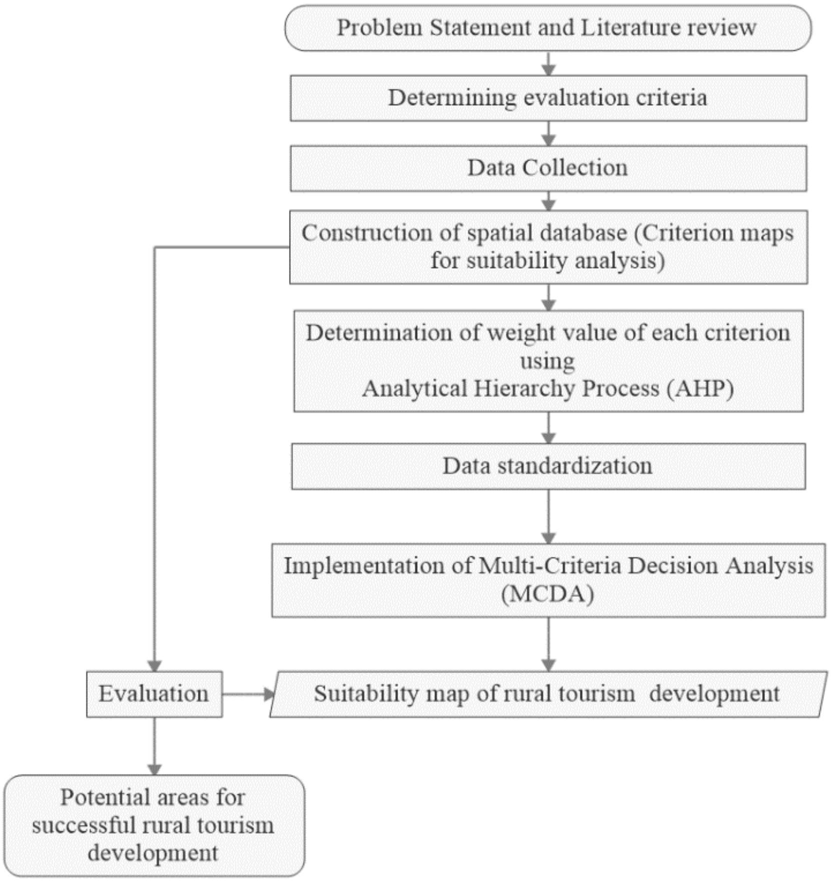

Figure 3.1 Conceptual Framework of Methodology

Land Cover: This criterion indicates the Flora and Fauna of Chiapas. The state of Chiapas is well known for its great biodiversity and remarkable tropical landscape which has been a major source of attraction for visitors who seek adventure and loves nature. The land cover classes selected for this criterion includes; Vegetation (herbaceous, shrubland, grassland, savanna), Forest (deciduous or semi-deciduous), Water (rivers, lakes, waterfalls). The land cover classes also represent the habitat of different animal species that are in Chiapas and include protected areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area. They are managed mainly for ecosystem protection and for recreation.

Attractions: This criterion indicates the natural and man – made tourist attractions in Chiapas. For a tourism project to be successful in any area, there needs to be the presence of a strong attraction which will guarantee the flow of tourist to the area. These attractions may include; caves, cenotes, beaches, monuments, buildings etc.

Cultural Elements: This is another important criterion which complements areas that have low attractions for tourism. The available cultural elements like; festivals, artisanal crafts, historical ruins, museums, archaeological sites etc. offers travellers an engagement with the lifestyle and culture of the indigenous people. These cultural elements can be a strong attraction on its own and for rural areas it can be a huge complement to already existing natural features which will increase the flow of tourist.

Facilities and Services: One of the most important aspect of rural tourism development is the availability of facilities and services that will make the experience of visitors worthwhile. Chiapas is well known for its forest and mountainous landscape and mostly attract tourists who seek adventure and a close experience with nature and the availability of comfortable accommodation facilities and services like internet, restaurants, banks, hospitals etc. enriches the experience of the place and increases its marketability. Even though visitors seek adventure and nature experience, most are always inclined to still have access to these services that they are used to in their daily lives. Whiles most rural communities in the jungles may not readily have some of these facilities their proximity to nearby towns where these services are available influences their tourism potential.

Population Density: This criterion indicates the population density of Chiapas. The state has 51% of its population living in rural areas hence areas with low population density will be the focus of this study.

Relief: This criterion indicates the high mountainous areas in Chiapas that has resulted from volcanoes. This shows the unique landscape that complements the flora and fauna of Chiapas. It provides a continuous surface of the high and low lands which is a key component of rural tourism development. Next after defining the evaluation criteria is to select suitable indicators and variables (i.e. Parameters to be used to measure the selected criteria) and this is represented in Table 3.1

3.1.2 Data Collection and Sources

The datasets used in this project were collected from a variety of sources which are mainly secondary. The datasets comprise of the spatial data layers for the individual evaluation criterion described in the previous section. The data sources include Mexican government departments such as the National Institute of Statistics and Geography (Instituto Nacional de Estadísticas y Geografía - INEGI), National System for Statistical Information of the Tourism sector in Mexico – DATATUR. Other sources also include the Data User Element (*DUE- a component of the Earth Observation Envelope Programme (EOEP)*), OpenStreetMap database and WorldPop datasets. Table 3.2 presents each data layer and the related data source.

