COMPARISON OF TWO METHODS FOR REGIONAL ANALYSIS OF FUNCTIONS; THE CASE OF INTERNALLY DISPLACED PERSONS RESETTLEMENT IN NORTH DARFUR STATE

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ALFRED DONGZAGLA Enschede, The Netherlands, March, 2013

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ABSTRACT

The conflict in Darfur which started in 2003 has caused insecurity, displacements, destruction of functions and disruption of livelihood activities resulting in low standard of living. Following the adoption of the Doha Document for Peace in Darfur in 2011, Darfur is relatively peaceful and currently undergoing recovery from the adverse effects of the conflict. As part of efforts in the recovery of Darfur, the United Nations (UN) together with the Sudanese governments and Civil Society Organizations are developing a regional planning strategy for the reconstruction of Darfur. Resettlement of Internally Displaced Persons is key in the recovery and reconstruction of Darfur.

Owing to the destruction of social services, infrastructure and economic functions in Darfur caused by the conflict, some Localities (sub-administrative units) may not have important functions to sustain the livelihood of IDPs. A regional analysis of functions can help in the identification of places that are functionally suitable to support decision making in the resettlement of IDPS. Existing methods in regional analysis of functions are descriptive in nature. In such descriptive methods, system analysts do not consider societal functional preferences in determining the functional level of places. A Matrix of Function is one of such descriptive methods. Given the objectives of stakeholders in Darfur to resettle IDPs in functionally suitable areas, a normative method like Multicriteria Evaluation can help order Localities based on the functional preferences of stakeholders to support decision making in the resettlement of IDPs. The study therefore compared Matrix of Function and Multicriteria Evaluation methods in analysing the functional hierarchy of Localities suitability to support decision making in the resettlement of IDPs in Darfur.

The two methods were compared with regards to seven criteria. These include; data requirements, ease of computation, amount of interaction required between the decision maker and system analyst, weighted values /importance of functions, the nature of the alternative system being analysed, consistency of results of methods and finally robustness of the results.

A five level functional hierarchy of Localities was identified in both Matrix of Function and Multicriteria Evaluation methods. The functional hierarchies of the two methods are fairly consistent. In both methods, El-Fasher Locality is on top of the hierarchy with a wide functional gap between it and the next level. The functional suitability of other Localities if compared to El-Fasher Locality are generally low and need to be upgraded through the provision of services that are absent in those Localities to ensure a balance regional development. El-Fasher Locality is therefore a potential Locality for the resettlement of IDPs. Despite the fact that the two methods yield a fairly consistent functional hierarchy, an assessment of the methods against other criteria indicates that the two methods have varied strengths and weaknesses.

Keywords: resettlement, Internally Displaced Persons, functions, functional hierarchy, Matrix of Function, Multicriteria Evaluation

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ABBREVIATIONS AND ACRONYMS

Centrality Index
Central Place Theory
Focus Group Discussion
Inter-Agency Standing Committee
Internal Displacement Monitoring Centre
Internally Displaced Persons
Integrated Land and Water Information System
International Training Centre, (currently Faculty of Geo-Information Science and Earth
Observation, University of Twente)
Multi-Attribute Decision Making
Multicriteria Decision Making
Multicriteria Evaluation
Matrix of Function
Multidimensional Scale Analysis
Spatial Decision Support System
Spatial Multicriteria Evaluation
United Nations
United Nations Development Programme
United Nations Educational, Scientific and Cultural Organization
United Nations Population Fund
United Nations Human Settlements Programme
United Nations Children's Fund
United States Agency for International Development
Water, Sanitation and Hygiene
World Health Organization

1. INTRODUCTION

1.1. Background and Justification

Displacement remains a critical factor of vulnerability to many people across the world (Birkeland, 2010). The phenomenon of internal displacement arising from conflict, violence and human rights violation has been widely described by international observers as one of the biggest challenges of our time (Norwegian Refugee Council, 2002).

At the end of 2011, the global number of people internally displaced by armed conflict, generalized violence or human rights violations stood at 26.4 million (Internal Displacement Monitoring Centre, 2012). The Internal Displacement Monitoring Centre (IDMC) report for 2011 indicates that, Sub-Saharan Africa has the largest number of Internally Displaced Persons (IDPs) (9.7million), which is almost twice that of Latin America (5.6million) (ibid.). At the country level, Colombia (3.9-5.3million), Iraq (2.3-2.6million) and Sudan (2.2million) are the top three countries with the largest number of IDPs (ibid.)

Given the enormity of conflict induced displacement, particularly in developing countries, durable solution for displaced people is important in reconstructing their livelihood. IDPs can find solutions to their displacement by returning to their place of origin, integrating in the place to which they have been displaced or settling in a third location (IASC, 2010). These options can be considered durable once IDPs have "safety and security; adequate standard of living; access to livelihoods; restoration of housing, land and property; access to documentation; family reunification; participation in public affairs; and access to effective remedies and justice" (IASC, 2010, pp. 31-32).

Since 2003, the Darfur region of Sudan has experienced protracted armed conflict resulting in displacement and loss of lives. About 300,000 people have been killed and 2.7 million people displaced from their homes and lands to camps around the main cities of Darfur, and other neighbouring countries (Olsson, 2010). Map 1-1 below shows the location of Darfur's IDPs/refugees camps and their population.



Map 1-1: Location of Darfur's IDPs/refugees camps and their

Following the adoption of the Doha Document for Peace in Darfur in 2011, humanitarian support by international aid agencies and the UN peace keeping mission to IDPs in Darfur are being reduced and will probably be terminated in the near future. "Leaving IDPs in continued marginalization without the prospect of a durable solution may become an obstacle to long-term peace, stability, livelihood recovery and reconstruction in post-crisis countries" (IASC, 2010, p. 1). The United Nations as part of its efforts to protecting the rights of IDPs and sustainable restoration of their livelihood has consolidated into one document all international norms relevant to IDPs, i.e. the Guiding Principles on Internal Displacement (United Nations, 1998). Guiding Principles 28-30 on Internal Displacement emphasizes the responsibilities of national authorities and the role of humanitarian and development actors to assist IDPs to achieve durable solutions (IASC, 2010). It is in this regard that, UN-HABITAT, the Sudanese government and other organizations are developing a regional planning strategy for the reconstruction of Darfur including sustainable re-integration of IDPs.

Due to the destruction of social services, infrastructure and economic functions in Darfur caused by the conflict, some Localities (sub-administrative administrative units) do not have basic settlement functions to sustain livelihood. Therefore, a functional analysis of Localities in North Darfur State (one of the three states of Darfur) can provide a regional understanding of the existing functional hierarchy of Localities to support decision making in the resettlement of IDPs. Also, such an analysis can be used to identify Localities which are of low functional levels and decision can be taken to strengthen their functional levels thereby ensuring equitable regional development.

1.2. Research Problem

Settlement functions are important for the sustenance of human livelihood. Functions such as water supplies, health services, educational services and security services are basic necessities of life for human development (UNDP, UNESCO, UNFPA, UNICEF, & WHO, 1995). However, the availability of settlement functions is not only constrained by resources but other factors such as disasters. In period of disasters like flood, earthquakes and conflicts, settlement functions are destroyed resulting in livelihood deterioration and consequently impedes regional development.

Source: (USAID, 2007)

Young (2006) noted that, the abysmal livelihood situation in Darfur is partly due to the destruction and loss of settlement functions that took place during the conflict. Settlement functions such as health facilities, educational facilities, water supplies, economic functions, security services, among others were ruined. Also, the availability of public services has been further decimated as civil servants, teachers, health workers and other professionals have either been displaced or decided not to stay in Darfur. IDPs living in camps are the hardest hit of this unpleasant situation of livelihood deterioration.

One option through which durable solution can be achieved for IDPs in Darfur is by resettlement. Resettling IDPs in Localities (sub-administrative units) with important functions like water supplies, health services, primary educational services etc can help in the attainment of durable solution for IDPs, particularly in meeting the IASC (Inter-Agency Standing Committee) durable solution criteria of safety and security, and adequate standard of living (refer to section 2.2). However, as a result of the destruction of settlement functions in Darfur, some Localities do not have the basic functions to sustain the livelihood of IDPs. Therefore, as part of post-conflict reconstruction of Darfur including sustainable resettlement of IDPs, an analysis of the functional complexity and hierarchy of Localities can help planners identify Localities with a lot of functions to support decision making in the resettlement of IDPs. Furthermore, such an analysis can also help in the identification of functions that are absent in Localities and decision can be taken on their provision particularly those important to IDPs for their resettlement. The provision of functions in Localities that they are missing can also contribute enormously towards an equitable regional development of Darfur.

Over the years, various descriptive methods have been used in geographic and planning studies to analyse the functional level of places (see for example Bromley & Bromley, 1979; Carruthers, 1957; Clark University & Institute for Development Anthropology, 1988; Davies, 1966; Grove & Huszar, 1964; Magdalena, 1977; Musterd & Dieleman, 1981; Rondenelli, 1985; Spaliviero, 2004). A Matrix of Function (MoF)/scalogram method is one of such descriptive methods. The method help defines the centrality of functions (weighted values of functions) and centrality of places in a region. In the MoF method, the weighted value of a function in a region is assumed to be inversely proportional to its frequency (Rondenelli, 1985). Functions that are present everywhere get low weighted values while rare functions get high weighted values. A MoF analysis of the functional complexity and hierarchy of places in a region involves the following steps: an inventory of places (settlements/administrative units) and the functions they provide, an analysis of functional frequencies and their 'weighted values', and finally a summation of the respective 'weighted values' of functions in each place where functions are present to obtain the Centrality Indices (CIs) with which they are ordered (Rondenelli, 1985, 1997; Spaliviero, 2004).

An application of the MoF method in North Darfur can help in the identification of Localities with high functional levels to support decision making in the resettlement of IDPs. The method can also help show a quick overview of the presence or absence of functions in Localities and decision can be taken on the provision of functions which are missing in Localities for equitable regional development. Furthermore, the ordering of Localities into functional levels can help in the identification of some Localities as growth centres for investment to strengthen the linkages among Localities.

Notwithstanding the potential uses of MoF, the relevance of such a descriptive method in identifying Localities that are functionally suitable for the resettlement of IDPs might be limited because it only accounts for the presence of at least one type of a given function in a place irrespective of the total number of that function in that place. Also, in the MoF analysis, the assumption that the weighted value

of a function (i.e. its importance) is inversely proportional to its frequency resulting in scarce functions having more weights than more frequent functions might not entirely be true. A scarce function does not necessarily mean that it is of much value to society than more frequent functions. Given the objectives of stakeholders in Darfur to resettle IDPs in Localities with suitable functions, a methodology that takes into account the total number of each functional attribute in a Locality and the relative social value of functions from stakeholders' perspective can help order Localities based on stakeholders' preference.

Multicriteria Evaluation (MCE) approach for the past three decades has evolved as a value based approach to decision making. It structures and evaluates decision problems based on the decision maker's preference (Malczewski, 1999). MCE provides a logical and scientific foundation in which the values of stakeholders are integrated (Zucca, Sharifi, & Fabbri, 2008). In regional and urban planning, MCE method inter alia can help to inventorize, classify and conveniently structure available information concerning choice possibilities (Voogd, 1982). It explicitly takes into account value judgments of stakeholders particularly political priorities, and also as a means of arriving at substantial better decisions (Voogd, 1982).

MCE method is a normative tool that can be adopted to evaluate the functional suitability of Localities to better inform resettlement of IDPs in post-conflict regional planning because it allows for the identification and prioritization of stakeholders' objectives in the evaluation process compared to MoF analysis. The study therefore seeks to compare MoF and Multicriteria Evaluation methods in providing a regional understanding of the functional suitability of Localities in North Darfur State for the resettlement of IDPs. A comparison of the two methods will also allow for an examination of their differences/similarities, potentials and limitations in regional analysis of functions in periods of post-conflict reconstruction including resettlement of IDPs.

1.3. Research Objectives and Questions

The objectives of the study together with their specific/operational questions are explicitly stated in Table 1-1.

Table 1-1: Research Objectives and Questions

Main Objective: to provide a regional understanding of the functional hierarchy of Localities to support decision making in the resettlement of IDPs in North Darfur State using Matrix of Function and Multicriteria Evaluation methods

Specific Objectives	Specific/Operational Questions
	(i) Which settlement functions do stakeholders consider
	as important to IDPs?
Objective 1:	(ii) What are the frequencies of functions?
To analyse the functional levels of Localities to support	(iii) What is the weighted value of each function?
decision making in the resettlement of IDPs using Matrix of Function method.	(iv) What is the Centrality Index of each Locality?
	(v) What are the functional levels of Localities?
	(iv) What are the potentials uses and limitations of the
	MoF method in regional analysis of functions in the
	resettlement of IDPs?
	(i) Which settlement functions do stakeholders consider
	as important to IDPs?
	(ii) What is the total number of each important function
Objective 2:	to IDPs in each Locality?

To analyse the functional suitability of Localities to	(iii) What are the main broad classes of settlement			
support decision making in the resettlement of IDPs	functions?			
using Multicriteria Evaluation method.	(iv) What are the levels of importance of the main broad			
	classes of settlement functions?			
	(v) What are the levels of importance of settlement			
	functions within each broad class of function?			
	(vi) What is the functional suitability index of each			
	Locality?			
	(vii) What are the functional suitability levels of			
	Localities?			
	(viii) What are the potentials uses and limitations of the			
	MCE of functions in regional analysis of functions in the			
	resettlement of IDPs?			
	(i) What are the criteria to be considered for comparing			
Objective 3:	the two methods?			
To compare Matrix of Function and Multi-Criteria				
Evaluation of functions methods in analysing the	(1) What are the differences and/or similarities of the			
functional hierarchy of Localities to support decision	two methods based on identified criteria for			
making in the resettlement of IDPs.	comparison?			

1.4. Thesis Structure

The study is organized in six (6) chapters as follows:

Chapter 1: This chapter introduces the background and justification of the study, problem statement, research objectives and questions including an outline of the thesis structure.

Chapter 2: This chapter reviews literature on durable solution for IDPs; CPT and its assumptions of hierarchical order of places. The review also looks at methods which have been used by geographers and planners over the years in classifying places hierarchically. A detail review has been done on MoF and Multicriteria Evaluation methods which have been adapted in this study to analyse the functional suitability of Localities in North Darfur State, and finally a framework for comparing the two methods.

Chapter 3: This chapter outlines the methodology of the study. The data requirements, data sources, data collection techniques and methods of analysis for both Matrix of Function and Multicriteria Evaluation of functions are outlined.

Chapter 4: This chapter presents the results of the study in three main sections in line with the study objectives; (a) MoF analysis of the functional levels of Localities, (b) Multicriteria Evaluation of the functional suitability of Localities (c) comparison of Multicriteria Evaluation of functions and MoF methods.

Chapter 5: This chapter discusses the results of the study in line with the objectives and sub/operational questions as well as the Limitations of the study.

Chapter 6: This chapter comprises recommendations and conclusion of the study.

STATE

2. LITERATURE REVIEW

2.1. Introduction

In this chapter, literature relevant to the study has been reviewed to put the study in perspective. In Section 2.2, the term 'Internally Displaced Persons' and resettlement as used in this study have been defined. Also, the United Nations Inter-Agency Standing Committee criteria in achieving durable solutions have been outlined and criteria related to IDPs access to functions highlighted. The Central Place Theory which laid the foundation in regional analysis of places and their hierarchy based on central functions is reviewed in section 2.3. Section 2.4 looks at broad approaches used by Geographers and Planners to classify places in a region while sections 2.6 examines some methods which have been used over the years to measure the functional/service level of places. Sections 2.6 and 2.7 respectively provides a detail review on MoF and MCE methods which have been adopted in this study to analyse the functional suitability of Localities in North Darfur State. In section 2.9, a framework for comparing MoF and MCE methods has been developed.

2.2. Internally Displaced Persons and Durable Solutions

According to the Guiding Principles on Internal Displacement (United Nations, 1998, p. 1), IDPs are "persons or groups of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of generalized violence, violations of human rights or natural or human-made disasters, and who have not crossed an internationally recognized state border" This study is limited to the resettlement of conflict-induced IDPS in Darfur.

Former United Nations (UN) secretary general Kofi Annan observed that internal displacement is one of the most humanitarian challenges in recent times (United Nations, 1998). IDPs are among the most vulnerable of the human population; they suffer from various forms of deprivation, hardship and discrimination resulting in low standard of living. Although the often distressing experience of displacement cannot be averted, internally displaced persons (IDPs) need to be assisted to resume a normal life. As articulated in Principle 28 of the Guiding Principles on Internal Displacement, competent authorities are been urged to establish conditions and means which allow IDPs to return, settle elsewhere in the country or integrate locally in safety and dignity (United Nations, 1998).

According to IASC (2010, p. 5), a durable solution "is achieved when internally displaced persons no longer have any specific assistance and protection needs that are linked to their displacement and can enjoy their human rights without discrimination on account of their displacement. It can be achieved through: sustainable reintegration at the place of origin (return); sustainable local integration in areas where internally displaced persons take refuge (local integration); sustainable integration in another part of the country (settlement elsewhere in the country)". The latter two options are referred to as "resettlement" in the Guiding Principles of Displacement (United Nations, 1998). Therefore, the term resettlement as used in this study encompasses local integration of IDPs in North Darfur in areas where they seek refuge and settlement of IDPs elsewhere in North Darfur.

The IASC which involves key UN and non-UN humanitarian partners came out with 8 guiding criteria for determining the extent to which a durable solution has been achieved. These include "safety and security; adequate standard of living; access to livelihoods; restoration of housing, land and property; access to

documentation; family reunification; participation in public affairs; and access to effective remedies and justice" (IASC, 2010, p. 27).

A summary of the IASC framework on durable solutions for internally displaced persons is shown in Figure 2-1 below.



Figure 2-1: Frameworks on Durable Solution for Internally Displaced Persons. Adopted from IASC (2010)

From Figure 2-1 above, analysing the functional suitability of Localities in Darfur can support in decision making in the resettlement of IDPs in Localities with important functions particularly to IDPs towards the realization of the IASC durable solution criteria of *Safety and security* and *adequate standard of living*. The United Nations Inter-Agency Standing Committee emphasis effective protection of IDPS by national and local authorities in any effort towards achieving safety and security (IASC, 2010). In the area of adequate standard of living, the ISAC is of the view that "at a basic minimum, IDPs should have adequate access on a sustainable basis to: essential food and potable water; basic shelter and housing; essential medical services, including post-sexual assault care and other reproductive healthcare; sanitation; and at least primary school education" (IASC, 2010, pp. 31-32). Following the IASC recognition of IDPs access to some settlement functions as important in the achievement of durable solution, settlement functions stakeholders consider as important to IDPs in North Darfur State will be identified and used to assess the functional suitability of each Locality.

2.3. Hierarchy of Places and Central Place Theory

. An application of the idea of the CPT is North Darfur State will provide a regional understanding of the functional hierarchy of Localities and their 'complementary regions' (areas of influence). This will aid decision making in terms of strengthening the centrality of Localities (through the identification of growth centres and provision of functions) for equitable development. Also, the presence or absence of important functions in places will be clearly identified and decision can be taken with regards to their provision.