Table 3.1 Evaluation Criteria and Variables for Measurement

Objective	**Criterion**	**Indicators**	**Variables**	**Measurement**
To assess areas with high potential for rural tourism development	Land cover	Forest protected areas Mosaic Vegetation *(Grassland, Shrubland, Herbaceous)* Water bodies Bare Areas Croplands Artificial surfaces and associated areas *(Urban areas)*	Areas with dense deciduous forest and water bodies are considered most suitable for rural tourism, Protected areas and mosaic vegetation have minimum suitability whiles urban areas and croplands have low suitability.	The landcover classes were reclassified into values representing Most suitable, suitable, less suitable and not suitable
	Attractions	The natural and manmade features both within and adjacent to a community	Areas with high number of attractions are considered most suitable for tourism whiles suitability decreases with less number of attractions	Kernel density of attractions where high-density values are most suitable and low values are less suitable as proximity to dense areas decreases
	Cultural Elements	Festivals Museums Historical sites (e.g. Mayan ruins) Indigenous traditions and events	Areas with high number of Cultural elements are considered most suitable for tourism whiles suitability decreases with less number of Cultural activities	Kernel density of Cultural elements where high density values are most suitable and low values are less suitable as proximity to dense areas decreases

	Facilities and Services	Accommodation *(Hotels, Lodges etc)* Restaurants Retail Services Auxiliary services *(banks, hospitals, etc.)*	Areas with high number of Facilities and services are considered most suitable for tourism whiles suitability decreases with less number of services	Kernel density of Facilities and Services where high-density values are most suitable and low values are less suitable as proximity to dense areas decreases
	Accessibility	Main Roads Main cities, Ports, Stations etc.	Proximity to main roads, airports and main cities increases suitability for tourism, the farther away the less suitable	Kernel density of main roads and ports where high-density values are most suitable and low values are less suitable as proximity to roads decreases
	Population	Population density	Areas with low population density is considered most suitable and suitability decreases as population density increases	Low population density values are most suitable and high population density values are less suitable
	Relief	Digital Elevation Model of Chiapas	High mountainous areas are considered most suitable and suitability decreases as height values decreases	High elevation values considered as most suitable and suitability decreases as elevation values decreases

Table 3.2 Data Layers and their sources

Data	***Source***
Landcover	Global Landcover map (2009) of European Space Agency (ESA) released in 2010. The products have been processed by ESA and by the Université Catholique de Louvain and available online at Data User Element (*DUE - a component of the Earth Observation Envelope Programme (EOEP) of ESA)* website. Link: http://due.esrin.esa.int/page_globcover.php
Attractions	Attractions in Chiapas was collected from the OpenStreetMap database, available for download at https://www.geofabrik.de/data/download.html, accessed on 11 November 2017
Cultural Elements	OpenStreetMap database available for download at https://www.geofabrik.de/data/download.html Accessed on 11 November 2017
Facilities and Services	OpenStreetMap database available for download at https://www.geofabrik.de/data/download.html Accessed on 11 November 2017
Accessibility *(Roads, bus stations, airports)*	National Institute of Statistics and Geography (Instituto Nacional de Estadísticas y Geografía - INEGI) Available at http://www.inegi.org.mx/ http://cuentame.inegi.org.mx/default.aspx#. Even though data was available on the INEGI website, it should be noted the original source is from OpenStreetMap database
Population Density	WorldPop datasets available at http://www.worldpop.org.uk/search/?link=data_search.php&search=Mexico at resolution 100m.
Relief	National Institute of Statistics and Geography (Instituto Nacional de Estadísticas y Geografía - INEGI) Available at http://www.inegi.org.mx/ at resolution of 15m.

3.1.3 Development of Criterion Maps

The data layers for the evaluation criteria were processed using conversion tools and spatial analyst functions in ArcGIS 10.5. They were then standardized using raster calculations in R. They when then scored and assessed in the MCDA using the AHP tool. Details of how the various data layers were processed are explained in the following text.

The Land Cover data layer contains the different vegetation types, forest types, croplands, water areas etc. This data layer was reclassified from its original values according to the physical vegetation characteristics that are normally associated with rural tourism resources (particularly ecotourism). The reclassification is shown in Table 3.3 along with the associated suitability measure and the landcover classes.

Table 3.3 Reclassification of Landcover

Original Values	**New Values**	**Landcover class**	**Suitability Measure**
0 14 170 190 200	0 -20	Bare areas, Artificial surfaces and associated areas Permanently flooded forest and shrublands	Not Suitable
20 150	21-50	Rainfed croplands, Mosaic croplands (50 – 70%)	Less Suitable
30 120 130 140	51 - 70	Mosaic vegetation (grassland/shrubland/forest 50-70%) Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses) Mosaic grassland (50-70%) / forest or shrubland (20-50%)	Suitable
40 50 110 210	71 -100	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m) Closed (>40%) broadleaved deciduous forest (>5m) Water bodies	Most Suitable

The population density data layer was also classified from 0 -100 where areas with high population density were given lower scores and areas with low population density were given higher scores. This was done because the rural areas are the focus of this study and they are the places with lower population densities. The Relief data layer was processed from the digital elevation model of Chiapas. This data layer was also scored from 0-100 where areas with high elevation values were given higher score and considered more suitable for rural tourism than areas with lower elevation values. This is because, these high mountain areas have been created as a result of volcanoes and is known to be very attraction for visitors who like mountain climbing and wants to experience the unique creation of nature. These mountainous areas are also characterised by waterfalls which also contribute to tourism potential of these areas. In the remaining data layers (i.e. attractions, cultural elements, accessibility and services) the objective was to create a surface raster where closer proximity to their locations will constitute high suitability. For this purpose, the kernel density tool in ArcGIS 10.5 was used to create raster layers with a continuous surface where values increase as proximity to dense areas increases. The output of the criterion maps is shown in the results section of this project.

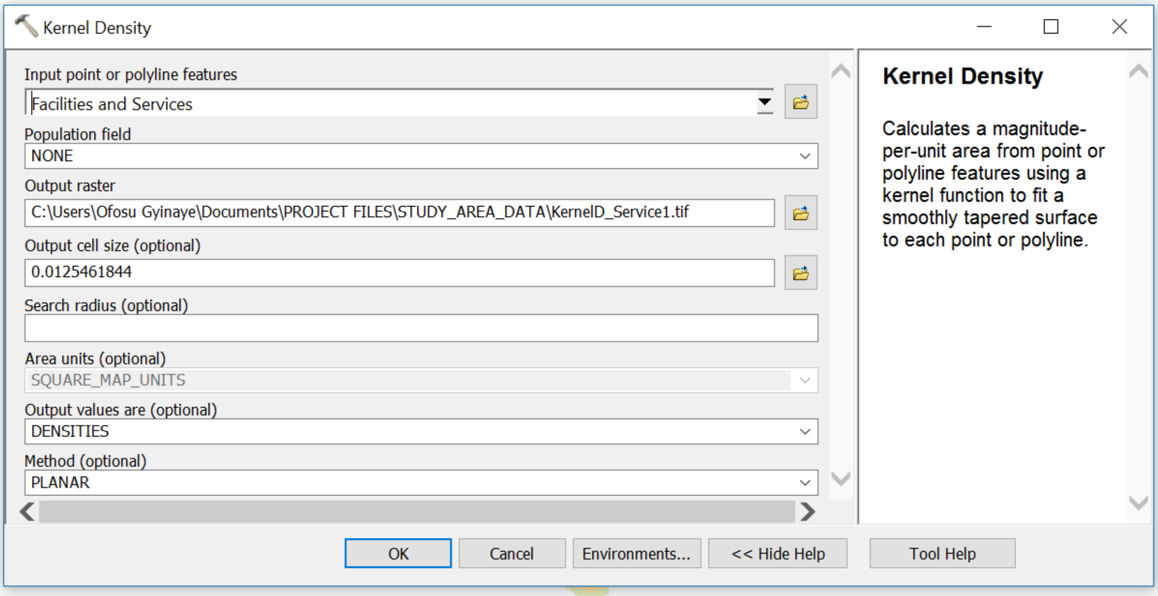

Figure 3.2 Kernel Density calculations

3.1.4 Pairwise Comparison and Criteria Weights

The next step in the methodology after processing the criterion maps was to assign the criterion score for each data layer. This was done by comparing the importance of each criterion against another criterion in a pairwise comparison method since the criteria are characterized by different important levels. In order to make an informed decision when assigning scores to the criterion maps, a number of tourism experts in Mexico were asked of their opinion on what they will consider as important among certain criteria for rural tourism development. They were asked to rate the importance of each criterion on a 1-5 (1= less important, 5= most important) linear scale with respect to each other.

Figure 3.3 Importance of tourism criteria according to experts

The responses from the questionnaire is shown figure 3.3. These responses show the different views of what different experts thinks is important to be considered when choosing an area for rural tourism development. In addition to these charts, direct discussions with some of the experts revealed the reasons for attaching more importance to some criteria with respect to the nature of tourism in the study area. A lot of emphasis was placed on the need for a strong attraction (natural and manmade), accessibility and services. The reason being that, for all the beautiful natural and manmade features that may exist in a community, if the road infrastructure to access the community is very poor or non-existent it greatly affects its potential as a tourist destination. The same is for facilities and services that may exist in the community or at least close to such a community. All these different views and reasons from experts were taken into consideration and used as a guide to assign criterion scores in the score matrix.

The AHP toolkit in ArcGIS 10.5 was used to construct the criterion matrix for the score assignment. Since there are always discrepancies in the individual judgement on criterion scores, the AHP tool incorporates a consistency ratio which checks the degree of consistency in the judgments before deriving final criterion weights. The Consistency Ratio (CR) must be less than or equal to 0.1 for the criterion scores to be acceptable in the AHP. The output of the criterion score matrix from this process is shown in Table 4.1 in the results section of this report.

3.1.5 Data Standardization

In practice, evaluation criteria are normally expressed in different measurement scales (eg. Ordinal, ratio etc.) and since most MCDA techniques (including AHP) require that all of the criteria involved are evaluated on a similar scale, there is a need to represent all the data layers on a uniform scale. The data layers in this project was standardized using the raster package in 'R' by Hijmans (2016) with the following syntax:

```
>raster_layer <- raster("raster_name.tif")
>ratio <- raster_layer/cellStats (raster_layer, max)
>score <- (ratio)*100
```

To write the scored raster for importing to ArcGIS:

```
>writeRaster (score, filename="scored_raster.tif", format="GTiff",
overwrite=TRUE)
```

The standardization procedure rescales the criteria dimensions between 0 and 1 but in this instance, the scoring was done with scale of 0-100 in all data layers to get more details in the raster data layer.