The spatial distribution of places in a region often exhibits a certain pattern of hierarchy. According to McCann (2001, p. 71) "regions tend to be dominated by one or two primal cities, generally located in the centre of the region. These cities are mostly the production locations of the region with smaller cities focusing on it. At the same time, smaller cities focusing on a primal city are also important cities to less populated hinterlands surrounding them".

In the field of regional planning and development, the CPT laid the foundation in the analysis of urban hierarchy based on functions. The Central Place Theory (CPT) was put forward by Walter Christaller a German geography in 1933 in his book *Die Zentralen Orte in Suddeutschland* and translated by Baskin (1966 in Chaudhuri, 2001). The theory explains the hierarchical order of central places (settlements) in terms of central functions they provide to population of surrounding areas besides its own population in a region (Mandal, 2001). Christaller called the surrounding area in which a settlement serves the 'complementary region' (Chaudhuri, 2001, p. 67).

Implicit in Christaller's CPT is the concept of *threshold* and *range* of goods or services (Chaudhuri, 2001; Mulligan, Partridge, & Carruthers, 2012). The threshold is the minimum population required to support a service activity while the range is the distance over which people will travel to purchase goods or services offer at a central place (Chaudhuri, 2001). High order central places have specialized functions with large threshold and range than low order settlements because they provide specialized functions which cannot be found in low order settlements.

The CPT is concerned with the number, size, spacing and arrangement of central places in a region (Mandal, 2001). Christaller classified central places in Southern Germany into hierarchies ranging from high order to low order by considering population and an index calculated from the number of telephone connections in a central place (Mandal, 2001). Christaller developed a series of central place hierarchies on the assumption that the area of influence of centres are arranged in a geometric pattern with higher order centres always having lower order centres nesting within them (refer to Figure 2-2 below).



Figure 2-2: Christaller hexagonal patterns of central Adopted from Centre for Spatially Integrated Social Science (2001)

Losch (1941) argues that Christaller hierarchy of settlements was rigid and restrictive (Losch 1941 in Mulligan et al., 2012). "He did not accept that there was a discontinuous hierarchy of settlements at each level instead he believed that settlements were of a continuous distribution" (Glasson, 1974, p. 134), all of which focus on the system's most central location – the largest metropolitan complex. In Losch's view, the largest metropolitan centre "is the most efficient spatial allocation of activity, and thus will arise naturally from a competitive economy" (McCann, 2001, p. 73). According to Glasson (1974, p. 134) "although both Losch and Christaller agree on many basic principles of spatial structure, Christaller's approach is purely an explanation of service element in a spatial structure, whereas that of Losch could be said to be more of an explanation of the spatial distribution of market-oriented manufacturing industry".

Ulman (1960 cited in Mandal, 2001) noted that the used of telephone connections as a measure of centrality as used by christaller will not be valid in places where telephones are non-central functions. Christaller used telephones services because of its importance at that time as business link (Davies, 1966). This goes to say that, a functional ranking of places should take into account important functions within the local context at a point in time.

2.4. Approaches in Analysing Hierarchy of Settlements in a Region

Settlements vary enormously in size, functions and organizational structure. Geographers, demographers and planners have usually used three basic approaches to analyse and classify settlements: (a) morphological classifications that attempt to determine which communities are urban or rural based on few easily observed physical characteristics as distinguishing criteria; (b) population size classifications that seek to categorize settlements into metropolitan areas, cities, towns, villages and hamlets based on the number and density of residents within their boundaries; and (c) functional classifications that attempt to distinguish among settlements on the basis of the types and diversity of functions located in them. (Rondenelli, 1985).

In this study, a functional approach has been adapted to define the existing hierarchy of Localities in North Darfur State. Due to the destruction of settlement functions caused by the war in Darfur (from 2002 - 2011), an analysis of the presence or absence of important functions in Darfur will aid in the identification of Localities that are functionally suitable to support decision making in the resettlement of IDPs and regional planning at large. It must be stated that, the analysis is morphological in nature because the functional levels of Localities and their spatial hierarchy is based on the current distinctive social and economic activities of Localities. Population approach could not be considered in this study due to the lack of complete population data for all Localities. It would have been interesting to analyse the correlation between the functional level of Localities and their population.

2.5. Methods in Measuring the Functional Levels of Settlements

Current concern on settlements redevelopment as well as recognition of regional planning rather than local planning has made the determination of the functional status of settlements not only an academic problem but increasingly a technical one (Davies, 1966). Following Walter Christaller postulation of the CPT, various methods have been devised to classify settlements into hierarchies according to their functional (service) level as discussed below.

Direct summation of functions in settlements is the simplest but crudest measure of the functional level of settlements (Davies, 1966). Clark University and Institute for Development Anthropology (1988)

employed this method to order settlements into hierarchy in Kismayo region in Somalia. Davies (1966) is of the opinion that, this technique maybe useful at the local scale but as one moves upward in the scale of urban and commercial status, functions become more increasingly differentiated. Hence, a summation of the number of functions does not provide an adequate measure of comparability as it gives equal weight to all functions (Davies, 1966).

Recognition of the differences in the value of functions has given rise to various scaling techniques where well-defined rules are used to assign numbers to objects (functions) (Musterd & Dieleman, 1981). Musterd and Dieleman (1981) noted that although most authors agree that the functional level of a settlement cannot be expressed by the mere sum total of functions present in the settlement, the procedure involve in determining the allocated values of functions is in most cases based on the subjective decision of the researcher. Scaling techniques can be broadly categorised into two - unidimensional and multidimensional methods. Unidimensional scaling techniques are grounded on the Guttmann scale which yields rank order measurements and uses a lot of items (functions). The Guttmann scaling method of determining the functional level of settlements of lower order centres (Musterd & Dieleman, 1981, p. 134). In a perfect Guttmann scale of functions in places, a higher order place is expected to have all functions of lower order place (Rondenelli, 1985) . Musterd and Dieleman (1981) employed a unidimensional Guttmann scaling technique to measure the service level of 61 centres in Noord-Brabant in the Netherlands.

Rondenelli (1985) also adopted the Guttmann scale method to measure the service level of settlements in Bicol river basin in the Philippines but in a somewhat different way as employed by Musterd and Dieleman (1981). Rondenelli (1985) used the frequency of functions to determine the weighted values of functions i.e. the weight of a function was assumed to be inversely proportional to its frequency. A sum total of the weighted values of functions in a settlement was called the Centrality Index (CI) with which settlements were ordered (refer to section 2. 6 for details review of this method). Spaliviero (2004) calls the scale methodology employed by Rondenelli (1985) for ordering settlements into hierarchical levels a Matrix of Function (MoF.

Another group of related scale analysis which show similarity to factor analysis are known as Multidimensional Scale Analyses (MSA). In MSA, scores of objects on a relatively large number of variables are reduce to scores on a much smaller number of dimensions (Musterd & Dieleman, 1981). MSA starts with an analysis of dissimilarities in coefficient of variables (functions) but not a matrix of correlation coefficient as in factor analysis (Musterd & Dieleman, 1981). Bloombaun (1968 P. 77 cited in Magdalena, 1977) describes the method as follows; "MSA is in a sense a generalization of the familiar Guttmann scale. Instead of focusing attention on the question of whether a set of items is unidimensional, MSA directs attention to the question of how many dimensions it takes to represent adequately a body of data. MSA establishes the smallest space in which points, characterized by their category scores on all the items, fall into contiguous regions". As a distance analysis, objects (cities or centres or settlements) are plotted as points in a Euclidean space where similar objects are grouped together (Magdalena, 1977). Musterd and Dieleman (1981) applied a MSA method to group 61 centres in Noord-Brabant to four clusters.

Another way of measuring the service level of settlements is through an analysis of the linkages among centres. W. Christaller in his study of the functional level of settlements in Southern Germany used telephones as business links to calculate an index to determine the functional level of settlements (Davies, 1966). Bromley and Bromley (1979) probably drawing inspiration from Christaller used origins and destinations of bus services as a basis of their analysis of the service level of settlements in Ecuador.

In this study, the Matrix of Function methodology as applied by Spaliviero (2004) and Rondenelli (1985) was adapted because it shows on a matrix chart the presence or absence of a wide diversity of functions in settlements as compared to other methods. As part of post-conflict regional planning of Darfur, a matrix chart indicating the presence or absence of functions in Localities will clearly show important functions that are missing in Localities and decision can be taken on their provision. Furthermore, the reason for the choice of MoF is due to the fact that, the study is a contribution towards UN-HABITAT/ITC project on post-conflict regional planning of Darfur where this method has been applied by a Regional Planner consultant (Giovanni Spaliviero) to the project.

2.6. Matrix of Function and Centrality Index Analysis of Places

A matrix or scalogram of functions is an array of the presence or absence of a range of functions in places (Rondenelli, 1985; Spaliviero, 2004). The method help defines the centrality of functions and places in a region. Rondenelli (1985, p. 108) indicated that "in a perfect hierarchical matrix of functions, each place would be expected to possess all functions of those places of lower order, but would not be expected to possess those functions of places ranking higher in the scale. Any deviation from the expected pattern is considered as an error, that is, if a function is present in low order place but missing in high order place". However, he further observed that due to distance and other factors, there are usually many 'unexpectedly present' and 'unexpectedly absent' functions in a settlement hierarchy. In the case of North Darfur State, the conflict that spanned from 2002 - 2011 can be a factor causing the 'unexpectedly present' and 'unexpectedly absent' of functions in localities.

The data required for constructing a scalogram as well as the steps in its construction are minimal. Rondenelli (1985) outlined the data requirements as follows; (1) a list of all places (settlements/administrative units) in the region, (2) the population of each place, (3) a digital map showing the location of places and (4) an inventory showing the presence or absence of functions. The procedures involved in constructing a scalogram as provided by Rondenelli (1985, p. 115) include the following;

- 1. On the left side of a worksheet, list places as rows in descending order of their population;
- 2. Across the top of the worksheet, list the functions found in the region in their descending order of ubiquity (frequency of presence);
- 3. Draw row and column lines so that the worksheet becomes a matrix in which each cell represents a function that may appear in the place;
- 4. Fill in with a dark color, an "X", or a "I" all cells in which a function is actually found in a place, leave cells for which a function does not appear in a place blank, or fill in a "O";
- 5. Reorder the rows and columns so as to visually minimize the blank cells appearing in the dark pattern found in the upper left section of the matrix, or in decreasing order of presence of functions;
- 6. The scalogram is complete when no shifting of places (rows) or functions (column) can reduce the number of blank cells in this pattern;
- 7. The final order of places (rows) identifies a ranking of places which can be interpreted as an ordinal centrality score.

Some potential uses of scalogram analysis in regional planning as outlined by Rondenelli (1985, p. 117) include the following:

1. It can be used to categorize places into levels of functional complexity and determine the types arid diversity of services and facilities located in central places at various levels of a hierarchy;

- 2. The scalogram shows rough associations among services and facilities in specific locations and potential linkages among them;
- 3. The scalogram indicates the sequence in which places accumulate functions and the implications for sequencing complementary or catalytically investments;
- 4. By reading any column the ubiquity of a service or facility, and its distribution among places, can be easily seen:
- 5. The array of functions in the scalogram, analyzed in conjunction with a map showing locations of functions and their distribution and with population-service criteria, can be used to make determinations about the adequacy of services and facilities in the region:
- 6. "Missing" or unexpectedly absent functions are clearly identified and investigations can be made to found out why places at a certain level do not have some services or facilities, and decisions can be taken about the appropriateness of investing in those functions;
- 7. Unexpectedly present functions are also identified, and the reason for the appearance of services and facilities in those places can be determined:
- 8. Rough indicators of population threshold size needed to support various services and facilities can be determined from scalogram that show the population sizes of places in which functions currently appear: and,
- 9. The scalogram can be used to make decisions about appropriate "packages" of investments for places at different levels in the spatial hierarchy.

A scalogram is a relatively easy way of examining both the functional complexity of places and the distribution of functions among places in a region. However, in terms of classifying places into levels, a summation of the different types of functions present in each place does not provide an adequate measure of comparability because functions are of different levels (Davies, 1966). Musterd and Dieleman (1981, p. 132) observed that "almost all authors agree that the functions in the various sectors are not of the same value and that the functional level of a place cannot be expressed by the mere sum total of all functions in that place, how the methods involve in determining the importance of functions varies".

Rondenelli (1985) and Spaliviero (2004) carried out a scale analysis of the functional diversity of places together with what they called 'weighted value of function' and 'Centrality Index' with which places are classified into levels. The Centrality Index measures the functional level of a place in terms of not only the number of functions in a place, but also their frequency of occurrence. The weight of a function which measures its centrality is assumed to be inversely proportional to the frequency with which functions occur (Rondenelli, 1985). The centrality index of a place is therefore a sum of the weights of functions for all functions present in that place. The procedure involve in calculating the Centrality Index of a place as outlined by Rondenelli (1985, p. 126) include the following;

- 1. In the matrix showing the presence or absence of functions in places, total functions by rows and columns;
- 2. Using the assumption that the total number of functional attributes in the entire system has a combined centrality value of 100, determine the weight or "location coefficient" of the functional attribute by applying the formula:
 - C = t/T

Eq. (1)

Where C= the 'weighted value' of functional attribute t. t= combined centrality value of 100 and T= total number of attributes in the system" (refer to sample analysis in Table 2-1)

- 3. Add one block to the table and enter the weights computed;
- 4. Reproduce another table similar to that in step "1" displaying the weights calculated in step "3".

5. Sum the weights of each row to produce the centrality indices (refer to sample analysis in Table 2-2)

Table 2-1 and Table 2-2 respectively show sample analysis of weight of functions and centrality index whilst Figure 2-3 shows a sample of a Matrix of Functions/scalogram analysis of settlements by Spaliviero (2004) in the Kolda region of Senegal.

Table 2-1: Calculating Weight of Functions

					Fund	ctions	3				
Places	1	2	3	4	5	6	7	8	9	10	<u>Total</u>
	1	1	1	1	1	1	1	1	1	1	10
B	1	î	î	î	î	î	î	ō	î	ō	10
č	î	î	î	î	î	î	ô	ŏ	ô	ŏ	ĕ
Ď	î	î	î	î	î	î	ŏ	ĩ	ŏ	ŏ	7
Ē	ĩ	ĩ	ĩ	ĩ	ĩ	õ	ŏ	õ	ŏ	ŏ	5
F	· ĩ	ĩ	ĩ	ĩ	õ	ŏ	ŏ	ŏ	ŏ	ŏ	4
Ğ	ĩ	1	ĩ	õ	0	Õ	Õ	Õ	Õ	Ő	3
Н	1	1	1	0	0	0	0	0	0	0	3
Total		_									
Function	ns 8	8	8	6	5	4	2	2	2	1	46
Total Central	-										
ity	100	100	100	100	100	100	100	100	100	100	
Weights	12.5	12.5	12.5	16.6	20.0	25.0	50.0	50.0	50.0	100.0	

Adopted from Rondenelli (1985, p. 126)

Table 2-2: Calculating Centrality Indexes

Functions											
Places	1	2	3	4	5	6		8	9	10	Total
Α	12.5	12.5	12.5	16.6	20.0	25.0	50.0	50.0	50.0	100.0	349.1
в	12.5	12.5	12.5	16.6	20.0	25.0	50.0		50.0		199.1
C	12.5	12.5	12.5	16.6	20.0	25.0					99.1
D	12.5	12.5	12.5	16.6	20.0	25.0				· · ·	149.1
E	12.5	12.5	12.5	16.6	20.0	25.0		50.0			74.1
F	12.5	12.5	12.5	16.6	20.0						54.1
Ğ	12.5	12.5	12.5	16.6							37.5
H	12.5	12.5	12.5								37.5

Adopted from Rondenelli (1985, p. 126)

A Scalogram analysis of Localities in North Darfur will provide a regional understanding of the functional hierarchy of Localities for regional planning including resettlement of IDPs. Such an analysis will inform decision makers on the relative functional level of localities, and decision can be made to improve the functional level of localities with the provision of services. Also, functions missing in settlements can be clearly identified and investigation can be made on why they do not exist.

Notwithstanding the importance of scalogram analysis in regional planning, the method does not take into account the total number of a given type of function in a place. Also, in the scalogram analysis, the assumption that the weight of a function is inversely proportional to its frequency resulting in scarce functions having more weights than more frequent functions might not entirely be true. A scarce function does not necessarily mean that it is of much value to society than more frequent functions.



Figure 2-3: Example of a scalogram analysis of the functional complexity and hierarchy of settlements

Adopted from Spaliviero (2004)

2.7. Multicriteria Evaluation

Multicriteria Decision Analysis (MCDA) is increasingly becoming important in the evaluation of choice possibilities (Malczewski, 2006). MCDA provides a rich collection of techniques and procedures for structuring decision problems and prioritizing alternatives based on the decision makers' preference (Malczewski, 1999). Multicriteria evaluation method can be used to inventorize, classify, analyze and conveniently arrange available information concerning choice possibilities in urban and regional planning (Voogd, 1982). These choice possibilities can be alternative plans or strategies, administrative zones or regions, potential residential areas, urban renewal neighbourhoods and so forth.

Multicriteria decision making (MCDM) may be considered as "a complex and dynamic process including one managerial level and one engineering level" (Duckstein & Opricovic, 1980, p. 14). "The managerial

level defines the goals, and chooses the final optimal alternative whereas the engineering level defines the alternatives, points out the consequences of choosing any one of them from the stand point of various criteria and performs the multi-criteria ranking of alternatives. Decision makers, who provide the preference structure at the managerial level are "off line" from the optimization procedure done at the engineering level. Very often, the preference structure is based on political rather than on technical criteria. At the managerial level, decision-makers have the power to accept or reject the solution proposed by the engineering level" (Opricovic & Tzeng, 2004, p. 145). Figure 2 below shows the main steps of MCDM as outlined by Opricovic and Tzeng (2004):

Figure 2-4: Main steps of MCDA



Source : (Opricovic & Tzeng, 2004)

The MCDA steps as outlined above are iterative in nature. According to Opricovic and Tzeng (2004, p. 446), "steps (1) and (5) are performed at the upper level, where decision makers have the central role, and the other steps are mostly engineering tasks. For step (4), a decision maker should express his/her preferences in terms of the relative importance of criteria, and one approach is to introduce criteria weights. The use of weights in MCDM process help model the actual aspects of decision making (i.e. the preference structure)".

Malczewski (1999, p. 82) identified six elements associated with Multicriteria Decision Analysis: "(1) a goal or a set of goals the decision maker (interest group) attempts to achieve; (2) the decision maker or group of decision makers involved in the decision-making process along with their preferences with respect to evaluation criteria; (3) a set of evaluation criteria (objectives and/ or attributes) on the basis of which the decision makers evaluate alternative courses of action; (4) the set of alternatives, that is, the decision or action variables: (5) a set of uncontrollable variables or states of nature (decision environment); and (6) the set of outcomes or consequences associated with each alternative". In this study, the goal of the evaluation is to assess the functionally suitability levels of Localities to support decision making in the resettlement of IDPs in North Darfur State. 17 Localities in North Darfur State were considered as alternatives and 36 identified important functions as the evaluation criteria. Decision makers whose

opinions were sorted in the identification of important functions and the relative importance of functions for the evaluation structuring and analysis include IDPs, planners and experts in North Darfur State.