3.1.6 Suitability Analysis

The final process in the methodology was to perform the suitability analysis from the results of the weighted evaluation criteria in the AHP and assess potential areas for rural tourism development. The overlay analysis toolkit in ArcGIS 10.5 was used to perform this task. There are two main methods in the overlay analysis tool that are predominantly used in site suitability analysis, Weighted sum and Weighted overlay. Both methods provide the ability to combine multiple raster layers that represent different criteria by incorporating their relative levels of importance or weights to produce an integrated analysis. In this project however, the Weighted Sum overlay method was preferred since the output model maintains its resolution and shows the most favourable sites according to the input layers. It also allows for the input of float raster layers which is convenient since most of the criterion data layers had float values. The weighted sum works by multiplying the value field of each input raster layer (criterion map) by the assigned weights and then summing all the input data layers to create a final suitability map as output. The final output of the overlay analysis is shown in Figure 4.8 in the result section.

4 Results and Discussions

This chapter presents the output of the raster processing and the AHP analysis performed in chapter 3. The final suitability map is also discussed and evaluated to see potential areas for rural tourism development. Figures 4.1 to 4.7 shows the result of the criterion maps with a standardised score of 0 – 100.

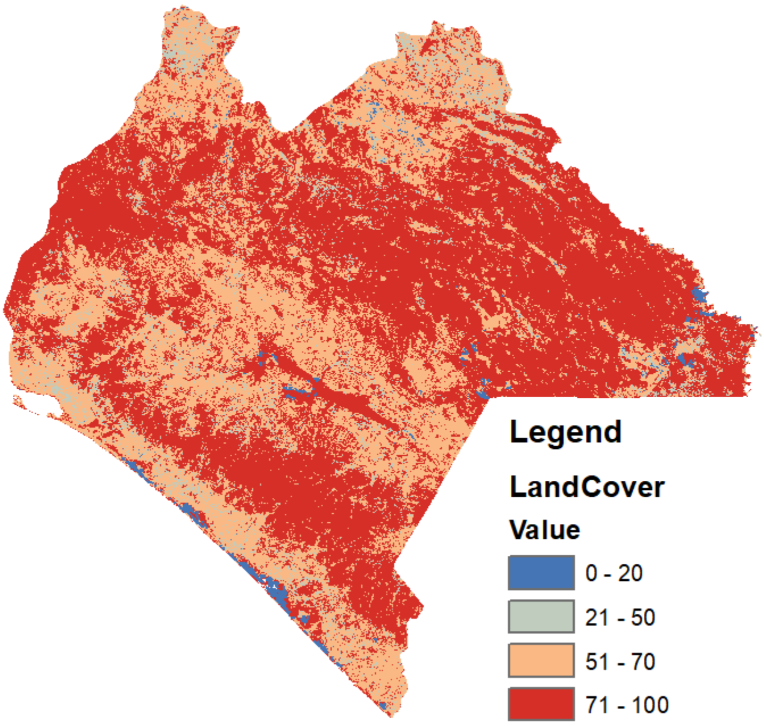

Figure 4.1 Reclassified Landcover

The result of the landcover map shown in figure 4.1 displays the dense forest and water areas within the value range of 71-100. These are the areas given higher scoring for tourism potential. The areas within the value range of 51-70 are mostly vegetation (shrubs, grassland, savanna etc). Range values of 21-50 and 0-20 represent crop lands and urban areas respectively.

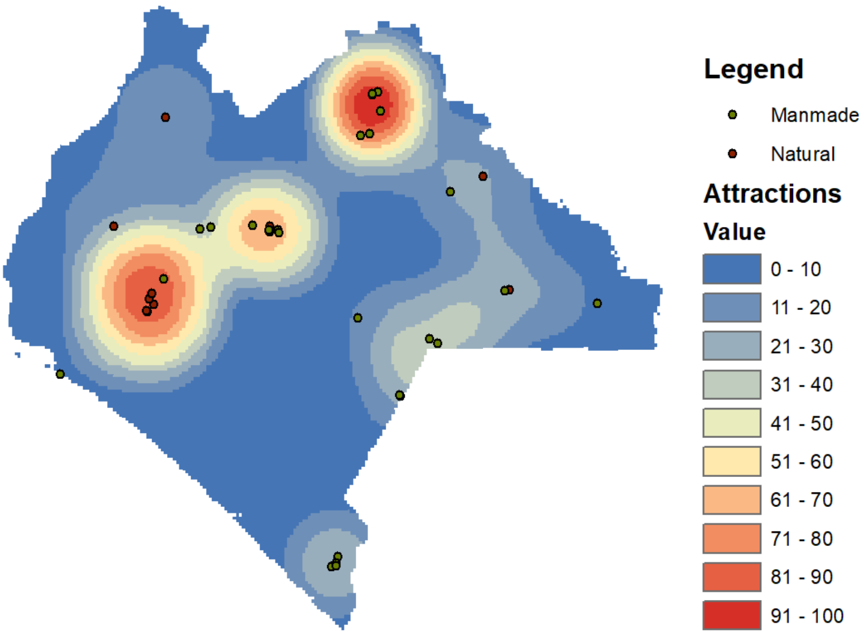

Figure 4.2 Attractions

Figure 4.2 shows the resulting criterion layer for attractions. The values represent proximity to areas with more number of attractions. Range values of 71-100 represent areas of high tourism suitability whiles suitability decreases as proximity values decreases.

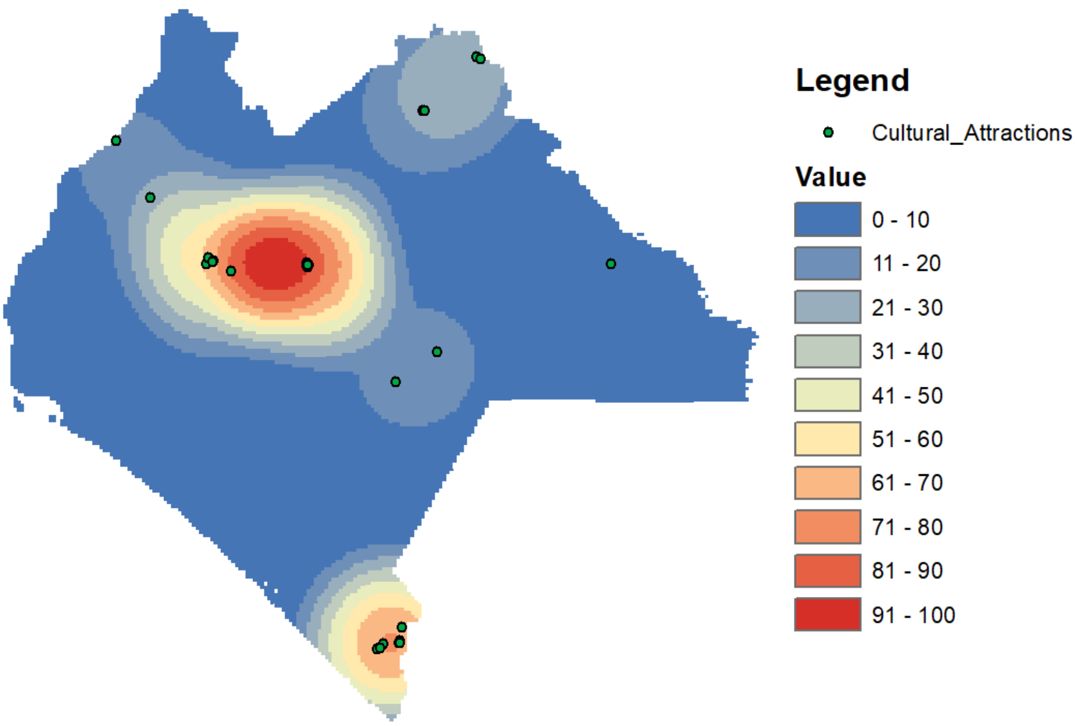

Figure 4.3 Cultural Elements

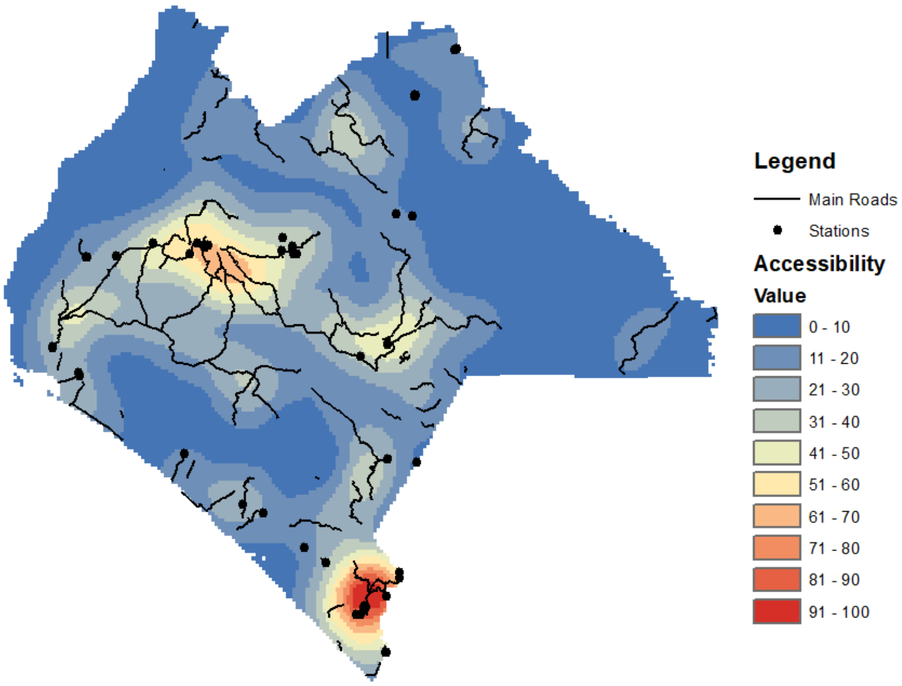

Figure 4.4 Accessibility

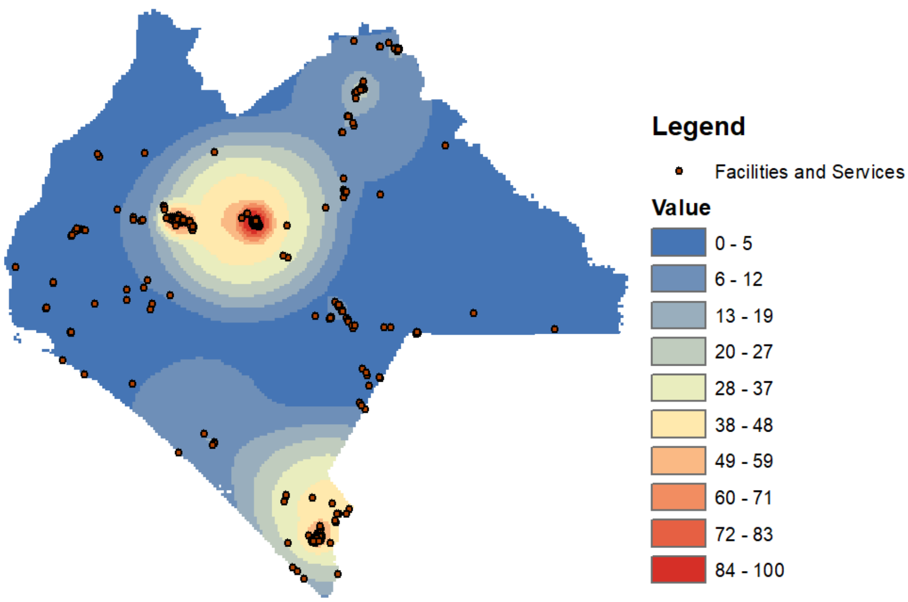

Figure 4.5 Facilities and Services

Figures 4.3 – 4.5 shows proximity to cultural elements, accessibility and facilities and services. High Proximity values in these criterion maps represent areas with high suitability whiles the suitability decreases as proximity values decreases.

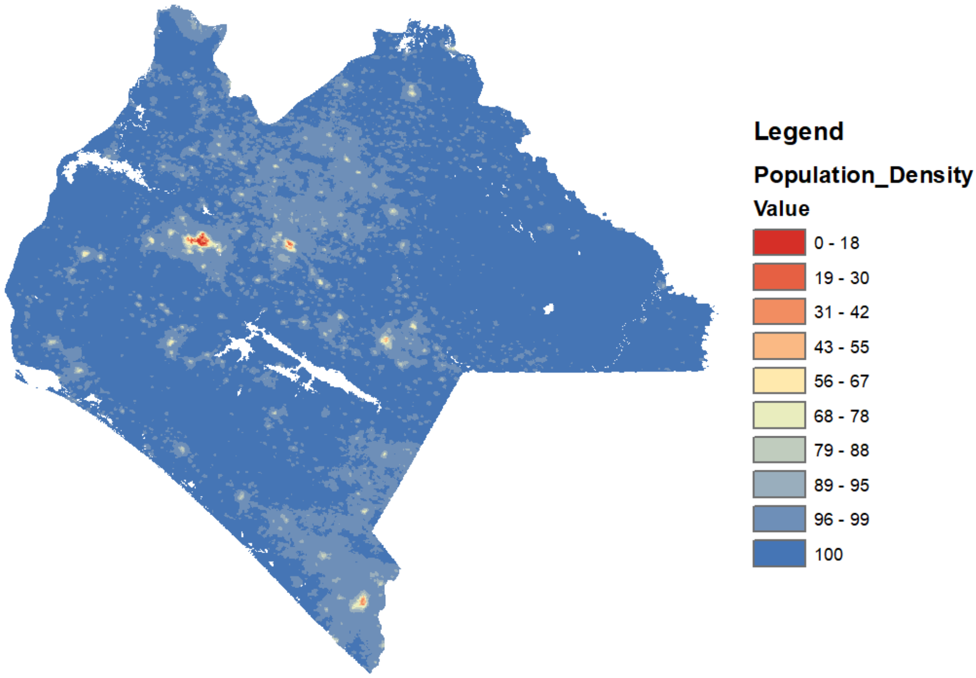