Voogd (1982) catalogued the positive characteristics of MCE in urban and regional planning as follows; (a) MCE as a means to arrive at a surveyable classification of factual information (b) MCE as a means to get better insight into various value judgments of the problem at hand (c) MCE as a means to incorporate differences in interest and/or political views in an analytical research framework (d) MCE as a means to give more substance to the notion of openness of a planning process (e) MCE as a means to arrive at a reduction of available information (f) MCE as a means to arrive at a substantially better considered decisions (g) MCE as a means of arriving at a better position of the expert in a planning process h) a means to account for or justify policy decisions and finally (i) MCE as a means to structure research contributions in a planning process.

A Multicriteria Evaluation of functions at Locality level in North Darfur state can help aggregate the total number of each functional attribute in a Locality in relation to their relative importance to IDPs in the identification of functional suitability areas to support decision making in the resettlement of IDPs. Such an analysis can also show the partial attractiveness of Localities in various functional categories such as security, health, education etc. Moreover, functions which are of much value to IDPs from stakeholder's point of view can be clearly identified and decision taken on their provision in Localities where IDPs may be located but such important functions do not exist.

2.8. Framework for Comparison of Methods

The aim of this section is to review existing literature on comparison of methods in order to develop a framework for comparing the Matrix of Functions and Multicriteria Evaluation methods as employed in this study. The literature search was limited to comparison of methods in regional analysis of the functional/service level of places and or Multicriteria Decision Making (MCDM) methods because the methods applied in this study are related to those fields.

According to Kaschek and Mayr (1998, p. 13) a method is "a systematic goal driven procedure for gaining knowledge or practical results". This definition is compatible with the Marriam-Webster online dictionary definition of method as a way, technique or process of or for doing something (Merriam-Webster, 2012). Comparison of methods is a fundamental tool of analysis that help bring into focus suggestive similarities and contrast among methods (Collier, 1993). Whereas computer scientists try to develop general (theoretical) framework for comparing methods (see for example Song & Osterweil, 1992), development practitioners and senior managers compare methods by judging situations from prior experiences and case studies.

Scientific literature on comparison of methods in regional analysis of functions could not be found although a variety of methods have been devised by Geographers and Planners over the years (as reviewed in section 2.5). Please refer to Appendix E for an example of the search strategy implemented in Web of Science database. Three hits were obtained but not of relevance.

In the field of Multi-attribute Decision Making (MADM), various studies have been conducted to compare and evaluate methods using a variety of criteria for experimental design (Mahmoud & Garcia, 2000). Comparison of results of different methodologies when applied to the same decision problem is the simple and easily used criterion in comparing methods (see for exampleDuckstein & Opricovic, 1980). Duckstein, Gershon, and McAniff (1982) in their study on Tucson river basin planning compared three

different MADM methods (i.e. ELECTRE, compromise programming and Multiattribute Utility Theory) in relation to six criteria. These include; (1) type of data required (i.e., qualitative of quantitative), (2) nature of alternative system which can be analysed (i.e. whether or not they can be classified as discrete or continuous); (3) consistency of results between methodologies (i.e., whether methods yield the same ranking); (4) robustness of results with respect to changes in parameter values; (5) ease of computation; and (6) the amount of interaction required between the decision maker and system analyst. Duckstein et al concluded their study with the recommendation that more criteria can be added in the comparison of methods. These criteria used by Duckstein et al. (1982) to compare MADM methods were adapted as part of the framework developed to compare MoF and MCE methods in analysing the functional suitability of Localities in post-conflict North Darfur State (Figure 2-5).







3. METHODOLOGY

3.1. Introduction

Darfur is located in the westernmost part of Sudan, bordering Chad to the West. It's roughly 500,000 square kilometres with a population of 6,978,220 in 2008 (Sudan Central Bureau of Statistics, 2008). The region stretches from un-inhabited desert areas in the north, to the Sahel semi-arid area in the centre, and a more fertile savannah landscape in the south (Olsson, 2010). Administratively, Darfur is currently divided into five states (North, South, East, West and Central Darfur States) with each state sub-divided into small administrative units known as *Localities*.

The Darfur region of Sudan since 2003 has suffered from armed conflict until 2011 when a peace agreement was reached. The conflict has caused massive deaths, destruction of villages, services and infrastructure, displacements and disruption of livelihoods activities. Between 2003 and 2009, it is estimated that 300,000 people have been killed and 2.7million people displaced (Olsson, 2010). Following the signing of the Doha Document for Peace in Darfur (DDPD), in 2011, the United Nations together with the Sudanese government and Civil Society Organizations (CSOs) are developing a regional planning strategy for recovery and reconstruction of Darfur including resettlement of IDPs. It is in this regard that UN-HABITAT and ITC over the past year have been carrying out a regional analysis of settlements in Darfur to support decision making in the resettlement of IDPs and regional planning at large. This research is therefore a contribution to the UN-HABIATA/ITC project in Darfur.

The study employs Matrix of Function (MoF) and Multicriteria Evaluation (MCE) methods to provide a regional understanding of the functional hierarchy of Localities suitability to support decision making in the resettlement of IDPs in North Darfur State. The application of the two methods in this study will enable us compare the two methods in order to understand their differences and similarities, and most importantly, examine their potentials and limitations in analysing the functional suitability of Localities to supporting decision making in the resettlement of IDPs. Figure 3-1 below shows a general overview of the main operational processes of the study.





Figure 3-1: Methodology of the study

Before implementing the main processes of the MoF and Multicriteria evaluation methods, a cross section of functions considered as important to IDPs were identified from stakeholders' point of view and used for both MoF and MCE analysis. Functions were limited to 36 for the purpose of easy data processing particularly in the MCE method where stakeholders were required to prioritise functions according to their importance to IDPs. Sections 3.2.2 and 3.3 give a detail methodological description on the selection of functions.

The MoF method of analysing the functional hierarchy of settlements or administrative units as presented by Rondenelli (1985) and Spaliviero (2004) as reviewed in section 2.6 was adopted in this study. The major operational steps in the Matrix of Function analysis are as follows: an identification of the presence or absence of the 36 selected functions in each Locality; an analysis of the frequency and weight of functions; analysis of the Centrality Indexes (CIs) of Localities, and finally classification of Localities into

functional levels. A detail outline of the MoF operational steps to be implement in this study are presented in section 3.4.1

Multicriteria Evaluation of functions was carried out using SMCE (Spatial Multicriteria Evaluation) application module in ILWIS (Integrated Land and Water Information System) in order to aggregate the total number of a given type of function in each Locality in relation to stakeholders' preferences. The main processes involve in the Multicriteria Evaluation of functions include the following; an identification of the total number of each given type of function in each Locality; evaluation structuring of Localities as alternatives and functions as factors in ILWIS; standardization and weighting of factors (functions); aggregation of functions to obtain functional suitability indices of Localities and finally, classification of Localities into levels by their Functional Suitability Index. A natural jenks classification method was applied so that boundaries are set where there are large differences in the functional suitability indices.

After implementing the MoF and Multicriteria Evaluation methods, the two methods have been compared in order to bring out their similarities and or difference as well as weaknesses and strengths. As shown in Figure 3-1, the two methods were compared with regards to seven criteria: (1) nature of alternative systems being analysed, (2) data requirements, (3) ease of computation, (4) amount of interaction between system analyst and the decision maker (5) weighted values/importance of functions, (6) consistency of results and (7) robustness of results to changes in parameter values. With the exception of criterion 5, the other six (6) criteria were adapted from (Duckstein et al., 1982).

A detail outline of data collection techniques (section 3.2), data preparation (section 3.3) and methods of data analysis (section 3.4) are presented below.

3.2. Data Collection Techniques

Fieldwork data collection took place in Khartoum from $6^{th} - 21^{st}$ October, 2012 although the study area is Darfur due to security reasons and difficulty of foreigners in accessing domestic visa to Darfur. Data intended to be gathered during fieldwork for the study include: (1) spatial data of Localities boundary, administrative headquarters and other principal settlements in Darfur (2) inventory of the presence or absence of functions including the total number of each function in an administrative centre or principal settlement (3) population of administrative headquarters and other principal towns (5) identification of 40 important functions to IDPs and (6) stakeholders opinion on the importance(weights) of broad classes of functions and functions within each broad class to IDPs. UN-HABITAT agency in Sudan was my first point of contact for assistance and direction to appropriate organizations for required data.

During the first week of fieldwork, data was elicited from stakeholders from Darfur and Khartoum States who were participating in a workshop organized by UN-HABITAT/ITC on Spatial Decision Support Systems (SDSS) for regional settlement analysis in Darfur. Table 3-1 contains the list of trainees at the workshop. Data generated during this workshop include; (1) thirty-six (36) functions identified by stakeholders as important to IDPs (2) weights of broad classes of functions and functions within each broad class and (3) stakeholders opinion on the strengths, weaknesses and opportunities of MoF and MCE methods in regional settlement analysis and planning at large. Questionnaire and Focus Group Discussion (FGD) were the two basic primary data collection instruments used to gather data from stakeholders (as outline in section 3.2.2).

S/N	Title/position	Organization
1	Town Planner	Ministry of Physical Planning and Public Utilities, North Darfur
2	Town planner	Ministry of Physical Planning and Public Utilities, North Darfur
3	Housing administrator	Ministry of Physical Planning and Public Utilities, South Darfur
4	Town Planner	Ministry of Physical Planning and Public Utilities, South Darfur
5	Town Planner	Ministry of Physical Planning and Public Utilities, West Darfur
6	Town Planner	Ministry of Physical Planning and Public Utilities, West Darfur
7	Human Settlement Director	Ministry of Environment and Physical Development, Khartoum
8	Urban Planner	Ministry of Environment and Physical Development, Khartoum
9	Urban Planner Consultant	Khartoum, Sudan
10	Regional Planner of Darfur	UN-HABITAT, Sudan

Table 3-1: Stakeholders from which primary data was collected from

Secondary data gathered during field work include: inventory of functions absence or presence including the total number of a given function in each Locality in North Darfur State, inventory of functions presence or absence for South Darfur Localities, population of Localities based on old Localities boundary and spatial data of new Darfur State boundaries, new Localities boundaries and settlements as at August, 2012 (Table 3-2).

Data on the presence or absence of functions including the total number of a given type of function in each settlement could not be obtained but rather at Locality level (administrative unit). Even at the locality level, data could not be obtained for West, East and Central Darfur States. In North Darfur State, data was obtained on the presence or absence of functions in each locality as well as the total number of a given type of function whereas in South Darfur State, data was only obtained on the presence or absence of functions. The study is therefore limited to North Darfur State because data needed for the MCE analysis (that is, total number of a given type of function in each locality) could only be accessed in that State.

3.2.1. Secondary Data

Secondary data used in the study include; administrative boundary of North Darfur Sate Localities (spatial data from UNDP), North Darfur State Localities headquarters (spatial data from OCHA), inventory of settlement functions in Localities (from UN-Habitat) and population of Localities in North Darfur Sate (from Sudan Central Bureau of Statistics, 2008). Table 3-2 below shows detail of data format, source and reference year.

Data	Format	Source	Year	
Inventory of functions presence or absence including total				
number of a given type of function in North Darfur State	PDF	UN-Habitat, Sudan	2012	
localities				
Administrative boundary of North Darfur State Localities (spatial	CIS	UNDP Sudep	2012	
data)	015	UNDF, Sudali	2012	
North Darfur Sate Localities Headquarters (spatial data)	GIS	OCHA, Sudan	2011	
Population of Localities in North Darfur State		Sudan Central	2008	
		Bureau of Statistics		

Table 3-2: Secondary data, format and source

It needs to be mentioned that data on the presence or absence of functions in Localities were collected by UN-HABITAT agency in Sudan through a direct survey in the months of August and September, 2012. They developed a checklist consisting of 87 different types of functions that they believe exist in Darfur (refer to Appendix G). These broadly include health services, educational services, judiciary services, commercial establishments, public utilities and facilities, transportation services, recreational facilities, government extension services, professional services and personal services.

3.2.2. Primary Data collection Methods

Primary data collection methods employed to elicit data include questionnaire and Focus Group Discussion (FGD). Questionnaire was used as a first step in eliciting stakeholders' opinions on settlement functions they consider as important to IDPs. The rationale behind this exercise was to select a manageable number of functions for easy data processing, particularly in the MCE analysis where functions were prioritized. Ten (10) stakeholders (as listed in Table 3-1) responded to the questionnaire as shown in appendix B. The questionnaires were made up of two parts. In part one, each stakeholder was asked to select about 30-40 functions among a list of settlement functions they consider as important to IDPs. Appendix C shows a frequency distribution of the number of stakeholders who think that a particular function is important to IDPs. Part two of the questionnaire involves stakeholders ranking of broad classes of functions according to their level of importance to IDPs as well as functions within each broad class. Questionnaire was used because it is less time consuming and also allows each stakeholder to express his or her opinion.

Additionally, a three member FGD was also organized to discuss stakeholders' opinions on functions they consider as important to IDPs. This method was employed in order to have stakeholders reach an agreement on the first 40 important functions to IDPs. The three individuals selected for the FGD are professional Planners with much insight on the needs and aspirations of IDPs in Darfur region. They include an Urban Planner Consultant of UN-Habitat, UN-Habitat Regional Planner of Darfur Region and the Town Planner of North Darfur State.

A frequency distribution showing the number of stakeholders who think that a particular function is important to IDPs (as shown in appendix C) which was obtained during the questionnaire phase was presented to the three professional planners. They were then asked whether they think some of the functions which are not within the first 40 important functions during the questionnaire phase could be substituted for some of the functions within the first 40. Some functions which are not within the first 40 important functions which are not within the first 40 important functions which are not within the first 40 important functions which are not within the first 40 important functions which are not within the first 40 important functions which are not within the first 40 important functions which are not within the first 40 important functions which are not within the first 40 important functions during the questionnaire phase but mentioned as important during the FGD include grinding mills, Blacksmiths and adult-literacy centres. However, they could not be considered in the study due to lack of data on their presence or absence in the various Localities.

Furthermore, in the course of the UN-HABITAT/ITC stakeholder workshop on SDSS for regional settlement analysis, a FGD was held with stakeholders (participant trainees) to gather data on the strength weaknesses, opportunities and threats of MoF and Multicriteria Evaluation methods in regional analysis of functions and planning. Stakeholders were divided into two groups of five in order to make the discussion interactive and effective. During each session, a sample of MoF and Multicriteria evaluation of functions were presented to stakeholders and questions asked regarding the strengths, weaknesses, opportunities and threats of the two methods in regional settlement analysis and planning. Participants evaluation of MoF was quiet impressive than MCE because they have had training on it in Darfur by a Planner consultant of UN-Habitat. With regards to MCE, participants seem not to have a full grasp of the techniques for

effective evaluation since most of them were introduced to the method just two days before the FGD. Instead of evaluating the method in terms of its applicability in supporting decision making, participants were seeking for further clarification on standardization and weighting methods.

3.2.3. Limitations of Data Collection

The opinion of IDPs and or their leaders could not be seek in the identification of important functions to IDPs as well as in the prioritization of functions because they were not part of the workshop organized by UN-Habitat in Khartoum where primary data was collected for the study. Also, due to insecurity and difficulty of foreigners in accessing domestic visa to Darfur, fieldwork could not be done in Darfur for easy access to and consultation with IDPs. The inclusion of IDPs would have been beneficial for the research in identifying and prioritizing functions important to IDPs. Guiding principle 28 on internal displacement calls for the inclusion of IDPs in the planning and management of their return or resettlement (United Nations, 1998). Although IDPs could not be consulted in the identification of important functions for their resettlement as well as in the weighting of functions, stakeholders from Government ministries and UN-Habitat who were consulted have in-depth knowledge on the needs and aspirations of IDPs due to their frequent interaction with them.

Data on the presence or absence of functions including the total number of a given type of function in each settlement could not be obtained but rather at Locality level (sub-administrative unit). Even at the Locality level, data could not be obtained for West, East and Central Darfur States. In north Darfur State, data was obtained on the presence or absence of functions as well as the total number of a given type of function in each Locality except a pastoral Locality called Alwaha which has no clearly defined boundary. Alwaha has no clearly defined boundary because grazing route crosses other Localities. In south Darfur State, data was only obtained on the presence or absence of functions. The study is therefore limited to North Darfur State because data needed for the MCE analysis (that is, total number of a given type of function in each locality) could only be accessed in that State.

Furthermore, inventory of function data received from UN-HABITAT could not be validated on the ground since fieldwork took place in Khartoum instead of Darfur due to insecurity and difficulty of foreigners in accessing domestic visa to Darfur. It would have been appropriate to do a ground check of some sampled functions.

Moreover, population data could not be obtained for all Localities in North Darfur State based on current administrative divisions. The number of Localities in North Darfur State was increased from 13 to 18 in 2011. Since the current administrative division, there has not been complete enumeration of population in the Localities. Due to the absence of complete population data, the total number of each type of function in a Locality could not be related to the population within that administrative unit in the MCE analysis. Absolute number of functions in Localities were used to assume that the higher the number of a particular type of function in a Locality, the better it is.

Also, due to time constrain, not all stakeholders could take part in the FGD where a frequency distribution of the number of stakeholders who think that a particular function is important to IDPs was presented for a thorough review. The discussion on whether some functions within the first 40 important functions as obtained during the questionnaire phase could be substituted with other functions was limited to the subjective opinion of only three stakeholders.
3.3. Data Preparation

In this study, data preparation basically include; consistency check on inventory of function data, preparation of a table with the total number of each functional attribute in each locality and also preparation of spatial data into ILWIS for the Multicriteria Evaluation of functions as well as in the preparation Isopleth map.

Consistency checks carried out on the inventory of functions data sourced from UN-HABITAT are as follows;

- During fieldwork in Khartoum, the MoF inventory checklist sheet designed by UN-HABITAT (Appendix G) was shown to stakeholders for confirmation of the existence of functions listed in the inventory sheet. It was found out that *National Guard, national grain authority office and statutory courts* on the Matrix of function inventory sheet do not exist in Darfur although some respondents indicated that they are present in their Localities. These functions were therefore not considered in the study;
- Also as part of consistency checks on MoF data received from UN-HABITAT, Planners from North Darfur State were given two inventory sheets to indicate the presence or absence of functions in El-Fasher and El Tina Localities. The data provided by the planners on the presence or absence of functions in El-Fasher and El Tina Localities were in consistent with that received from UN-HABITAT. This was done during a workshop organized by UN-HABITAT/ITC on Spatial Decision Support Systems (SDSS) for regional settlement analysis in Darfur region for Planners in Darfur.
- Horse-drawn carriages and groceries could not also be considered in the study because data on total number of these functions in each Locality could not be obtained;
- It was also observed that, *Spare-parts shops* did not appear in all the inventory sheets, therefore it was also not considered in the study.

At the end of the consistency checks on inventory of function data, thirty-six (36) functions out of the first 40 important functions to IDPs per the frequency distribution of stakeholders' opinions were used in the study (Table 3-3). *National Guards* and *Statutory Courts* although among the first 40 functions do not exist in North Darfur State whilst required data for the MCE analysis could not be obtained for *Horse-drawn Carriages* and *Groceries*. In both MoF and MCE analysis, the same functions were used for the purpose of comparison of results.

Also, before data analysis, all spatial data were initially stored in ArcGIS geo-database to maintain consistency in their coordinates. Data (which include North Darfur Localities boundaries and North Darfur Localities Headquarters) was exported as Shapefiles and subsequently imported into ILWIS. Furthermore, an attribute table was prepared in ILWIS with the total number of a given type of settlement function in each locality for the 36 important functions used in the study. This attribute table was then linked to *North Darfur localities boundary map (raster)* for the MCE analysis.

Data on the total number of a given type of settlement function in each Locality was derived from the inventory of functions sheets sourced from UN-HABIAT. Table 3-4 shows a list of the thirty-six (36) functions used in the study and the total number of each function in each Locality.

Broad category	Functions
	Army camps
Society company	Police stations
Security services	Prison service
	Customs office
	Customary courts
Judiciary functions	Court of appeal
	Special criminal courts
	Kindergarten/nursery school
Educational functions	Primary school
Educational functions	Secondary school
	Vocational/technical School
	Government regional hospitals
	Rural hospitals/health centres
	Private hospital with surgical capacity
Health facilities/services	Doctors
	General registered nurses
	Midwives
	Pharmacies
	Established grain stores
	Banks
Commercial establishments	Manufacturing industry
Commercial establishments	Animal market
	Crop market
	Animal and crop market
	Radio station
	TV station
Dublic utilities /facilities	Mobile phone repeaters
Fubic utilities/facilities	Water supply company
	Potable water supply source
	Electricity company
Transportation functions	Bus terminals
Transportation functions	Petrol station
	Local government office
Covernment extension convince	Agricultural office
Government extension services	Animal health office
	Welfare service

Table 3-3: List of thirty-six (36) functions used for both Matrix of Function analysis and Multicriteria Evaluation of functions

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Ī	Radio Station	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ī	Water Supply Company	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Ī	Varuhacturing Industry	0	21	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0
Ī	Pharmacies	0	15	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ī	Electricity Company	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Ī	Special Criminal Courts	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Ī	Vocational Schools	0	3	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0
ľ	Animal and Crop Market	2	0	0	0	0	0	0	0	0	0	0	4	0	0	0	5	0
ľ	Welfare Service	0	12	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0
ľ	Custom Office	0	3	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1
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ľ	Banks	0	10	0	0	0	1	0	3	0	1	0	2	1	0	2	0	0
S	Established Grain Stores	0	1	0	0	0	1	1	1	0	1	1	4	1	1	0	0	0
ION	Petrol Station	0	10	0	1	0	2	0	1	0	0	1	1	3	0	1	2	0
VCT	Agricultural Office	0	3	0	1	1	1	1	1	1	1	1	1	1	0	1	0	0
FG	Bus Terminal	3	10	2	1	1	0	0	1	0	1	1	2	1	1	0	1	0
ľ	Registered Nurses	2	149	0	1	0	1	7	2	2	18	8	11	0	Ŋ	Ŋ	0	0
ŀ	Doctors	1	76	1	1	-	1	0	2	1	2	2	2	1	0	0	1	0
ŀ	Crop Market	2	3	1	0	-	1	0	1	1	1	0	7	1	9	2	2	1
ŀ	Mobile Phone Repeater	2	3	3	2	1	2	0	3	2	3	3	2	3	0	3	1	0
ľ	Animal Health Office	3	Ŋ	1	1	4	1	3	1	1	1	1	1	6	0	2	0	1
ľ	Primary Schools	43	249	30	52	52	32	28	28	40	120	56	37	91	49	51	20	\sim
ŀ	Kindergarten/Nursery Schools	6	206 2	17	24	8	37	24	26	11	34	62	16	65	12	55	40	0
ŀ	Animal Market	0	3.2	1	1	4	1	3	1	1	1	1	3	3	4	2	2	с
Ī	Rural hospitals/Health Station	12	18	25	19	Ŋ	3	9	27	16	21	4	4	25	4	11	19	1
ŀ	Secondary Schools	9	48	2	3	3	4	2	7	10	10	7	3	10	0	8	6	2
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ŀ	Customary courts	1	2	1	1	4	1	3	1	1	1	1	4	2	1	1	1	1
ŀ	Local Gov't Office	1	1	1	1	-	1	1	1	1	1	1	1	1	1	1	1	1
ŀ	Potable Water Sources	19	91	4	22	60	27	41	52	66	17	99	56	35	19	20	3	С
ŀ	Police Station	2 1	3 5	2	2	-	2	1	1	6	1	2 1	3	4	0	5	3	1
ŀ	Army Camp	2	1	1	1	1	1	3	1	1	1	1	1	2	1	2	2	З
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Table 3-4: Total number of each important function to IDPs in each Locality

3.4. Data Analysis

The MoF and Multicriteria Evaluation methods were implemented separately to come out with the functional hierarchy of Localities suitability in North Darfur State. In the MoF method, the presence of functions were analysed to obtain the weight of functions and centrality indices of Localities. Localities were manually classified into 5 functional levels based on their centrality indices and the presence of key central functions. In the Multicriteria Evaluation of functions, the total numbers of each function in a Locality were aggregated in relation to stakeholders' prioritization of functions to obtain the functional suitability index of Localities. A natural jenks classification method in ArcGIS was used to classify Localities into 5 functional levels by their functional suitability indices. A detail outline of the MoF and MCE of functions operational techniques are presented in sections 3.4.1 and 3.4.2 respectively.

After implementing the MoF and Multicriteria Evaluation methods, the two methods were compared and discussed based on seven criteria in order to bring out their similarities and differences (refer to Figure 2-5 for framework designed to compare the two methods). Also, the potentials and limitations of each method in supporting decision making with regards to the resettlement of IDPs have been discussed.

3.4.1. Matrix of Function Analysis

The MoF operational steps as provided by Rondinelli (1985) and reviewed in section 2.6 was adapted in this study. MoF analysis was done in an excel worksheet for easy computation. The steps followed in this study include; identification of a cross section of functions stakeholders consider as important to IDPs; identification of the presence/absence of functions in each Locality; structuring of Localities and functions in rows and columns in an excel worksheet respectively; black and white colours used to represent function present and absent in each cell respectively; analyse functions frequency and 'weighted values'; analyse centrality indexes of Localities; and finally classification of Localities into hierarchical levels (as shown in Figure 3-2)

Figure 3-2: Steps in Matrix of Function analysis



In step 1, thirty-six (36) functions considered as important to IDPs were identified and used in the study (Table 3-3). As indicated earlier in section 3.1, the number of functions was limited to thirty-six for easy processing of data. In step 2, data on the presence or absence of functions (i.e. for the 36 identified important functions) were obtained from the inventory of functions sheets sourced from UN-HABITAT before moving to step 3 and 4. In step 5, weighted values of functions were analysed (refer to Eq. 1 in section 2.6 for formula). In step 6, the Centrality Indices of Localities were obtained by adding the weighted values of functions for all functions present in a particular Locality. In step 7, Localities were manually classified into 5 functional levels by their Centrality Indices and or the presence of certain functions.

The hierarchical functional levels of Localities were used to prepare an isopleth map to show the areas of influence of Localities centres (headquarters) based on the idea of the CPT that settlements are always arranged in a hierarchical order with low central places surrounding high central places. Isopleth is a geography term which means a line connecting points of equal height. However, in the context of this study, the isopleth depicts the functional levels of Localities centres in North Darfur State. Although isopleth map is best suited for functional analysis at settlement level, the used of Localities headquarter as centroids for the preparation of isopleth maps was based on the assumption that, the headquarter of a Locality has most if not all of the functional levels of places for a clear explanation of their areas of influence was acquired from Giovanni, a regional planner expert, whose knowledge on Matrix of Function and regional planning at large was of enormous benefit in the implementation of the MoF method in this study.

3.4.2. Multicriteria Evaluation of Functions

Multicriteria Evaluation technique was also employed to assess the functional suitability of Localities to support decision making in the resettlement of IDPs. SMCE module in ILWIS was used for the MCE analysis in order to aggregate the total number of each functional type in each Locality in relation to stakeholders' prioritization of functions. The process involve in the MCE analysis of functions is depicted in Figure 3-3 below.

In step 1, thirty-six (36) functions considered as important to IDPs were identified and used in the study (Table 3-3). The functions used in the MoF analysis were equally used in the MCE analysis because the study seeks to compare the two methods. In step 2, data on the total number of each functional type in each Locality (i.e. for the 36 identified important functions to IDPs) were obtained from UN-HABITAT. In this analysis, the total number of each functional attribute in each Locality represents the *effects / impacts* of factors (functions).



Figure 3-3: Steps in Multicriteria Evaluation of functions

Step 3 involves evaluation structuring. Structuring in MCE refers to the identification of alternatives and criteria together with measurement or assessment of the performance of each alternative with respect to each criterion (Sharifi & Retsios, 2004). ILWIS SMCE module allows structuring through the development of a criteria tree. In this MCE analysis, Localities were structured as alternatives and functions as factors with the total number of each functional type in a Locality as impacts/effects.. Functions were categorized and structured within eight (8) broad classes representing broad functional objectives. The eight (8) broad classes of functions include; security services, judiciary functions, educational functions, health facilities/services, commercial establishments, public utilities/facilities, transportation functions and Government extension services. Hence, the criteria tree was made up of 2 levels. Level 1 involves broad functional objectives while level 2 consists of specific functional objectives (refer to Table 3-3 for a classification of the 36 functions used in the study into various broad categories).

Step 4 involves standardization of functions. Standardization enables us to show the partial attractiveness of factors by normalizing its effects for different alternatives between a value of 0 (no utility) and 1(highest utility). In this evaluation process, the effects/impacts of factors (functions) were standardized between a value of 0 and 1. All factors (that is functions) were considered as benefits because the higher the number of functions in a Locality, the better it is. Five standardization methods are available in ILWIS SMCE module. These include maximum, goal, interval, concave and convex standardization methods. Maximum standardization method was used because all values are standardized in relation to the maximum value and that keeps the relative order of the magnitude of the raw score

In step 5, functions were weighed in order to express their relative importance. Weighting of functions was done at two levels. In level 1, weighting was done among the broad classes of functions while in level

2 weighting was done among the functions within each broad class. A rank order method of weighting was applied to determine the weights of the broad classes of functions and functions within a broad class. In both level one and two, stakeholders were individual asked to do a ranking of the broad classes of functions on one hand and settlement functions within each broad class on the other based on their importance for the resettlement of IDPs. A Borda Count Method was used to determine the total rank score of the broad classes of functions and functions within each broad class by giving weights to the ranks. With this method, the total rank score of each broad class/settlement function is derived by summing up the respective points of the ranks as assigned by stakeholders. The Borda Count Method allows for the incorporation of the opinions of all stakeholders in determining the total rank score of each broad class/settlement function. Table 3-5 show the ranking of the broad categories of functions and specific functions within each broad category.

Broad category	Functions	Level 1 (broad categories)	Level 2 (specific functions)
	Army camps		2
	Police stations	1	1
Security services	Prison service	1	3
	Customs office		4
	Customary courts		1
Judiciary functions	Court of appeal	5	2
	Special criminal courts		2
	Kindergarten/nursery school		2
Educational functions	Primary school	2	1
Educational functions	Secondary school	2	2
	Vocational/technical School		3
	Government regional hospitals		2
	Rural hospitals/health centres		1
T I 141-	Private hospital with surgical capacity		7
facilities (services	Doctors	3	3
racinities/ services	General registered nurses		4
	Midwives		5
	Pharmacies		6
	Established grain stores		4
	Banks		5
Commercial	Manufacturing industry	0	5
establishments	Animal market	0	2
	Crop market		1
	Animal and crop market		3
	Radio station		4
	TV station		6
Public	Mobile phone repeaters	6	5
utilities/facilities	Water supply company	0	2
	Potable water supply source		1
	Electricity company		3
Transportation	Bus terminals	/	1
functions	Petrol station	4	2
Government	Local government office		1
extension services	Agricultural office	7	2
extension services	Animal health office		3

Table 3-5: Stakeholders ranking of broad categories of functions and specific functions within each broad category

Welfare service	4

The SMCE tool in ILWIS has three weighting methods. These are direct, pairwise and rank order weighting methods. Pairwise method could not be used in the field to determine weights because with many comparisons, it is difficult to maintain low consistency. It is also time consuming when many criteria are involved. Direct weighting was also not used so as to avoid personal biases or an exaggeration of the weights of functions. Rank order method was preferred because it is easy and less time consuming and also with a high probability of obtaining repeatable results.

After standardization and weighting of factors, the next step (step 6) is to obtain the overall attractiveness of each pixel in the map – the functional suitability index map. Although each Locality has a lot of pixel values, the overall attractiveness for all pixels in each Locality is the same because the unit of analysis has been Locality. Weighted summation aggregation technique which is supported by ILWIS SMCE tool was implemented. Sharifi and Retsios (2004, p. 6) describes the weighted summation aggregation technique supported by ILWIS SMCE tool as the "most transparent and understandable techniques that is implemented in a user-friendly fashion at each level, for every group of factors".

In step 7, the functional suitability indices obtained in step 6 were classified into 5 classes - highly functional suitable Localities, functional suitable Localities, moderately functional suitable Localities, low functional suitable Localities and very low functional suitable Localities. Localities were classified into five levels by their functional indices so that they can be compared with the five functional levels of Localities in the MoF analysis. A natural jenks classification method was applied so that boundaries are set where there are large differences in the functional suitability indices ArcGIS 10.1 which supports natural jenks classification method was used for this analysis. Also, as shown in Figure 3-3, a sensitivity analysis of the functional suitability score of Localities have been done by changing the standardization and weighting methods. Two scenarios were evaluated and results compared. In the first scenario, maximum standardization and rank sum ranking weighting methods were applied while in the second scenario, interval standardization and expected value ranking weighting methods was applied.

STATE

4. ANALYSIS AND RESULTS

4.1. Introduction

In this chapter, the results of the study are presented in three main sections - in line with the three specific objectives of the study. In section 4.2, the functional levels of Localities based on the Matrix of Function method is presented while section 4.3 presents the functional hierarchy of Localities suitability obtained in the Multicriteria Evaluation method. In both methods, El-Fasher Locality shows a clear functional predominance over other Localities. In section 4.4, the Matrix of Function and Multicriteria Evaluation of function methods have been compared based on seven criteria as outlined in Figure 3-1.

4.2. Matrix of Function and Functional Levels of Localities

It needs to be mentioned that, the use of the Matrix of Function method to define hierarchy of places in a region is best suited for analysis at settlement level but due to data constraint on the presence or absence of functions at settlement level in North Darfur State, the unit of analysis in this study is at sub-administrative level (Locality). One of the objectives of the study is to analyse the functional levels of Localities to support decision making in the resettlement of IDPs using MoF method. In an ordered MoF, the Centrality Index of places in a region signifies their functional levels. In this study, the Centrality Indices of Localities have been analysed and used as a measure of the functional levels of Localities in North Darfur State.

The MoF in Table 4-1 has been constructed with 17 Localities and 36 functions identified as important to IDPs. The operational technique involved in the MoF analysis is described in section 2.6. The matrix shows the presence or absence of functions in Localities, weighted value of functions and Centrality Index with which Localities were ordered into functional levels.

The weighted value of function indicates the degree of centrality of functions. This was calculated by dividing 100 by the number of times a function exist at least once in a Locality (refer to equation 1 in section 2.6). Therefore, the weighted value of a function in a MoF analysis is inversely proportional to its frequency. As shown in Table 4-1, the higher the frequency of a function, the lower its weighted value and vice versa. Based on the frequency of functions, functions were put into 3 broad groups i.e. basic functions (generally present everywhere), intermediate functions and central functions (rare functions).

The Centrality Index of each Locality was established by summing up the weighted values of functions for all functions that are present in a Locality. The Centrality Indices of Localities indicates their relative functional levels. In Table 4-1, Localities have been arranged by their Centrality Index in descending order from top to bottom. El-Fasher with a Centrality Index of 975 shows a clear predominance over other Localities. The centrality difference between El-Fasher and Kutum (i.e. Locality with the second highest Centrality Index) is 694.

Localities were manually classified into functional levels based on their Centrality Index and or the presence of certain functions in Localities. Five hierarchical Levels of Localities have been identified (Map 4-1). Table 4-2 shows a summary of the characteristics of the functional levels of Localities. On top of the hierarchy is El-Fasher Locality i.e., level 5 (highly functional Locality). El Fasher Locality was classified as level 5 due to its centrality dominance over other Localities. Aside the centrality predominance of El-

Fasher, it also has central functions like radio station, TV station, government regional hospital, private hospital with surgical capacity and court of appeal which are not present in other Localities (Table 4-1).

Next to El-Fasher Locality on the hierarchy is Kutum i.e., level 4 (functional Locality). Kutum was classified as level 4 because aside the fact that it is the Locality with the second highest Centrality Index, it has intermediary functions like prison service, custom office, Electricity Company and special criminal court but same cannot be said of other Localities below it (Table 4-1). Saraf Omra, Umm Keddada, Al Taweisha, Mellit and Kebkabiya with Centrality Index ranging 263 – 208 are third on the hierarchy i.e level 3 (moderately functional Localities). Generally, level 3 Localities have fewer functions than level 4 and 5 Localities. Out of the 36 functions which were used in the analysis, level 3 Localities have 23 or 22 functions each. Also, Level 3 Localities have 3 or 2 intermediary functions compared to other Localities below them (Table 4-1).

Localities classified as level 2 (low functional Localities) include Ailliet, Tawilla and Dar Alsalam with a Centrality Index of 177, 140 and 137 respectively. Tawilla and Dar Alsalam unlike lower order Localities have animal and crop market (rare intermediary function) while Ailliet has manufacturing factory – another rare intermediary function which is not present in lower order Localities below it (Table 4-1). Finally, Um Buru, El Kuma, El Tina, Kornoi, Klaimendo and Al Sireaf are at the bottom of the hierarchy i.e., level 1 (very low functional Localities). Level 1 Localities have Centrality Index ranging 122 – 99 (Table 4-1). Aside from the low Centrality Index of level 1 Localities, their functions are predominantly basic (Table 4-1).