Figure 4.6 Population density

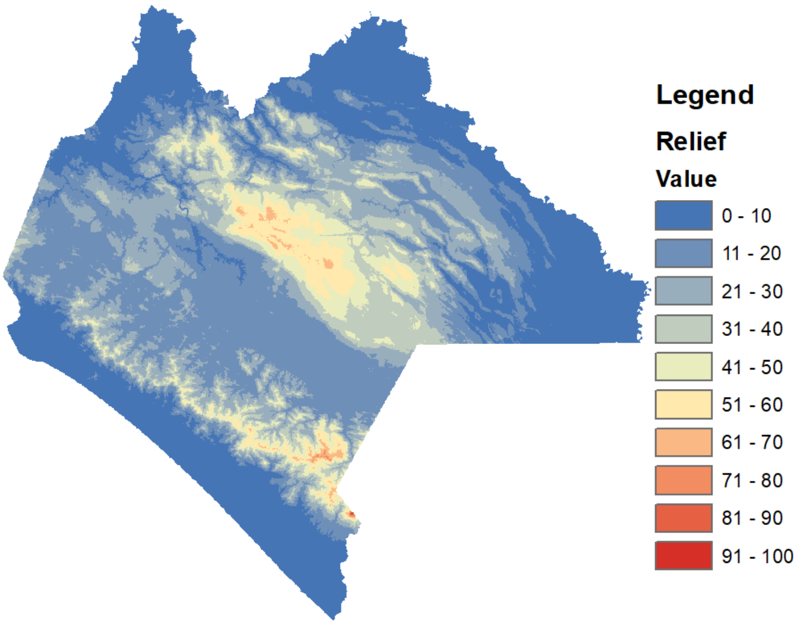

Figure 4.7 Relief

The population density layer is shown in figure 4.6, high values indicate areas of low population and these are the important areas for the objective of this project. Similar to the population density, high values in figure 4.7 shows areas with high elevation and these are the areas considered as being suitable for tourism. They represent mountainous areas which are ideal for adventure tourist who likes to hike and climb mountains.