		╞	+	ļ	╞	-	ļ	Ba	sic F	unct	ions		ļ	ļ	-	ļ	ļ						Inter	med.	iary i	Func	tion				Ţ	õ	entra	l Fun	Iction	S					
Locality Names	Population (2008)	amed yma	Potable Water Supply Source	Rural Hospitals/Health Stations	Local Gov't Office	Customary Courts	Primary Schools	Secondary Schools	səviwbiM	texhan laminA	Animal Health Office	Kindergarten/Nursery Schools	Mobile Phone repeater	Crop Market	Doctors	Registered Nurses	lsuiməT zu8	ອວຫຼືາO ໄຄາມາແນງແລ	Petrol Station	Established Grain Stores	Banks	Prison Station	Welfare Service	Sustoms Office	Electricity Company	Animal and Crop Market	Special Criminal courts	Vocational Schools	Water Supply Company	Vanufacturing factory	Pharmacists	Radio Station	noitet2 VT	Government Regional Hospital	Private Hospital with Surgical capacity	Court of Appeal	Number of functions in Locality	Centrality Index	Drop in Centrality Index	Functional Levels (Manual Classification)	
El-Fasher 50	4080 *																																				35	975		5	r
Kutum 15	50687																																				25	280	695	4	
Saraf Omra 2(3085																																				24	263	17	с	r
Umm Kaddada 9	3392																																				23	234	29	з	
A Taweisha 7	1468																																				23	221	13	с	r
Mellit 12	\$5831																																				8	211	10	3	
Kebkabiya 15	1414																																				83	208	3	з	r
Ailliet 6	7413																																				19	177	31	2	
Tawilla	XXX																																				17	140	37	2	r—
Dar Asalam	XXX																																				17	137	3	2	
EL Malha 10	5548																																				18	122	15	-	1
A Sireaf 15	6985																			_																	17	110	12	-	r
Klaimendo 7	2635																			_																	17	110	0	-	
Kormoi	XXX																		_																		16	106	4	-	r
El Tina	XXX																																				14	105	1	-	
El Kuma 6	9198																		Ц																		16	102	3	1	,,
Um Buru	XXX																																				15	66	3	٢	
Frequency of functi	ons	7 17	7 17	17	17	17	17	17	17	16	16	16	4	14	13	13	12	12	6	6	7	5	4	4	3	3	3	3	2	2	2	-	1	+	1	1					,,
Total Centrality	11	<u>)0</u> 10(0 100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100					
Weighted value	5.	9 5.5	9 5.9	5.9	5.9	5.9	5.9	5.9	5.9	6.3	6.3	6.3	7.1	7.1	7.7	7.7	8.3	8.3	11.1	11.1	14.3	20	25	25	33.3	33.3	33.3	33.3	50	20	50	100	100	100	100	100					
								Ba	sic F.	unct	ions												Inter	med	iary I	Func	tions	5				ő	entra	l Fun	Ictior	IS					
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		ļ	1		Fur	nctio	nal L	evels	6																																
Functi	on presen	÷			Lev	'el 5 -	highl	yfunc	tiona	alleve	-		Š	X Pop	Julatic	on no	tavai	lable	due t	o cha	inge i	n Loc	ality	poun	idary	after	2008	Idod	ulatio	n cen	SUS										

Table 4-1: Matrix of Function and functional levels of Localities in North Darfur State

Level 1 - very low functional level

Level 4 - functional level Level 3 - moderate functional Level 2 - low functional level

Function present

XXX Population not available due to change in Locality boundary after 2008 population census * Taweela population included Table 4-2: Summary of the characteristics of the functional hierarchy/levels of Localities in North Darfur State based on Matrix of Function Method

Functional	Localities	Centrality	
levels	names	Index	Distinctive Functions
Level 5	El-Fasher	975	In addition to having almost all basic and intermediate functions, it has the following central functions Radio station TV station Government regional hospital Private hospital with surgical capacity Court of appeal
Level 4	Kutum	280	In addition to having all basic functions, it has the following 7 intermediate functions Established grain store Banks Prison station Welfare service Custom office Electricity company Special criminal court
Level 3	Saraf Omra Umm Kaddada El Taweisha Mellit Kebkabiya	253 - 206	In addition to almost all basic functions, they have 5 or 6 of the following 7 intermediate functions Prison station Established grain store Banks Welfare service Custom office Petrol station Electricity company Animal and crop market Special criminal court Vocational school Water supply company Pharmacist
Level 2	Ailliet Tawilla Dar Alsalam	177 - 137	In addition to having almost all basic functions, they have one of the following less frequent functions • Manufacturing factory • Animals and crop market
Level 1	El Tina Kornoi Um Buru El Malha El Kuma El Sireaf Klaimendo	122 - 99	Generally have basic (non-central) functions (refer to Table 4-1)





From map 4-1, the following observations can be made about the functional hierarchy of Localities in North Darfur State:

- A unipolar system centered on El-Fasher Locality can be identified. El-Fasher Locality which is on top of the hierarchy is surrounded by other lower central places. Additionally, El-Fasher Locality is connected to almost all other Localities with primary or secondary roads and thus makes it's a nodal Locality. This allows El – Fasher Town to play its role as the capital of North Darfur State.
- Some pattern of hierarchy can be identified in the spatial configuration of Localities. El-Fasher (a level 5 Locality) is bordered to the North by levels 4 and 3 Localities i.e Kutum and Mellit respectively. Kutum is bordered to the west and north by level 1 Localities whilst Mellit is also bordered to the north by a level 1 Locality. Although, all Localities to the East of El-Fasher are below it, the hierarchy seems to broken due to the presence of level 1 Localities (El Kuma and El Kuma).

Klaimendo) between El-Fasher Locality (level 5) on one hand and Umm Kaddada (level 3), El Taweisha (level 3) and Ailliet (level 2) on the other hand.

- Kutum Locality (level 4) can be seen as an important centre to El Tina, Kornoi and Um Buru Localities (all of which are level 1 to the west of Kutum). Given the availability of a primary road from El Tina Locality passing through Kornoi, Um Buru, and Kutum to El-Fasher, the inhabitants of El Tina, Kornoi and Um Buru can easily commute to Kutum for services they do not have but further proceed to El-Fasher when the service needed is not available in Kutom.
- El Taweisha Locality and Umm Kaddada Locality (both of level 3) as well as Ailliet Locality (level 2) can be seen as an isolated territory. Whereas other Localities are linked to El-Fasher Locality with a primary road, Ailliet, El Taweisha and Klaimendo Localities are connected with a secondary road. Also, as mentioned earlier, the hierarchy between El-Fasher and these Localities seems to be broken due to the presence of level 1 Localities in-between them (i.e. Klaimendo and El Kuma. Among the three isolated Localities, El-Taweisha Locality (level 3) can be seen as an emerging growth centre which can be of important to Ailliet and Klaimendo levels 1 and 2 respectively.
- It is also striking to note that El Sireaf Locality (level 1) is not only functionally deprived but an isolated territory due to the lack of a major road to all other Localities hierarchically above it.

4.2.1. Analysing Areas of Influence of Localities Centres

The areas of influence of Localities centres (headquarters) were analysed based on the idea of the CPT that settlements are always arranged in a hierarchical order with low central places surrounding high central places. Isopleth maps were used to illustrate the areas of influence of Localities centres. *Isopleth* is a geography term which means a line connecting points of equal height. However, in the context of this study, the isopleth depicts the functional levels of Localities centres in North Darfur State (Map 4-2). Although isopleth map is best suited for functional analysis at settlement level, the used of Localities headquarter as centroids for the preparation of isopleth maps was based on the assumption that, the headquarter of a Locality has most if not all of the functions in that particular Locality. It must be noted that, isolines only account for the functional level Localities headquarters. In other words, the positions of isoples behind localities headquarters are arbitrary.



Map 4-2: Isopleth map showing functional levels of Localities centres in North Darfur State

The following observations can be made from the isopleth map showing the functional levels of Localities centres (headquarters) in North Darfur State (Map 4-2):

- A careful study of the isolines shows that El-Fasher Town is the highest point in North Darfur State because its Locality is on top of the functional hierarchy of Localities – level 5. This implies that El-Fasher Town influences all other Localities headquarters. The predominance of El-Fasher Town over other Localities headquarters allows it to play its role as the capital Town of North Darfur State. The influence of El-Fasher Town on other Localities centres is evident by the presence of major road network (primary or secondary roads) between El-Fasher Town and other Localities centres.
- Kutum Locality headquarter (level 4) can be seen as an important centre influencing El Tina, Kornoi and Um Buru Localities (all of which are level 1) located in the western part of North Darfur State. Given the availability of a primary road from El Tina passing through Kornoi, Um Buru, and Kutum to El-Fasher, the inhabitants of El Tina, Kornoi and Um Buru can easily commute to Kutum for services they do not have but further proceed to El-Fasher Town when the service needed in Kutum is not available.

Ailliet, El Taweisha and Klaimendo Localities headquarters can be described as isolated Towns with less influence from El-Fasher Town because they are linked to El-Fasher Town by a secondary road compared to most other Localities headquarters been linked with a primary road. Among the three isolated Towns, El-Taweisha Town (level 3) can be seen as an emerging growth centre influencing the other two Localities below it. It is also striking to note that there is no major road network from El Sireaf Town (level 1) to other Localities centres.

4.2.2. Sensitivity Analysis of the Functional Hierarchy of Localities of the Matrix of Function Method

The robustness of the functional hierarchy of Localities of a Matrix of Function analysis is highly depended on the exhaustiveness of functions in the region used in the analysis. In other words, the functional hierarchy of places based on a MoF analysis would be highly robust if it considers all or a lot of functions in the region. In order to ascertain the robustness of the results, the functional hierarchy of Localities of the 36 important functions to IDPs was compared with another Matrix of Function which considered 76 general functions (Appendix G shows the ordered MoF with 76 general functions).

The Centrality Index of Localities of the 36 important functions to IDPs matrix ranges from 975 to 99 whereas that of the 76 general functions matrix has Centrality Index ranging 2120 to 187 (Table 4-3). The ranges of the Centrality Indices of the two ordered matrices were different due to variations in the number of functions used in the analysis.

Like the first 36 important functions to IDPs ordered matrix as shown in Table 4-1, Localities in the 76 general functions ordered matrix were also manually classified into five levels so that results could be comparable. In both matrices, El-Fasher Locality is on top of the hierarchy with clear centrality index predominance (Table 4-3). With the exception of Ailliet and Alsiraif Localities, the functional level of any other Locality in the two matrices is the same (Table 4-3). Ailleit and Al Sireaf which were in Level 2 and 1 respectively in the 36 important functions to IDPs matrix have been moved a step upward in the matrix which considered 76 general functions due to their relatively high centrality score than other Localities in which they were at the same level (Table 4-3). Generally, the functional levels of Localities based on the 36 important functions to IDPs can be considered as fairly robust because it is quite similar to the matrix 76 general functions ordered matrix.

COMPARISON OF TWO METHODS IN REGIONAL ANALYSIS OF FUNCTIONS; THE CASE OF INTERNALLY DISPLACED PERSONS RESETTLEMENT IN NORTH DARFUR STATE

Localities	36 important functions to	IDPs MoF results	9L	general functions matrix results
names				
	Centrality Index	Functional Levels	Centrality Index	Functional Levels
El – Fasher	975	Level 5 (highly functional level)	2120	Level 5(highly functional level)
Kutum	280	Level 4 (functional level)	591	Level 4 (functional level)
Saraf Omra	263	Level 3 (moderately functional level)	532	Level 3(functional level)
Umm Kaddada	234	Level 3 (moderately functional level)	501	Level 3 (functional level)
Al Taweisha	221	Level 3 (moderately functional level)	458	Level 3 (functional level)
Mellit	211	Level 3 (moderately functional level)	507	Level 3 (functional level)
Kebkabiya	208	Level 3 (moderately functional level)	486	Level 3 (functional level)
Ailliet	177	Level 2 (low functional level)	<mark>330</mark>	Level 3 (moderately functional level)
Tawilla	140	Level 2 (low functional level)	259	Level 2 (low functional level)
Dar Alsalam	137	Level 2 (low functional level)	268	Level 2 (low functional level)
El Malba	122	Level 1 (very low functional level)	231	Level 1 (very low functional level)
Al Sireaf	<mark>110</mark>	Level 1 (very low functional level)	274	Level 2 (low functional level)
Klaimendo	110	Level 1 (very low functional level)	206	Level 1 (very low functional level)
Kornoi	106	Level 1 (very low functional level)	206	Level 1 (very low functional level)
El Tina	105	Level 1 (very low functional level)	209	Level 1 (very low functional level)
ЕІ Кита	102	Level 1 (very low functional level)	223	Level 1 (very low functional level)
Um Buru	66	Level 1 (verv low functional level)	187	Level 1 (verv low functional level)

Table 4-3: Comparison of centrality index and functional levels of Localities of 36 important functions to IDPs matrix and 76 general functions matrix

4.3. Multicriteria Evaluation of Functions and Functional Suitability Levels of Localities

The second objective of the study was to analyse the functional suitability of Localities to support decision making in the resettlement of IDPs using Multicriteria Evaluation method. The Multicriteria Evaluation method was implemented via an aggregation of the total number of each functional attribute in each Locality in relation to stakeholders' prioritization of functions according to their importance to IDPs. I wish to reiterate that due to the absence of complete population data, the total number of each type of function in a Locality could not be related to the population within that administrative unit. Absolute number of functions in Localities were used to assume that the higher the number of a particular type of function in a Locality, the better it is.

Figure 4-1 is part of the evaluation structuring of functions (i.e. the criteria tree) in ILWIS SMCE environment. In the criteria tree, functions have been structured at two levels. Level 1 include broad categories of functions representing broad objectives while level 2 represent specific functions under each broad category of function. Functions have been grouped and structured under various broad categories for the purpose of assessing the performance of Localities under each broad category. A Rank sum weighting method was applied to generate the numerical weight of functions. The rank sum method as a type of rank order weighting method ensures that weighting interval remains relatively equal for a group of criteria when ranked. Table 3-5 shows the order by which broad categories of functions and their associated functions were ranked by stakeholders (refer to Table 3-1 for lists of stakeholders who did the ranking). A maximum standardization method was also applied to normalize the effects/impacts of factors (functions) between a value of 0 (no utility) and 1(highest utility). All factors (that is functions) were considered as benefits because the higher the number of functions in a Locality, the better it is. Although five different standardization methods are available in ILWIS SMCE module (maximum, goal, interval, concave and convex standardization methods), maximum standardization method was used. In maximum standardization, values are standardized in relation to the maximum value and thus keep the relative order of the magnitude of the raw score.

Figure 4-1: Part of the criteria tree in ILWIS SMCE environment showing broad categories of functions and their associated functions, weights and standardization method

Provide the structuring of Functions in North darfur.smc - ILWIS	
File Edit Mode Analysis Generate View Help	
📴 🖬 📾 🔚 🖩 🐚 ங ங 🍬 🏠 😭 🗙 🕺 fn 💋 🖄 💩 📥	🔯 📮 🖾 🖳 📟 🖳 🖾 🖳 📩
Criteria Tree	
to identify localities with suitable functions for the resettlement of IDPs RankSum	Overall functional suitability
岿 📾 0.22 to identify localities with suitable security services RankSum	E Security Service Suitability
0.40 the more the availability of police stations , the better Std:Maximum	Admin_UTM:Police_Station
	Admin_UTM:Army_Camp
	Admin_UTM:Custom_Office
0.20 the more the availability of prison stations, the better Std:Maximum	Admin_UTM:Prison_Station
📴 📾 0.19 to identify localities with suitable educational functions RankSum	Educational function Suitability
0.40 the more the availability of primary schools, the better Std:Maximum	Admin_UTM:Primary_Schools
0.25 the more the availability of secondary schools, the better Std:Maximum	Admin_UTM:Secondary_Schools
0.10 the more the availability of vocational/technical schools, the better Std	Admin_UTM:Vocational_Schools
0.25 the more the availability of kindergarten schools, the better Std:Maxim	Admin_UTM:Kindergarten_School
📴 📾 0.17 to identify localities with suitable health functions RankSum	Health Function Suitability
0.21 the more the availability of Government regional hospitals, the better St	Admin_UTM:Govt_Regional_Hospitals
0.04 the more the availability of private hospitals, the better Std:Maximum	Admin_UTM:Private_Hospital
0.18 the more the availability of Doctors, the better Std:Maximum	Admin_UTM:Doctors
0.14 the more the avalibility of registered general nurses, the better Std:Max	Admin_UTM:Registered_Nurses
0.11 the more the availability of midwives, the better Std:Maximum	Admin_UTM:Midwives
0.25 the more the availability of rural hospitals/health stations, the better Std	Admin_UTM:Rural_Hosp_Health_Stations
0.07 the more the availability of pharmacies, the better Std:Maximum	Admin_UTM:Pharmacies
0.03 o identify localities with suitable commercial establishments RankSum	Commercial Establishments Suitability
0.14 the more the availability of established grain stores, the better Std:Maxi	Admin_UTM:Established_Grain_Stores
	Admin_UTM:Banks
0.07 the more the availability of manufacturing industry, the better Std:Max	Admin_UTM:Manufacturing_Industry
0.24 the more the availability of anaimal markets, the better Std:Maximum	Admin_UTM:Animal_Market
0.29 the more the availability of crops markets, the better Std:Maximum	Admin_UTM:Crop_Market
0.19 the more the availability of 'animal and crop markets', the better Std:Ma	Admin_UTM:Animal_and_Crop_Market
😑 🚳 0.08 to identify localities with suitable public utilities or facilities RankSum	Public Utilities or Facilities Suitability
0.14 the more the availability of radio stations, the better Std:Maximum	Admin_UTM:Radio_Station
0.05 the more the availability of TV stations, the better Std:Maximum	Admin_UTM:TV_Station
0.10 the more the availability of mobile phone repeaters, the better Std:Max	Admin_UTM:Mobile_Phone_Repeater
0.24 the more the availability of water supply companies, the better Std:Max	Admin_UTM:Water_Supply_Company
0.29 the more the availability of potable water sources, the better Std:Maxim	Admin_UTM:Potable_Water_Sources
KNY N TO IL	
Root Group 'to identify localities with suitable functions for the resettlement of IDPs'; 8 child	ren //

After standardization and weighting of factors (functions) in the criteria tree, the overall functional suitability map was generated with values ranging 0.14 (low suitability) to 0.85 (high suitability) (Map 4-3). With the exception of commercial establishments, El-Fasher Locality has the highest functional suitability value in each broad category of function (Figure 4-2). Given the high functional suitability score of El-Fasher Locality in almost all functional categories, it came out as the Locality with the highest overall Functional Suitability Index i.e., 0.85, a clear dominance over other Localities (Table 4-4). The predominance of El-Fasher Locality could be attributed to the location of North Darfur State capital (El-Fasher) in that Locality, and as a result there is high concentration of functions compared to other Localities (Table 3-4). Although El Tina and Kornoi are the least functionally suitable Localities, they score better in the area of commercial establishments than other Localities (Table 4-3). This is due to high number of crop markets, animal markets and established grain stores in Kornoi and El-Tina which are ranked high among other functions in the commercial establishment category.