Table 4.1 Pair wise comparison of Evaluation Criteria

	Attractions	Cultural	Land Cover	Accessibility	Services	Population	Relief
Attractions	1	4.0	7.0	1.0	2.0	9.0	5.0
Cultural	0.25	1	2.0	2.0	1.0	5.0	3.0
Land Cover	0.143	0.5	1	0.143	0.25	4.0	1.0
Accessibility	1.0	0.5	7.0	1	1.0	9.0	4.0
Services	0.5	1.0	4.0	1.0	1	9.0	7.0
Population	0.111	0.2	0.25	0.111	0.111	1	0.333
Relief	0.2	0.333	1.0	0.25	0.143	3.0	1

AHP indicators
λ = 7.494, the largest eigenvalue of the comparison matrix
CI = 0.082, the consistency index of the comparison matrix
CR = 0.062, this the consistency ratio of the matrix which indicates the comparison matrix is consistent.

The result of the pairwise comparison is shown in Table 4.1. In the assignments of criterion scores, results from questionnaire and expert opinions were taken into much considerations. Attractions, Accessibility and Services were the criterions given much importance when compared with the other criteria. Rural tourism development is highly dependent on the presence of a strong attraction in a community and this is the reason most experts gave a higher scoring to attractions. However, the presence of a strong is not enough if accessibility to the destination is highly limited. Limited accessibility will affect tourist flow to the destination even if the attraction is very strong. The third criteria given more importance is the facilities and services available. Experts argue that most rural tourist are more likely to visit destinations where services are available within or in close proximity to the destination. This is because tourist who visit rural areas always wants to stay in touch with the people they left behind, having these services (internet, hospital, banks) in or close to the tourist destination makes them comfortable and safe if there is any emergency that requires the need of these services. The resulting criterion weights from the comparison matrix is shown in Table 4.2.

Table 4.2 Weighted Evaluation Criteria

Evaluation Criteria	Weight
Attractions	0.0309
Cultural Elements	0.159
Accessibility	0.21
Landcover	0.053
Services	0.198
Population	0.022
Relief	0.049

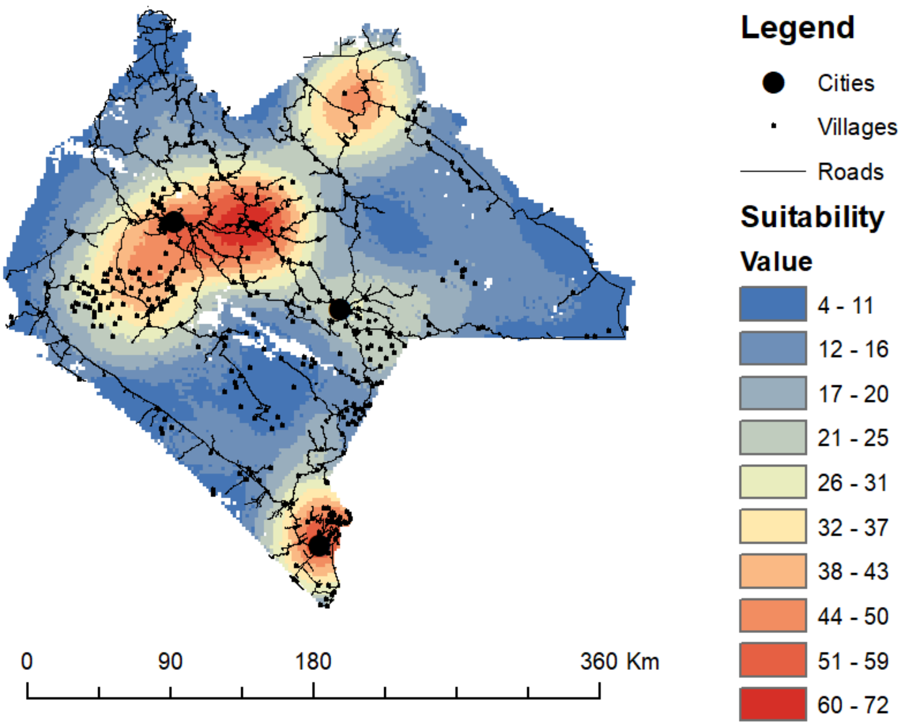

Figure 4.8 Final Suitability Map of Chiapas

The final output of the overlay analysis shows the suitability map for rural tourism in Chiapas. It must be noted that, in the weighted sum analysis, the output model values are not rescaled back to the defined evaluation scale of the input criterion maps but rather assumes that areas of high suitability result in high values in the output layer and the areas with low suitability result in the lower values. The output map is divided into four suitability classes according to the suitability measure used in the input data processing as follows; *Low Suitability* **(4 – 16)**, *Marginal Suitability* **(17 – 31)**, *Average Suitability* **(32 – 43)** and *High Suitability* **(44 – 72).**

From the suitability map shown in Figure 5.8, the areas of **High suitability (44 – 72)** constitute about 7.6% of the region and are mostly located in the central and southern part of Chiapas. These areas have close proximity to major cities in terms of distance and are highly accessible by roads. The landscape in the central areas is a mixture of forest and vegetation and quite mountainous but there are high number of attractions in these areas. The southern part has more forest areas when compared with the landcover map. These areas in the suitability map have the highest potential for rural tourism according to the evaluation criteria for this study, however, their closeness to urban centres could mean more influx of tourist. This could create major problems for the biodiversity of the area as developments will attempt to address the needs of tourist at the expense of the ecosystem. Potential rural tourism developments in these areas should be done with a detailed assessment of the environment impact of the biosphere and the carrying capacity of the ecosystem in order to preserve the natural environment.