Map 4-3: Functional suitability of Localities in North Darfur State based on Multicriteria Evaluation of functions



Table 4-4: Summary of functional suitability scores of Localities in broad categories of functions leading to the overall functional suitability score

Composite functional suitability index	0.85	0.38	0.28	0.24	0.23	0.22	0.22	0.21	0.21	0.20	0.19	0.18	0.17	0.17	0.17	0.14	0.14
Commercial establishments suitability index	0.14	0.19	0.12	0.21	0.70	0.07	0.07	0.13	0.34	0.16	0.14	0.18	0.07	0.03	0.12	0.52	0.14
Government extension service index	0.97	0.70	0.54	0.57	0.54	0.53	0.53	0.53	0.40	0.50	0.60	0.63	0.43	0.53	0.54	0.47	0.43
Transportation functions suitability	1.00	0.17	0.07	0.03	0.17	0.00	0.10	0.10	0.13	0.20	0.00	0.07	0.13	0.10	0.07	0.07	0.00
Public utilities/facilities suitability index	1.00	0.30	0.34	0.10	0.09	0.10	0.19	0.12	0.03	0.12	0.02	0.06	0.10	0.07	0.31	0.01	0.00
Health functions suitability index	0.92	0.26	0.24	0.12	0.07	0.17	0.05	0.31	0.19	0.12	0.07	0.05	0.24	0.19	0.05	0.05	0.02
Education function suitability index	1.00	0.28	0.29	0.19	0.09	0.13	0.27	0.15	0.11	0.11	0.08	0.11	0.08	0.13	0.12	0.10	0.02
Judiciary functions suitability index	0.75	0.58	0.46	0.13	0.50	0.13	0.13	0.13	0.13	0.13	0.38	0.50	0.13	0.13	0.13	0.13	0.13
Security functions suitability index	0.60	0.57	0.30	0.53	0.30	0.50	0.37	0.27	0.40	0.33	0.37	0.17	0.23	0.23	0.23	0.23	0.40
Localities	El-Fasher	Umm Keddada	Kutum	Ailliet	Saraf Omra	Klaimendo	Mellit	Kebkabiya	Tawilla	Dar Alsalam	Um Buru	Al Sireaf	El Kuma	El Malha	El Taweisha	Kornoi	El Tina

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Figure 4-2: Bar graphs showing functional suitability scores of Localities in broad categories of functions

Furthermore, a natural jenks classification method in ArcGIS was applied to classify Localities into five levels by their functional suitability index as visualized in Map 4-4. Localities classified into five levels so that results can easily be compared with the five functional hierarchies of Localities identified in the MoF method. The natural jenks classification method sets boundaries where there are large differences in the functional suitability values. Appendix D shows a snapshot of the natural jenks classification break values of the functional suitability index in ArcGIS. On top of the functional suitability hierarchy of Localities in North Darfur State is El-Fasher Locality i.e. a highly functional suitable Locality. Due to the clear dominance in the functional suitability score of El-Fasher Locality (Table 4-3), it was in a class of its own. Fourth on the hierarchy is Umm Keddada Locality with a functional suitability index of 0.38, i.e., functional suitable Locality. Third on the hierarchy are Kutum, Ailliet, Saraf Omra, Klaimendo, Mellit, Kebkabiya and Tawilla with a functional suitability index ranging 0.21 - 0.28 i.e., moderately functional suitable Localities. Dar Alsalam, Umm Buru, Al Sireaf, El Kuma, El Malha and El Taweisha were at level two with functional suitability index ranging 0.17 - 0.20 i.e. low functional suitable Localities. Localities at the bottom of the functional suitability hierarchy include Kornoi and El Tina with a functional suitability index of 0.14 i.e. very low functional suitable Localities.

Map 4-4: Functional suitability levels of Localities in North Darfur State based on Multicriteria Evaluation of functions



4.3.1. Sensitivity Analysis of the Functional Suitability Indices of Localities

A sensitivity analysis was done to find out the robustness of the functional suitability indices and levels of Localities by varying standardization and weighting methods. As indicated earlier, maximum standardization and rank sum ranking weighting methods were used in the first Multicriteria Evaluation of

functions (Figure 4-1). This first evaluation have been dubbed *scenario 1*. Another multicriteria evaluation of functions was carried using interval standardization and expected value ranking weighting methods i.e. *scenario 2*.

Whereas in scenario 1, the overall functional suitability index of Localities ranges from 0.85 (high suitability) to 0.14 (low suitability), in scenario 2, they ranges from 0.74 (high suitability) to 0.10 (low suitability)(Table 4-5). In both scenarios 1 and 2, El – Fasher Locality still performs best with a clear dominance although its overall functional suitability value has been lowered from 0.85 in scenario 1 to 0.74 in scenario 2 (Figure 4-2). With the exception of Umm Kaddada, Ailliet, Klaimendo and Tawilla which overall functional suitability index is either the same or has been increased slightly in scenario 2 compared to scenario 1, the functional suitability index of all other Localities have been lowered (Table 4-5).

The functional suitability hierarchy of Localities of the two scenarios are fairly similar (Table 4-5). Millit and Kebkabiya have dropped from been moderately functional suitable Localities in scenario 1 to low functional suitable Localities in scenario 2. Al Sireaf and El Taweisha have also dropped from been low functional suitable Localities in scenario 1 to very low functional suitable Localities in scenario 2 (highlighted in grey colour in Table 4-5). The rest of the Localities are at the same level of the hierarchy in both scenarios 1 and 2 (Table 4-5).

Notwithstanding the fact that the functional suitability indices of Localities are sensitive to the standardization and weighting methods that are been applied, the results can be described as fairly robust. A rank order of Localities by their functional suitability index in both scenarios has El-Fasher and Umm Kaddada been 1st and 2nd respectively while Localities like El Tina, Kornoi and El Taweisha are still at the bottom (Table 4-5).

It needs to be mentioned that, the robustness of the functional hierarchy of Localities suitability based on the 36 important functions to IDPs could not be assessed with the introduction of more functions. This is because, in the Multicriteria evaluation of functions, stakeholders were required to prioritize functions according to their importance to IDPs, therefore if more functions were considered, prioritization of functions would have been time consuming and ineffective. Moreover, incomplete data on the total number of functions in each Locality also constrained the possibility of doing a sensitivity analysis with the introduction of some few functions. Table 4-5: Comparison of the overall functional suitability indices and levels of Localities of two Multicriteria Evaluations of functions by varying standardization and weighting methods

	Scenario 1 (maximu	m standardiz:	ation - rank sum ranking	Scenario 2 (interv	val standardiz	ation - expected value ranking
	weighting method)			weighting methoo	ds)	
Localities	Overall functional suitability index	Rank order of Localities	Functional Suitability levels	Overall functional suitability index	Rank order of Localities	Functional Suitability levels
El Fasher	0.85	1st	highly functionally suitable	0.74	1st	highly functionally suitable
Umm Kaddada	0.38	2^{nd}	functionally suitable	0.39	$2^{ m nd}$	functionally suitable
Kutum	0.28	3rd	moderately functionally suitable	0.22	5^{th}	moderately functionally suitable
Ailleit	0.24	$4^{\rm th}$	moderately functionally suitable	0.28	3rd	moderately functionally suitable
Sharaf Omra	0.23	5^{th}	moderately functionally suitable	0.20	7^{th}	moderately functionally suitable
Klaimendo	0.22	6^{th}	moderately functionally suitable	0.26	$4^{\rm th}$	moderately functionally suitable
Mellit	0.22	γth	moderately functionally suitable	0.17	$10^{\rm th}$	low functionally suitable
Kebkabiya	0.21	8th	moderately functionally suitable	0.15	1 1 th	low functionally suitable
Tawilla	0.21	9th	moderately functionally suitable	0.21	6th	moderately functionally suitable
Dar Alsalam	0.20	$10^{\rm th}$	low functionally suitable	0.18	8^{th}	low functionally suitable
Um Buru	0.19	11th	low functionally suitable	0.18	8^{th}	low functionally suitable
Al Sireaf	0.18	12^{th}	low functionally suitable	0.12	14^{th}	very low functionally suitable
El Kuma	0.17	13^{th}	low functionally suitable	0.14	12^{th}	low functionally suitable
El Malha	0.17	14^{th}	low functionally suitable	0.14	12^{th}	low functionally suitable
El Taweisha	0.17	$15^{\rm th}$	low functionally suitable	0.11	16	very low functionally suitable
Kornoi	0.14	16^{th}	very low functionally suitable	0.10	17	very low functionally suitable
El Tina	0.14	17th	very low functionally suitable	0.12	$14^{ m th}$	very low functionally suitable

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COMPARISON OF TWO METHODS IN REGIONAL ANALYSIS OF FUNCTIONS; THE CASE OF INTERNALLY DISPLACED PERSONS RESETTLEMENT IN NORTH DARFUR STATE



Figure 4-3: Bar graph comparing the overall functional suitability indices of Localities of two Multicriteria Evaluations of functions by varying standardization and weighting methods

4.4. Comparison of Matrix of function and Multicriteria Evaluation of Functions Methods

The MoF and Multicriteria Evaluation methods adapted to analyse the functional hierarchy of Localities to support decision making in the resettlement of IDPs were compared in order to bring out their differences and or similarities using a framework designed in section 2.8. The framework has seven criteria. The seven criteria defined to compare the two methods were put into 5 sections for the purpose of discussion. Section 4.4.1 looks at the data requirements and ease of computation of the methods. In section 4.4.2, the amount of interaction required between the decision maker and system analyst is examined. Section 4.4.3 discusses the weighted values /importance of functions in each method while section 4.4.4 discusses the nature of the alternative system being analysed and consistency of results of methods. Finally, the robustness of the results in both methods is discussed in section 4.4.5

4.4.1. Data Requirements and Ease of Computation of the Methods

The data required for the Matrix of Function analysis is less demanding. In this study, the data requirements of the MoF analysis are as follows: (1) inventory of the absence or presence of a cross section of functions identified as important to IDPs, (2) administrative boundary of Localities in North Darfur State (spatial data), and (3) locations of Localities headquarters in North Darfur State (spatial data). The Multicriteria Evaluation of functions as implemented in this study has a high data demand. The data requirements include; (1) total number of a specific type of function in each Locality for a cross section of functions considered as important to IDPs, (2) importance of functions for to IDPs from stakeholders perspective (3) administrative boundary of Localities in North Darfur State (spatial data), and (3) locations

of Localities headquarters in North Darfur State (spatial data). The spatial data requirements of the two methods are the same.

Duckstein et al. (1982) operationalizes ease of computation of methods in terms of two main viewpoints; (1) knowledge required by system analyst to use the method and (2) time required to implement the method and analyse results. With regards to knowledge required by system analyst in the use of MoF and Multicriteria Evaluation of functions methods, the latter is easier to be implemented by system analyst compared to the former. Basic background knowledge of a system analyst in mathematical addition and division operations are enough in analysing the frequency of functions, weight of functions and centrality indices of Localities when implementing the Matrix of Function method. In the Multicriteria Evaluation of functions, a person must have skills in Multiattribute Decision Making (MADM) particularly in areas of evaluation structuring, standardization, weighting of objectives and aggregation. Also in the Multicriteria Evaluation of functions, background in GIS-MCE functionality is required for the implementation of the method. With regards to the second viewpoint (i.e. time required to implement the method and analyse results), the MoF method requires less implementing time than the Multicriteria Evaluation of function. The involvement of stakeholders in the prioritization of functions in the Multicriteria Evaluation method is time consuming. However, in terms of analysing results, the classification of places into a hierarchical order in the MoF method is quite tedious and not straightforward. Places are manually classified by their centrality index into function levels but taken into account the ubiquity of certain key central functions. In the Multicriteria evaluation method, classification of Localities into a hierarchical order by their functional suitability index in is simple and straightforward.

4.4.2. Amount of Interaction Required between the Decision Maker and System Analyst

The amount of interaction time between the decision maker and the system analyst is less in the MoF method than in the Multicriteria evaluation of functions method. During the implementation of the MoF method in this study, the researcher (herein refers to as the system analyst) only interacted with decision makers in the identification of important functions to IDPs whereas in the Multicriteria Evaluation of functions the system analyst first interacted with decision makers in the identification of important functions to IDPs and also in determining the relative importance of functions.

Multicriteria evaluation of functions can be seen as a normative method which allows for the representation of stakeholders preferences whereas the MoF method is more of a descriptive method. In the Multicriteria Evaluation of functions, stakeholders' preferences were represented first in the identification of important functions to IDPs and second in the determination of the relative importance of functions to IDPs.

4.4.3. Comparison of Weights/Importance of Criteria (Functions)

The methods involve in determining the weight of functions in the MoF analysis and the Multicriteria evaluations of functions are different. In the MoF method, the weight of a function is inversely proportional to its frequency and is driven using a prescriptive mathematical formula (refer to equation 1, p.). In the Multicriteria Evaluation of function, weights (importance) of functions were determined through ranking of functions by stakeholders based on their value judgement of the importance of functions to IDPs (refer to Table 3-5). During evaluation of functions in ILWIS SMCE, a rank sum method i.e., a type of rank order method (ITC, 2007; Malczewski, 1999), was used to determine the numerical weights of functions as shown in the criteria tree in Figure 4-1 above.

Table 4-6 shows the weights of functions in both MoF and Multicriteria Evaluation of functions methods. The weighted values of functions in the MoF method indicate their degree of centrality – it ranges from 5.9 (basic functions) to 100 (centralized functions). In the Multicriteria Evaluation of functions, weighted

value of a function indicates the level of importance of a function to IDPs. It must be stated that, the *total weight of function* in the Multicriteria Evaluation method is highly influenced by the number of functions within a particular broad category of functions (refer to Table 4-4). For instance, even though primary school and bus terminals are both ranked first in educational broad category and transportation broad category, yet the total weight of function of bus terminal is higher than primary school because the transportation category has only two functions compared to the education category with four functions.

			Weight	(import	ance) of	Weighted
Broad category	Functions (Level 2)		function	ns in Mu	lticriteria	centrality
of functions		Functions	Evaluat	ion meth	od (rank	values of
(Level 1)		Code	sum we	ighting m	ethod)	functions in
			Level	L2 weight	1 otal	MOF
			weight	weight	(L1*L2)	memou
	Army camps	F1		0.30	0.066	5.9
Security services	police Stations	F2	0.22	0.40	0.088	5.9
	Prison service	F3		0.20	0.044	20
	Customs office	F4		0.10	0.022	25
	Customary courts	F5		0.50	0.055	5.9
Judiciary	Court of Appeal	F6	0.11	0.17	0.019	100
functions	Special criminal courts	F7		0.33	0.036	33.3
	Kindergarten/Nursery	F8		0.25	0.048	6.3
Educational	Primary school	F9	0.19	0.40	0.076	5.9
functions	Secondary school	F10		0.25	0.048	5.9
	Vocational/Technical School	F11		0.10	0.019	33.3
	Government Regional hospitals	F12		0.21	0.036	100
Lloolth	Rural hospitals/health centres	F13		0.25	0.043	5.9
facilities/services	Private hospitals	F14	0.17	0.04	0.007	100
facilities, services	Doctors	F15	0.17	0.18	0.031	7.7
	General registered nurses	F16		0.14	0.024	7.7
	Midwives	F17		0.11	0.019	5.9
	Pharmacies	F18		0.07	0.012	50
	Established grain stores	F19		0.14	0.004	11.1
Commonial	Banks	F20	0.02	0.07	0.002	14.3
establishments	Manufacturing industry	F21	0.05	0.07	0.002	50
cotublionnento	Animal market	F22		0.24	0.007	6.3
	Crop Market	F23		0.29	0.009	7.1
	Animal and Crop market	F24		0.19	0.006	33.3
	Radio Station	F25		0.14	0.011	100
D-11	TV Station	F26		0.05	0.004	100
utilities/facilities	Mobile phone repeaters	F27	0.08	0.10	0.008	7.1
dunities, facilities	Water Supply company	F28	0.00	0.24	0.019	50
	Potable water supply source	F29		0.29	0.023	5.9
	Electricity company	F30		0.19	0.015	33.3
Transportation	Bus terminals	F31		0.67	0.094	8.3
tunctions	Petrol Station	F32	0.14	0.33	0.046	11.1

Table 4-6: Weighted values of functions in both Matrix of function and Multicriteria Evaluation of functions methods.

	Local government office	F33		0.40	0.024	5.9
Government extension services	Agricultural Office	F34	0.06	0.30	0.018	8.3
	Animal Health office	F35		0.20	0.012	6.3
	Welfare service	F36		0.10	0.006	25

The correlation coefficient between the weighted values of functions in the MoF and Multicriteria Evaluation of functions methods is -0.346, i.e. a weak negative correlation, significant at p<0.05 (1-tailed) (Table 4-7). This implies that the centrality level of functions and their importance to IDPs are not directly related - rare functions are not necessarily of much importance to IDPs than functions which appear at least once in most places. Figure 4-4 shows a scatter plot of the weights of functions in the MoF Vis a Vis the weights (importance) of functions in the Multicriteria Evaluation method.

Table 4-7: Correlation coefficient between weighted centrality of functions and importance of functions to IDPs

		Weight (importance) of functions in Multicriteria Evaluation method	Weighted centrality values of functions in MoF method
Importance of functions	Pearson Correlation	1	- 0.346*
	Sig. (1-tailed)		0.019
(MCE method)	Ν	36	36
	Pearson Correlation	-0.346*	1
Weighted centrality values of	Sig. (1-tailed)	0.019	
functions (MoF method)	N	36	36

*. Correlation is significant at the 0.05 level.

Figure 4-4: Relationship between weighted centrality values of functions in Matrix of Functions and weight (importance) of functions in Multicriteria Evaluation method



NB: refer to Table 4 6 for code of functions

4.4.4. The Nature of the Alternative Systems being Analysed and Consistency of Results of Methods

The nature of alternative systems which can be analysed by a method looks at whether the sets of systems the method handles can be classified as being either discrete or continuous ((Duckstein et al., 1982). Both MoF and Multicriteria Evaluation of methods adapted in this study analyses a discrete set of systems - a finite number of Localities.

With regards to consistency of results, the two methods yield a fairly similar functional hierarchy of Localities with El-Fasher always on top (Table 4-8). In both methods, El –Fasher, Saraf Omra, Mellit, Kebkabiya, Dar Alsalam, Kornoi and El Tina occur at the same levels i.e. their functional levels as measured in the MoF method commensurate with their levels of functional suitability as obtained in the Multicriteria evaluation method. Umm Kaddada, Ailliet, El Kuma, Al Sireaf, Klaimendo and El Malha in the Multicriteria Evaluation method have moved one step up compared to their levels in the Matrix of function method (highlighted in green colour in Table 4-8). This contradiction can be explained by the following; (1) the total number of each given function present in these Localities are generally more than other Localities in which they were at the same level with in the MoF method (Table 3-4), (2) some functions present in these Localities are relatively of high importance in the Multicriteria Evaluation method. For instance, El Malha has a petrol station which is relatively important in the Multicriteria evaluation method (Table 4-6); this can account for the better performance of El Malha than Kornoi and El Tina in the Multicriteria evaluation of functions.

Kutum and Al Taweisha have also dropped from being level 4 and 3 Localities in the MoF hierarchy to level 3 and 2 respectively in the Multicriteria Evaluation method (highlighted in grey colour in Table 4-8). This inconsistency can be explained by the following; (1) the total number of each given function present in these Localities are generally less than other Localities in which they were at the same level with in the MoF method (Table 3-4), (2) some functions present in these Localities are relatively of low importance in the Multicriteria Evaluation method than in the MoF method (refer to Table 4-6).

Localities	Matrix of Function method	Multicriteria Evaluation method
names	Functional levels	Functional suitability levels
El – Fasher	level 5(highly functional level)	Level 5 (highly functionally suitable)
Kutum	Level 4 (functional level)	Level 3 (moderately functionally suitable)
Saraf Omra	Level 3 (moderately functional level)	Level 3 (moderately functionally suitable)
Umm Kaddada	Level 3 (moderately functional level)	Level 4 (functionally suitable)
Al Taweisha	Level 3 (moderately functional level)	Level 2 (low functionally suitable)
Mellit	Level 3 (moderately functional level)	Level 3 (moderately functionally suitable)
Kebkabiya	Level 3 (moderately functional level)	Level 3 (moderately functionally suitable)
Ailliet	Leve 2 (low functional level)	Level 3 (moderately functionally suitable)
Tawilla	Leve 2 (low functional level)	Level 3 (moderately functionally suitable)
Dar Alsalam	Leve 2 (low functional level)	Level 2 (low functionally suitable)
El Malha	Level 1 (very low functional level)	Level 2 (low functionally suitable)
Al Sireaf	Level 1 (very low functional level)	Level 2 (low functionally suitable)
<u>Klaimendo</u>	Level 1 (very low functional level)	Level 2 (low functionally suitable)
Kornoi	Level 1 (very low functional level)	Level 1 (very low functionally suitable)
El Tina	Level 1 (very low functional level)	Level 1 (very low functionally suitable)

Table 4-8: Comparison of classified functional hierarchy of Localities of Matrix of Function and Multicriteria Evaluation of functions methods

El Kuma	Level 1 (very low functional level)	Level 2 (low functionally suitable)
Um Buru	Level 1 (very low functional level)	Level 2 (low functionally suitable)

4.4.5. Robustness of Results to Changes in Parameters Values

Duckstein et al. (1982) assess robustness of methods by changing parameters values (e.g. weights of criteria) to see if there would be changes in the ranking of alternatives. In this study, the robustness of methods were also analysed by changing some parameter values in each method to see whether there would be changes in the functional hierarchy of Localities. Sections 4.2.2 and 4.3.1 show the sensitivity analysis of the MoF and Multicriteria Evaluation of Functions methods respectively.

The robustness of the functional hierarchy of Localities of a Matrix of Function analysis is highly depended on the exhaustiveness of functions in the region used in the analysis. In other words, a MoF analysis would be highly robust if it considers all the functions in the region. Although this study considers a cross section of 36 important functions to IDPs, the functional hierarchy of Localities obtained can be considered as robust. This is because the functional hierarchy of Localities of the 36 ordered matrix if compared with the 76 general functions matrix yields almost the same functional hierarchy (Table 4-3).

In the Multicriteria evaluation of functions, the robustness of the functional hierarchy of Localities suitability was examined through changes in standardization and weighting methods (refer to section 4.3.1). Notwithstanding the fact that the functional suitability indices of Localities are sensitive to the standardization and weighting methods that are been applied, the results can be described as fairly robust. It needs to be mentioned that, the robustness of the functional hierarchy of Localities suitability based on the 36 important functions to IDPs could not be assessed with the introduction of more functions. This is because, in the Multicriteria evaluation of functions, stakeholders were required to prioritize functions according to their importance to IDPs, therefore if more functions were considered, prioritization of functions in each Locality also constrained the possibility of doing a sensitivity analysis with the introduction of more functions. In conclusion, the functional hierarchy of Localities suitability obtained in the two methods can be described as robust.

5. DISCUSSION

5.1. Introduction

This chapter discusses the results and limitations of the study in four main sections taken into consideration the objectives and sub/operational questions of the study. The first section discusses functions considered as important to IDPs which were identified by stakeholders and used in the study. The second section discusses the functional hierarchy of Localities based on the Matrix of Function method including its potentials and limitations in supporting decision making in the resettlement of IDPs and planning in general. The third section also discusses the functional suitability indices and levels of Localities based on the Multicriteria Evaluation method as well as its potentials and limitations in supporting decision making in the resettlement of IDPs and planning at large. The Third section highlights and discusses major differences and similarities of the two methods with regards to seven criteria. The last section of this chapter discusses general limitations of the study.

5.2. Important Functions to Internally Displaced Persons as Identified by Stakeholders

For the purpose of easy processing of data particularly in the Multicriteria Evaluation method where functions have been prioritized, the regional analysis of functions in this study was limited to a cross section of functions considered as important to IDPs from the perspective of stakeholders. Out of an inventory of over 76 functions in North Darfur State by UN-HABITAT, 36 functions were identified by stakeholders as important to IDPs. The 36 important functions to IDPs which were used in the study broadly include; 4 security functions, 3 judiciary functions, 7 health functions, 4 educational functions, 6 commercial establishments, 6 public utilities/facilities, 2 transportation functions and 4 government extension services (Table 3-3).

In terms of the relative importance of broad category of functions to IDPs stakeholders ranked security services first, followed by Judiciary services. The ranking of security and judiciary services as important in the resettlement of IDPs could be due to the general insecurity in Darfur despite the adoption of the DDPD in 2011.

5.3. Functional hierarchy of Localties based on Matrix of Function Method

In order to analyse the functional levels of Localities to support decision making for the resettlement of IDPs using the Matrix of Function method, the following specific/operational questions were raised; (i) what are the frequencies and weighted values of functions considered as important to IDPs by stakeholders?; (ii) what are the centrality indices of Localities?; (iii) what are the functional levels of Localities?; (iv) what are the potential uses and limitations of the MoF method in regional analysis of functions in the resettlement of IDPs? The results of this analysis is presented in section 4.2 with key findings discussed below.

From Table 4-1, the frequency of functions ranges from 17 (i.e. appears atleat once in all 17 Localities) to 1 (appears in only 1 Locality). Based on the frequency of functions, the thirty-six important functions to IDPs can be distinguished to include basic functions (have frequency between 17 and 12), intermediate functions (have frequency between 11 and 2) and central functions (rare functions with a frequency of 1) (Table 4-1). The total number of basic functions, intermediate functions and central functions is 18, 13 and 5 respectively. All central functions with a frequency of 1 were found to be Located in El-Fasher Locality. These include; government regional hospital, radio station, TV station, private hospital with surgical capacity and Court of appeal.

The weight of a function is inversely proportional to its frequency - the higher the frequency of functions the lower its weight and vice versa. The weight of a function measures the degree of its centrality. In the MoF analysis, the weight of functions ranges from 5.9 to 100 (Table 4-1). Functions with a weight of 5.9 are non-central functions which are present in all Localities while functions with a weight of 100 are highly centralized functions which occur in only 1 Locality. Therefore, all central functions in El-Fasher Locality as mentioned above get a weighted value of 100.

5.3.1. Centrality Indices and Functional Hierarchy of Localities

The centrality index of Localities ranges from 295 for El-Fasher Locality to as low as 99 for Um Buru Locality (Table 4-1). The higher the centrality index of a Locality the more functional it is. The study reveals a large dropped in centrality index of 695 between El-Fasher Locality and Kutum Locality which ranked first and second respectively. The high centrality score of El-Fasher is due to the presence of government regional hospital, radio station, TV station, private hospital with surgical capacity and Court of appeal in only El-Fasher Locality.

Localities were manually classified into functional levels based on their centrality indices but taken into account the presence of key functions (Table 4-2). The functional hierarchy of Localities in North Darfur State is illustrated in Figure 5-1 below. El-Fasher Locality is on top of the hierarchy as the most functional Locality due to its centrality index dominance as mentioned above. The highly functional level of El-Fasher is further evident by the presence of primary or secondary roads from all other Localities linking El-Fasher Locality so that inhabitants of other Localities can easily commute to El-Fasher Locality to access functions that they do not have (Map 4-1). The functional dominance of El-Fasher Localities over other Localities allows it to play its role as the Locality with the capital Town of North Darfur State.





From Map 4-1 which shows the spatial configuration of the functional hierarchy of Localities, El Taweisha Locality and Umm Kaddada Locality (both of level 3) as well as Ailliet Locality (level 2) can be seen as an isolated territory. The functional hierarchy between El-Fasher and these Localities seems to broken due to the presence of level 1 Localities (El Kuma and Klaimendo) in between them. Also, whereas other Localities are linked to El-Fasher Locality with a primary road, Ailliet, El Taweisha and

Klaimendo Localities are connected with a secondary road. Among these isolated Localities, El-Taweisha Locality (level 3) can be seen as an emerging growth centre which can be of important to Ailliet and Klaimendo if upgraded.

The study also reveals that, the functional hierarchy of Localities in North Darfur state is not a perfect hierarchy where by higher order Localities possess all functions of lower order Localities (Table 4-1). For instance, it is striking to note that whereas all level 3 Localities have petrol station, Kutum a level 4 Locality do not have a petrol station. Also, Um Buru (a level 1 Locality) has custom office which is not present in Level 3 (except Mellit) and 2 Localities. It can therefore be said that both higher and Lower order Localities provide services to each other although the latter receive more services from the former.

Generally, the functional hierarchy of Localities in North Darfur State based on the MoF method depicts a unipolar system centered on El-Fasher Locality (Map 4 1), and thus reflects Losch economy of an economic system with focus on the most efficient central place. The high concentration of population (including IDPs) in El-Fasher Locality makes it an ideal economic (efficient) landscape in the provision of functions. The highly functional level of El-Fasher Locality compares to other Localities clearly epitomises an unbalanced regional development in North Darfur state.

5.3.2. Potential Uses and Limitations of the Matrix of Function in Post-Conflict Regional Planning and Resettlement of IDPs in North Darfur State

One major limitation of the MoF method in the classification of places (administrative units or settlements) into functional levels is that it does not consider the total number of each function in a place. The method is based on the absence or existence of at least one of each functional type in a place. Additionally, the classification of Localities into functional levels is not based on any standard classification method. The manual classification of Localities based on their centrality indices and presence of key functions is tedious and requires a lot of experience.

Notwithstanding the limitations of the MoF method in the analysis of functional levels of places in a region, the method can still be useful in post-conflict regional planning and resettlement of IDPs in North Darfur State. The MoF analysis in Table 4-1 gives a general overview of the present or absence of a cross section of functions which stakeholders consider as important to IDPs in each Locality in North Darfur State. This can help planners and decision makers design various service packages for each Locality particularly in Localities where IDPs are Located or will be resettled. Furthermore, during fieldwork in Khartoum, stakeholders were also of the view that the MoF analysis can help Planners in North Darfur State make a follow up to some Localities to find out why some functions do not exist in case they think that the function should have been available.

The functional predominance of El-Fasher indicates that it has a variety of functions compared to other Localities, and thus can be a potential place for the resettlement of IDPs. However, the distribution of population in North Darfur State in 2008 shows that El-Fasher Locality host about 20% of the population of North Darfur State while other Localities have population below 10% (Sudan Central Bureau of Statistics, 2008). In order to avert the current continuous migration of people (including IDPs) to El-Fasher Locality and or population concentration, planners and decision makers need to develop policies and plans that will bring about balanced regional development. For instance, Localities headquarters can be identified as growth centres and their functional suitability levels upgraded through the provision of functions that they do not have. From Table 4-1 important functions such as Doctors, registered nurses, banks and vocational schools which do not exist at all in some Localities can be made available in their

headquarters as a way of improving their functional levels as well as ensuring an equitable regional development.

Due to the availability of diverse functions in El-Fasher Locality compared to other Localities, the demand for services in El-Fasher Locality from the inhabitants of other Localities will be high particularly for functions which are only present in El-Fasher Locality like radio station, TV station, government regional hospital, private hospital with surgical capacity and court of appeal (refer to Table 4-1). Planners and decisions makers can identify the headquarters of some Localities which are further away from El-Fasher as growth centres for the provision of services which are not available in those Localities. For instance, the functional level of Kornoi can be upgraded with the provision of functions such as mobile phone repeaters, medical Doctors, petrol station, established grain stores, banks, electricity company, vocational school and other services which are absent (Table 4-1) with the aim of offering services closer to the population of Kornoi and surrounding areas like El Tina and Um Buru. Furthermore, the service level of Al Taweisha can also be upgraded with services like government hospital of regional status, radio station, Electricity Company, vocational school and manufacturing factory which are currently absent (Table 4-1) to service its population and surrounding Localities like Ailliet, Umm Keddada and Klaimendo.

Additionally, the functional levels of Localities if overlaid with existing road network can help in the identification of broken communication links for improvement, particularly between lower and higher order Localities. This can help strengthen the level of interaction between Localities. As shown in Map 4-1, with the exception of Al Sireaf Locality, all other Localities are linked to El-Fasher Locality with either primary or secondary roads. The provision of a good road network between Al Sireaf Locality and El-Fasher Locality will enhance their level of interaction in terms of trade and access to services. Additionally, the communication, link from Ailliet through Al Taweisha, Klaimendo, and Dar Alsalam to El-Fasher is a secondary road and can be improved to strengthen the link between the latter and the former Localities.

5.4. Functional Suitability Indices and levels of Localities based on Multicriteria Evaluation of Functions

The second objective of the study seeks to analyse the functional suitability of Localities to support decision making in the resettlement of IDPs using Multicriteria Evaluation method. Among the questions raised to achieve this objective include the following; (i) what is the functional suitability index of each Locality?; (ii) What are the functional suitability levels of Localities?; and (iii) what are the potentials uses and limitations of the Multicriteria Evaluation of functions in regional analysis of functions in the resettlement of IDPs?

The functional suitability index of Localities ranges from 0.85 for El-Fasher Locality to as low as 0.14 for Kornoi and El Tina Localities. Like in the MoF method, a large dropped in functional suitability index of 0.47 was also found between El-Fasher Locality and Umm Kaddada Locality which ranked first and second respectively (Figure 5-2). The high functional suitability of El-Fasher Locality compared to other Localities can be attributed to the following; (1) El-Fasher Locality has almost all the different functional types used in the study (35 out of 36 functions) and (2) generally, the total number of each type of function in El-Fasher Locality is high compared to other Localities.

Localities were classified into five levels based on their functional suitability index so that results can easily be compared with the functional hierarchy of Localities obtained in the Matrix of Function method. Figure 5-2 shows the functional suitability levels of Localities. On top of the hierarchy is El-Fasher Locality due to its functional suitability index dominance over other Localities. This implies that, El-Fasher Locality is highly attractive to IDPs, and thus a potential place for their resettlement.

Figure 5-2: Pyramid showing functional suitability levels of Localities based on Multicriteria Evaluation of functions



From Map 4-4, we can observe a hierarchical pattern in the functional suitability levels of Localities in North Darfur State. El -Fasher Locality which is a highly functionally suitable Locality is Located in the southern part of north Darfur state and surrounded by moderately functionally suitable Localities i.e. Kutum, Mellit, Kebkabiya, Tawilla and Klaimendo. Kutum, Mellit and Kebkabiya are adjoined by low functionally suitable Localities. Localities on the northern and western part of North Darfur State (El Tina, Kornoi, Um Buru, El Malha and Al Sireaf) are generally less functionally suitable compared to Localities at the central and eastern part of North Darfur State. The functional suitability level of Localities decreases as one move away from El-Fasher towards other Localities, particularly Localities to the north and west of El-Fasher are semi-arid areas with less population and services.

5.4.1. Potential Uses and Limitations of Multicriteria Evaluation of Functions in Post-Conflict Planning and Resettlement of IDPs in North Darfur State

As mentioned earlier, the Multicriteria Evaluation of functions is based on absolute number of functions. Due to the absence of complete population data of Localities in North Darfur State, the populationfunction ratio of functions could not be analysed and considered in the study. More value could have been added to the results if an indicator like population per function had been used in the evaluation. Additionally, the use of rank order weighting method to determine the importance of functions can result in an exaggeration of the relative importance of functions.

Notwithstanding the limitations of the Multicriteria Evaluation of Functions, it can be useful in postconflict planning and resettlement of IDPs. In the first place, the functional suitability levels of Localities as shown in Map 4-8 above can support individuals, government agencies and CSOs who are working on the resettlement of IDPs in North Darfur State make an inform decision in the identification of Localities that are functionally suitable for the resettlement of IDPs. In terms of functional suitability of Localities, El-Fasher Locality performs best with a score of 0.85 compared to other Localities with a functional suitability index less than 0.40 (Table 4-3). This shows that El-Fasher is highly attractive to IDPs, and thus a potential place for their resettlement.
Moreover, with the Multicriteria evaluation of functions, planners and decision makers will be well informed of the partial functional suitability of Localities in various broad categories of functions. For example, in terms of security services suitability, Umm Kaddada, Ailliet and Klaimendo equally perform better like El-Fasher (Figure 4-3a). This goes to say that, if decision makers are looking for Localities with a suitable security services for the resettlement of IDPs, then Umm Kaddada, Ailliet and Klaimendo are worth considering.

As indicated earlier in section 5.1.1, the high functional suitability of El-Fasher Locality to IDPs and possibly to the inhabitants of Darfur at large could be one of the reasons accounting for the concentration of about 20% of the population of North Darfur State in 2008 in El-Fasher Locality while other Localities have population below 10% (Sudan Central Bureau of Statistics, 2008). In order to avert the current continuous migration of people (including IDPs) to El-Fasher Locality and or population concentration, planners and decision makers need to develop policies and plans that will bring about balanced regional development. For instance, Localities headquarters can be identified as growth centres and their functional suitability levels upgraded through the provision of functions that they do not have. From Table 3-4, important functions or services such as Doctors, registered nurses, banks and vocational schools which do not exist at all in some Localities can be made available in their headquarters as a way of improving their functional suitability as well as ensuring an equitable regional development.

5.5. Comparison of Matrix of Function and Multicriteria Evaluation of Functions Methods

The third Objective of the study was to compare the MoF and Multicriteria Evaluation of functions methods. The specific questions of this objective include the following; (i) what are the criteria to be considered for comparing the two methods? and (ii) what are the differences and/or similarities of the two methods based on identified criteria for comparison?

As presented in section 4.4, the two methods were compared with regards to seven criteria: (1) nature of alternative systems being analysed, (2) data requirements, (3) ease of computation, (4) amount of interaction between system analyst and the decision maker (5) robustness of results to changes in parameter values, (6) weighted values/importance of functions and (7) consistency of results. These criteria should not be seen as exhaustive in comparing the two methods - they can be extended. A summary of the key differences and or similarities of the two methods based on the above criteria are discussed below;

The alternative systems being analysed by the two methods is the same – Localities in North Darfur State. In terms of data requirements and ease of computation of the two methods, the Multicriteria Evaluation of functions has a high data demand and also time consuming to implement than the MoF method. In the Multicriteria of Evaluation of functions, data on the total number of each function in a Locality might not be easy to gather, however if planners are able to collect such as data, it will give much insight on the functional level of a place than just the presence or absence of functions as used in the MoF method Also, basic background knowledge of a system analyst in mathematical addition and division operations are enough to implement the Matrix of Function method whereas in the Multicriteria Evaluation of functions, a person must have skills in Multiattribute Decision Making (MADM). Given the ease of implementation of the MoF method, system analyst without background in MCDM can easily adopt it in regional analysis of functions.

Multicriteria evaluation of functions requires much interaction time between stakeholders and the system analyst leading to a better representation of stakeholders' preferences than in the MoF method. In the

Multicriteria Evaluation of functions, stakeholders' preferences were represented first in the identification of important functions to IDPs and second in the determination of the relative importance of functions to IDPs. In the MoF method, the weight of a function is inversely proportional to its frequency and is driven using a prescriptive mathematical formula as defined by Rondinelli (1985).

A sensitivity analysis of the functional hierarchy of each method shows that the hierarchies are fairly robust. The weighted values of functions (centrality values) in the MoF method and the relative importance of functions based on stakeholders' prioritization show a weak negative correlation, however, the functional hierarchy of Localities of the two methods is fairly consistent. This is because, in both MoF and Multicriteria evaluation of functions methods, the number of functions in a Locality directly affects the centrality index and functional suitability index of Localities respectively. The consistency in the functional hierarchy of the two methods implies that the higher the centrality or functional level of a Locality as obtained in the MoF method, the higher its functional suitability to IDPs. In both methods, El-Fasher Locality is on top of the hierarchy with a wide functional gap between it and the next level. The functional suitability of other Localities if compared to El-Fasher Locality are generally low and need to be upgraded through the provision of services that are absent in those Localities to ensure a balance regional development. El-Fasher Locality is therefore a potential place for the resettlement of IDPs.

Generally, Multicriteria evaluation of functions can be seen as a normative method in regional analysis of functions whereas the MoF method is a descriptive method.

5.6. Limitations of the Study.

Some key limitations of the study which needs to be highlighted are as follows:

A regional analysis of functions at sub-administrative level as implemented in this study conceals differences at settlement levels. As mentioned earlier, data on the presence or absence of functions including the total number of a given type of function in each settlement could not be obtained except at Locality level (sub-administrative unit).