The areas with **Average suitability (32 – 43)** constitute 11.07% of the study area. They are very close to the high suitability areas in the map in terms of tourism resources designated as important for this study. These areas are in the central and western part of Chiapas as well as the north-east and southern part of the state. There are a good number of attractions and services in those areas and they are accessible too. When compared to the landcover data layer, there exist a lot of vegetation in the western and north-eastern part of these areas and some forest in the southern part. The potential for tourism development in these areas is good but might require the presence of a strong attraction and other intangible cultural elements to compensate for the lack of other important tourism indicators for that are required for development.

In the remaining suitability classes, 48.5% and 33% unexpectedly constitute areas with **Low suitability (4 – 16)** and **Marginal suitability (17 – 31)** respectively. Areas with marginal suitability has good road connections which means communities in those areas are accessible but may lack other important criteria like strong attractions and available services. In the east and south – west parts of Chiapas where the areas show low suitability for tourism, there is limited accessibility, lower number of recorded attractions and in many of the other evaluation criteria. This explains the high percentage in lower suitability areas.

4.1 Error Assessment

In many Multicriteria evaluation techniques, it is presumed implicitly that there is complete information available to the decision maker to make informed judgements on the criterion options that relates to alternatives in the decision problem. However, in practice this presumption does not hold because decision makers often have insufficient information in the decision-making process. This is because the available information often has uncertainties and imprecision in them due to measurement and conceptual errors. Hence, there is the need to perform assessment of the errors that are associated with the input data layers and judgements by the decision maker that ultimately affects the final output in the suitability analysis.

One of the main concerns in the suitability analysis was the uncertainties associated with the geographic data that was used to construct the criterion maps for the multicriteria evaluation. The geographic data, based upon which the evaluation criteria maps are created is normally associated with uncertainties in the positional (location) accuracies during measurements and errors in their attributes. These inherent errors in the data are propagated in the criterion maps and effectively unto the output suitability map. These errors are normally estimated by using observed values in the sample location and measured values to estimate the *root mean square* value which gives a measure of the error in the data. In this study however, the location data for attractions, cultural elements, accessibility and services were all taken from sources where the initial gathering of the data might be prone to errors. Another source of errors is the uncertainties that is associated when judging the importance of criteria according to the decision makers preference. Even though in this study, steps were taken to get good information from tourism experts in an attempt to give better judgements on criteria weighting, there can never be enough information to ascertain the inconsistencies in preferences. This is in-part because the information from experts are also borne out of their own estimation of what's important.

4.2 Limitations in this Study

This study has primarily focused on assessing the potential of rural tourism development and therefore based the analysis on selected general criteria necessary for a tourism project to thrive. However, there are other inherent tourism indicators that are specific to different regions and communities in the study area that are not considered in this study but can equally influence the viability of tourism in Chiapas. The findings in this study might also be affected by the errors in the data used for the analysis. The uncertainties in the data source could introduce errors in the results that have not been measured. Another limitation in this study is the number of attractions, cultural elements, services and accessibility used for the analysis. The data count of these criteria by no means constitute an exhausted list of all that this available in Chiapas. This is in-part due to the unavailability of a reliable resource inventory of these criteria in spatial data form. There is also a weakness in the technique used in the criterion preference and this is due to the highly subjective way in which a criterion is given more importance over another when assigning weights.

5 Conclusion

This study started with the aim of applying methodologies in GIS and MCDA to assess suitable areas in Chiapas which will have a high potential for rural tourism development. The concepts of rural tourism development were studied in order to select tourism indicators that are known to be essential to rural tourism development and rightly compliment the characteristics of the study area. This study showed the integrated approach of determining suitable sites for rural tourism which will prove beneficial in aiding decision-making process by stakeholders when planning tourism development projects. The research procedure also proves that the integration GIS and Multicriteria evaluation techniques can be a powerful approach in dealing with multiple criteria problems associated with site selection in tourism development. The geospatial capabilities of GIS can greatly enhance tourism development analysis through powerful visualizations of locations of attractions, closest facilities and services, route selections etc.

5.1 Future Studies

This study has established a base for exploring the integration of GIS and MCDA in dealing with tourism development issues in Mexico where there has not been a lot of studies with this approach. There are multiple criteria that are essential in site selection for rural tourism development. Other evaluation criteria that can be integrated to enhance the results in this study include: *1) Marketability of a tourism product in a community;* that's the measure of interested tourist to the destination, availability of travel agencies and tour operators to promote the tourism product, *2) Institutional and legal framework;* How the community is organised (Cooperatives, groups etc), *3) Financial support from public and private sectors;* presence or absence. *4) community participation*: Active or passive

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