The application of different classification methods in defining the functional hierarchy of Localities of the two methods could have an effect on the consistency of results of the two methods. In the MoF method, a manual classification method was used to classify Localities based on their centrality indices but taken into account the presence of key functions whereas in the Multicriteria evaluation of functions, a natural jenks classification method was used to classify Localities based on their functional suitability indices.

As mentioned earlier, the Multicriteria Evaluation of functions is based on absolute number of functions. Due to the absence of complete population data of Localities in North Darfur State, the population-function ratio of functions could not be analysed and considered in the study. More value could have been added to the results if an indicator like population per function had been used in the evaluation.

Furthermore, the use of the MoF and Multicriteria Evaluation of function results in making resettlement decision might be limited by the fact that the identification of suitable area (s) for the resettlement of IDPs in Darfur cannot be based merely on functions availability but also factors like amount of rainfall, soil types, conservation areas, hazardous areas, etc.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The study has been able to apply and compared Matrix of Functions and Multicriteria Evaluation of functions methods in regional analysis of the functional hierarchy of Localities in North Darfur State with the aim of supporting decision making in the resettlement of IDPs. The comparison of the two methods has been made possible with regard to seven criteria. These criteria include; data requirements, ease of computation, amount of interaction required between the decision maker and system analyst, weighted values /importance of functions, the nature of the alternative system being analysed, consistency of results of methods and finally robustness of the results. A summary of the aforementioned criteria with regards to the two methods is provided below.

The alternative systems being analysed by the two methods in this study are the same i.e. 17 Localities. With respect to data requirements and ease of computation of the two methods, the Multicriteria Evaluation of functions has a high data demand and also time consuming to implement than the MoF method. Multicriteria evaluation of functions also requires much interaction time between stakeholders and the system analyst leading to a better representation of stakeholders' preferences than in the MoF method. A sensitivity analysis of the functional hierarchy of Localities of each method shows that the results are robust. In terms of consistency of results, the five levels functional hierarchy with a clear functional dominance over other Localities. The functional suitability of other Localities if compared to El-Fasher Locality are generally low and need to be upgraded through the provision of services that are absent in those Localities to ensure a balance regional development. El-Fasher Locality is therefore a potential Locality for the resettlement of IDPs.

Notwithstanding the fair consistency of the functional hierarchies of the Matrix of Functions and Multicriteria Evaluation of functions methods in this study, they have varied strengths and weaknesses. The two methods should therefore be seen as complementary in providing a much better understanding of the functional hierarchy of places in periods of post-conflict reconstruction to support decision making in the resettlement of IDPs and planning in general.

6.2. Recommendations for Further Study

A regional analysis of functions at administrative level conceals details at settlement level i.e., variability in the functional level of settlements is not known. I recommend that a regional analysis of functions in North Darfur state using MoF and or Multicriteria evaluation of functions be done at settlement level.

For a better insight on spatial network of Localities, I recommend that future studies on the functional hierarchy of places include an accessibility analysis based on drive time from low functional places to high functional places. Such an analysis will help in the identification of Localities that are inaccessible to high functional places as priority places in regional planning.

In the multicriteria evaluation of functions, absolute numbers of functions in each Locality were used and the utility function simplistically defined as the higher the number of function in a Locality the better off it is. This simplistic definition of the value function does not consider the average number of people serviced per function in each Locality. Future studies on multicriteria evaluation of functions should consider population-service ratios of functions. Such a relative indicator will give much insight on the functional suitability of areas.

Additionally, notwithstanding the relevance of a functional analysis of places in post-conflict regions, it does not provide much insight on the suitability of areas to support decision making in the resettlement of IDPs because important spatial factors and constraints such as hazardous areas, roads, topography, drainage, soil types, rainfall, pastoral routes etc. are not considered. Future studies on the identification of suitable areas to support decision making in the resettlement of IDPs in North Darfur State should not be limited to the evaluation of functions but include spatial factors and constraints.

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LIST OF APPENDICES

Appendix A: Reseach Matrix

Research Objectives and	Data requirement	Data collection	Method of analysis	
Questions		method		
Objective 1: To analyse the functional suitability of Localities to support decision making in the resettlement of IDPs using				
Multi-Criteria Evaluation method				
Sub/Operational Questions				
(a) Which settlement functions do stakeholders consider as important to IDPs?	List of a cross section of functions considered as important to IDPs	Questionnaire and Focus group discussion with Planners from Darfur Region, Khartoum State and UN-HABITAT	Excel worksheet used to analyse the frequency distribution of the number of stakeholders who think that a particular function is important for the resettlement of IDPs. This was complemented with FGD on functions important for the resettlement of IDPs.	
(b) What is the total number of each important function to IDPs in each Locality?	Inventory of the total number of each identified important function to IDPs in each Locality	Secondary data sourced from UN-Habitat	An attribute table showing the total number of each important function to IDPs in each locality	
(c) What are the main broad classes of functions?	Broad classes of functions	Secondary data sourced from UN-Habitat	Classification of functions within various broad categories of functions	
(d) What are the levels of importance of the main broad classes of settlement functions?	Level of importance of broad classes of functions	Questionnaire. Respondents include Planners from Darfur region, Khartoum State and UN-Habitat	Borda count method used to determine the level of importance of broad classes of functions based on stakeholders ranking of the broad classes of functions?	
(c) What are the levels of importance of settlement functions within each broad class of function?	Level of importance of functions within each broad class	Questionnaire. Respondents include Planners from Darfur region, Khartoum State and UN-Habitat	Borda count method used to determine the level of importance of settlement functions within each broad class based on stakeholders ranking of functions?	
(f) What is the functional suitability index of each Locality?	An attribute table showing the total number of each important function in each Locality. North Darfur Localities map (spatial data). Broad classes of functions ranked in order of importance. Functions under each broad class ranked in order of importance.	Field data analysis Secondary data sourced from OCHA Field data analysis Field data analysis	ILWIS SMCE tool used to structure and evaluate functions to obtain functional suitability indices of Localities	
(g) What are the functional suitability levels of Localities?	Functional suitability indices of Localities.	Field data analysis	Classification of Localities into levels by their functional suitability indices using natural jenks classification method	

	Functional suitability		
	levels of Localities.		
(h) What are the potentials	Functional suitability		
uses and limitations of the	indices of Localities		
MCE of functions in regional	ni broad functional	Field data analysis	
analysis of functions in the	Processes and data	Field data analysis	Content analysis and discussion
resettlement of IDPs?	involve in		
	implementing the		
	MCE method.		
Objective 2 : To come out with	n the functional hierarchy	of Localities suitability for t	he resettlement of IDPs using Matrix of
Function method	,	,	0
Sub/Operational Questions			
(a) Which settlement functions do stakeholders consider as important to IDPs?	List of a cross section of functions considered as important to IDPs	Questionnaire and Focus group discussion with Planners from Darfur Region, Khartoum State and UN-Habitat	Exec worksheet used to analyse the frequency distribution of the number of stakeholders who think that a particular function is important for the resettlement of IDPs. This was complimented with further discussion on the first 40 functions important for the resettlement of IDPs.
	Inventory of the		Technique of analysing frequency of
	presence or absence		functions in an ordered MoF as provided
(b) What are the frequencies	of settlement	Secondary data sourced	by Rondinelli (1985) and reviewed in
of functions?	functions in each	from UN-Habitat	section 2.6 was adapted. Analysis was
	Locality		done in an excel worksheet
			McE mathed survided by Readinalli
			(1985) and reviewed in section 2.6 was
(c) What is the weighted	Frequencies of		adapted. Refer to equation 1 in section 2.6
value of each function?	functions	Field data analysis	for formula used to calculate <i>weight of</i>
			functions.
			Analysis was done in an excel worksheet.
			Respective weighted values of functions
(d) What is the centrality	Weighted value' of	Field data analysis	summed up for each Locality (for only
index of each Locality?	functions		functions that are present). Analysis was
	0.1.1		done in an excel worksheet.
	Ordered matrix		Localities manually alocalities into
	which are present in		functional levels based on their centrality
(e) What are the functional	each Locality	Field data analysis	index but the taken into account the
levels of Localities?	each 130 canty	r tota ana ana yoto	presence of key central functions
	Centrality indices of		r
	localities		
(f) What are the potentials			
uses and limitations of the	Functional levels of		
MoF method in regional	Localities.	Field data analysis	Content analysis and discussion
analysis of functions in the	Processes and data		
resettlement of IDPs?	involve in		
	implementing the		
Objective 2. To compare Mart	wor method	critaria Exclustion math - 1-	in analyzing the functional biomethy of
Localities to support decision m	aking in the resettlement	of IDPs in North Darfur Sta	in analysing the functional nierarchy of
(a) What are the criteria to be	aning in the resettientent		
considered for the two	Criteria for	Literature review	Develop framework for comparing
methods?	comparing methods		methods

(b) What are the differences	Framework	
and/or similarities of the two	developed to	
methods based on identified	compare the two	
criteria for comparison?	methods.	
	Process involve in	Content analysis
	implementing each	
	method, results &	
	data requirements	

Appendix B: Context of Questionnaire

PART ONE

This research is in partial fulfilment of the requirement for the award of a Master of Science degree in Geo-information Science and Earth Observation in Urban Planning and Management. The aim of the study is to provide a regional understanding of the functional hierarchy of settlements suitability for the resettlement of Internally Displaced Persons (IDPs) in Darfur. Data to be provided will be used confidentially and solely for this study.

Please respond to the question below. It will take a maximum of 10 minutes of your time.

Date.....

Job title of respondent.....

Which Town/settlement do you live?in which

Locality.....?

Q1. Which of the following settlement functions do you consider as important for the resettlement of IDPs? Please tick ($\sqrt{}$) between 30 – 40 functions.

Category/group of		Settlement functions	Please tick ($$) between 30
function			– 40 functions.
	1	Army camps	
Security services	2	Police station	
	4	Prison service	
	5	Custom office	
	7	Customary courts	
	8	Court of appeal	
Judiciary services	9	Special criminal courts	
	10	Statutory courts	
	11	Government regional hospitals	
Health facilities/services	12	Rural hospitals/health stations	
	13	Private hospital with surgical capacity	
	15	Doctors	
	16	Registered Nurses	
	17	Midwives	
	19	Pharmacists	
	20	Nursery school	
	21	Primary school	
Educational institutions	22	Secondary school	
	24	Vocational/technical school	

	25	Radio station
Public utilities and	26	TV station
facilities	27	Mobile phone repeaters
	28	Water supply company
	29	Permanent water supply
	30	Electricity Company
	31	Irrigation system
	33	Bus terminals
	34	Filling station
Transportation Services	35	Horse drawn-carriages
	36	Petrol Station
Commercial	37	Groceries
establishments	38	Established grain stores
	39	Manufacturing industry
	41	Bank
	42	Animal market
	43	Crop market
	44	Animal and crop market
Government extension	46	Local government office/Municipal
services		administrative service
	47	Agricultural office
	49	Welfare service
	50	Animal health office
		Specify Others below

PART TWO

This research is in partial fulfilment of the requirement for the award of a Master of Science degree in Geo-information Science and Earth Observation in Urban Planning and Management. The aim of the study is to provide a regional understanding of the functional hierarchy of settlements suitability for the resettlement of Internally Displaced Persons (IDPs) in Darfur. Data to be provided will be used solely for this study.

Please respond to the questions below. It will take a maximum of 10 minutes of your time.

Date.....

Job Title of Respondent.....

Locality name.....

Q1. Rank the following **category of functions by their** *level of importance* for the resettlement of IDPs. NB: Order of ranking should be from 1(highest) – 8 (lowest)

Category/group of functions Ranking		
	Category/group of functions	Ranking

Q2a. Rank the following **Security Services** by their level of importance for the resettlement of IDPs. NB: Order of ranking should be from 1(highest) – 6 (lowest)

Security services	Ranking
Army camps	
Police station	
Prison service	
Custom office	

Q2b. Rank the following **judiciary functions** by their level of importance for the resettlement of IDPs. NB: Order of ranking should be from 1(highest) - 4 (lowest)

Judiciary function	Ranking
Customary courts	
Court of appeal	
Special criminal courts	
Statutory courts	

Q2c. Rank the following **educational functions** by their level of importance for the resettlement of IDPs. NB: Order of ranking should be from 1(highest) - 4(lowest)

Educational functions	Ranking
Nursery school	
Primary school	
Secondary school	
Vocational/technical school	

Q2d. Rank the following **health functions** by their level of importance for the resettlement of IDPs. NB: Order of ranking should be from 1(highest) - 7 (lowest)

Health functions	Ranking
Government regional hospitals	
Rural hospitals/health stations	
Private hospital with surgical capacity	
Doctors	
Registered Nurses	
Midwives	
Pharmacists	

Q2e. Rank the following **commercial establishments** by their level of importance for the resettlement of IDPs. NB: Order of ranking should be from 1(highest) - 7 (lowest)

Commercial establishments	Ranking
Groceries	
Established Grain Stores	
Banks	
Manufacturing industry	
Animal market	
Crop market	
Animal and crop market	

Q2f. Rank the following **Public Utilities/facilities** by their level of importance for the resettlement of IDPs. NB: Order of ranking should be from 1(highest) - 6(lowest)

Public Utilities/facilities	Ranking
Radio station	
TV station	
Mobile phone repeaters	
Water supply company	
Permanent water supply	
Electricity company	

Q2g. Rank the following **Transportation Functions** by their level of importance for the resettlement of IDPs. NB: Order of ranking should be from 1(highest) - 3(lowest)

Transportation Functions	Ranking
Bus terminals	
Horse drawn-carriages	
Petrol Station	

Q2h. Rank the following **Government Extension Services** by their level of importance for the resettlement of IDPs. NB: Order of ranking should be from 1(highest) – 4 (lowest)

Government Extension Services	Ranking
Local Government office/municipal administrative	
service	
Agricultural office	
Animal health office	
Welfare service	

S/N FUNCTIONS Number of Stake	eholders
1 Police station 10	
2 Rural hospitals/health stations 10	
3 Doctors 10	
4 Registered Nurses 10	
5 Midwives 10	
6 Primary school 10	
7 Secondary school 10	
8 Water supply company 10	
9 Potable water supply source 10	
10Electricity Company10	
11Horse drawn-carriages10	
12 Groceries 10	
13Animal market10	
14Crop market10	
15Local government office10	
16Agricultural office10	
17Animal health office10	
18Customary courts9	
19Government regional hospitals8	
20Mobile phone repeaters8	
21Bus terminals8	
22Bank8	
23Welfare service8	
24Court of appeal7	
25Special criminal courts7	
26Vocational/technical school7	
27Manufacturing industry7	
28National guards7	
29Army camps6	
30Prison service6	
31Custom office6	
32 Nursery school 6	
33 Radio station 6	
34Animal and crop market6	
35Statutory courts5	
36Private hospital with surgical capacity5	
37 Petrol Station 4	
38 Established grain stores 4	
39 TV station 4	

Appendix C: Frequency distribution of the number of stakeholders who think that a particular function is important to IDPs

40	Pharmacists	4
41	Irrigation system	3
42	Train station	3
43	Fire Station	2
44	Dentists	2
45	National Grain Authority	2
46	Carpentry shops	2
47	Grain mills	2
48	Post-secondary college	1
49	Blacksmiths	1
50	Handcraft markets	1
51	Adult literacy centres	1
52	Women Development centre	1
53	Unspecified market	1



Appendix D: A snapshot of ArcGIS natural jenks classification break values of functional suitability index

Appendix E: Example of search strategy in Web of Science database for literature on compariosn of methods in regional analysis of functions.

Web of Science®

Search History

Set	Results	Save History / Create Alert Open Saved History
#5	3	#4 AND #3 AND #2 AND #1 Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=All Years Lemmatization=On
#4	1,032,290	TI=(compar*) OR TI=(difference*) OR TI=(similarit*) Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=All Years Lemmatization=On
#3	534,471	TI=(towns) OR TI=(settlement*) OR TI=(administrative*) OR TI=(region*) OR TI=(place*) Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=All Years Lemmatization=On
#2	1,091,489	TI=(function*) OR TI=(service*) Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=All Years Lemmatization=On
#1	392,947	TI=(Matrix) OR TI=(scalogram) OR TI=(scale) Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=All Years Lemmatization=On

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United Nations Human Settlement Programme (UN-HABITAT Urban and Regional Planning for Darfur Region

Checklist for available locality facilities and Functions

Administrative unit......State............Locality......Locality......

Data Set Class	Data Required	Availability			Location (village, settlement or town)	Comments/remarks: e.g
1. Public Utilities and Facilities		Yes	No	count (if possible)		
	 Mobile Phone repeater Post office Radio Station TV station Police station Fire station Electricity company Amny camp Water supply company Permanent Water supply Source National Highway Irrigation system 					

79

	 IDP Camps Refugee Camp 	
2. Transportation Services	 Bus termini Horse-drawn carriages Airstrip/airport Train station Petrol station 	
3. Commercial Establishments	 Established grain stores Groceries Auto repair garage Bakeries Barks Banks Hardware (building materials) store Hardware (building materials) store Turniture shops Chemists Manufacturing factory cooking fuel store/depot animal market Crop market Unspecified market animal and crop market 	
4. Health Facilities	 Government Regional Hospital Rural hospitals/health stations Private hospital with surgical capacity Specialized hospitals 	
5. Recreational Facilities	 Football field Recreational halls Cultural centers Cinema (??) 	
 Government Extension Services 	 Agricultural office Local government Office/Municipal administration services 	

	 National grain authority office Forestry Animal health office Welfare service 		
7. Judiciary services	 Customary Court Court of Appeal Special Criminal Courts Statutory Courts 		
8. Security Services	 Police station Fire Station National Guard Prison Customs Office 		
9. Community Organizations	 Religious organization Trade/labor union Cooperative union 		
10. Educational institutions	 Kindergartens/nursery schools Primary schools Secondary schools Post-secondary colleges Universities Vocational schools 		
11. Health Services	 Doctors Registered Nurses Midwives Dentists Pharmacists herbalists 		

12. Professional Services	•	Lawyers			
	•	Engineers			
	•	Accountants			
	•	Architects			
	•	Building contractors			
	•	Surveyors			
	•	Teachers			
	•	Licensed electricians			
	•	plumbers			
13. Personal Services	•	Barber shops			
	•	Tailor shops			
	•	Hotels and lodgings			
	•	Cafeterias			
	•	Laundries			

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	Manually classified functional levels Locality MAR	El-Fasher	Kutum	Sharaf Omra	Mellit	Umm Kaddada	Kabkabiya	Al Taweisha	Alaeit	Alsiraif	Dar Alsalam	Ta weel a	El Malha	El Kuma	ELTina	Kalamendo	Karnoi	Um Buru	Frequency of functions	Total Centrality	Weighted value' of function	
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	Engineers																		7	100	14.3	
	Banks																		7	100	14.3	
	IDPs Camps																		7	100	14.3	
	sgnigbod bne sletoH																		8	100	12.5	
	Furniture shops																		8	100	12.5	
	Cooking fuel Store/depot																		6	100	11.1	
	Established Grain Stores																		6	100	11.1	,
	Petrol Station																		6	100	11.1	

MATRIX OF FUNCTION LEGEND Functional Levels Level 5 - highlyfunctional level

Level 3 - moderately functional level

Level 4 - functional level

Function present Function absent Level 1 - very low functional level

Level 2 - Iow functional level