AN INTEGRATED MODELLING APPROACH TO ASSESS INDUSTRIAL LOCATION SUITABILITY IN THE GA WEST MUNICIPALITY, GHANA

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February, 2019

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ABSTRACT

Industrial location decision making is of crucial importance to both entrepreneurs and municipal authorities. Multiple factors interact to determine the most optimal locations in the industrial suitability analysis. Previous studies have mostly derived possible location factors from the literature or from the local knowledge of a given study area. However, only a few studies have obtained the factors through expert interviews. The aim of this research is therefore to explore the influence of location - specific factors on industrial site selection decisions in the Ga west municipality of Ghana. AHP Multi-criteria Evaluation method is integrated with expert knowledge to assess the suitability of various locations in the municipality for industrial development. In view of this, 5 expert interviews were conducted with top business officials to elicit information concerning the location factors that were considered during the site selection for 5 manufacturing firms in the Ga west municipality. 15 factors collated from the interviews were used to construct the AHP questionnaire consisting of 40 pairwise comparisons for rating by 32 respondents drawn from large scale manufacturing firms in the municipality.

Data analysis was undertaken in two phases, firstly, global weights were computed from the AHP scores to obtain the highest and lowest rated factors according to the respondents' perceptions. Secondly, following the validity analysis, 8 most important factors were selected and processed into standardized raster map layers for the weighted suitability model. Prior to the suitability analysis, 4 ecologically sensitive areas comprising rivers and streams, floodable areas, nature reserve and slopes greater than 15% were erased from the study area in a process referred to as the constraint analysis. The constraint analysis assumed that the built –up area and the waste sorting site were not likely to be converted into industrial land use hence they were also erased.

The results from the global weights showed that respondents perceived the "availability of developable land" and the "distance to Accra waste sorting plant" as the most important location factors in the municipality. The distance to the Municipal Assembly was a less important factor according to the global weights. It was interesting to note that despite the many mineral water producing companies who use groundwater available in the municipality, this factor was the least important in the assessment. This result can be interpreted that respondents perceived economic factors such as the "availability of developable land", the "availability or proximity to raw material source" and "distance to CBDs" as more important than the socio-economic factors.

The constraint analysis revealed that more developable land was available in the north eastern and south western parts of the municipality. Therefore the weighted suitability model concerned itself with analysing the two areas in terms of suitability. The final weighted suitability model is an ArcGIS output showing the ranking of 5 suitable industrial areas from the best to the worst. The results from the model indicated that the Doboro - Mpehuasem and Hebron – Korleman - Gonse areas were the most highly rated areas; this identified them as future prime industrial areas. Although disadvantaged in terms of proximity to some location factors, the abundance of land in these areas played a major role in the model by influencing the suitability rankings. When the factors were analysed for reliability and validity, the results suggested that all the 15 factors used in the AHP questionnaire were relevant. This finding implies that the model is highly practicable in the study area.

The general objective of this research was to develop an approach to understand how location-specific factors determine prime industrial areas the Ga west municipality. The findings show that comparative advantages play a significant role in industrial location decisions in Ga west. The research therefore recommends that the Municipal Assembly embarks on the improvement of the conditions of roads, extension of health facilities and the provision of market centres in prime industrial areas. Furthermore, a spatial database for all settlements in the municipality is recommended to improve on industrial zoning and urban planning in the municipality.

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"Great is the LORD and most worthy of praise…" Psalm 145:3

Enschede, February 2019.
Elsie Angeley Nai

TABLE OF CONTENTS

1. Introduction 1
   1.1. Background and justification 2
   1.2. Problem statement 4
   1.3. Research objective 4
   1.4. Thesis structure 5
2. Literature review 7
   2.1. Definition of suburbs or suburbanization 7
   2.2. Analyzing metropolitan expansion and the suburbanization of manufacturing 8
   2.3. Dimensions of industrial location in Africa's metropolitan areas 9
   2.4. GIS based multi-criteria evaluation for land suitability 11
   2.5. Multi-attribute evaluation methods for land suitability 14
   2.6. Conceptual model 21
3. Study area 23
   3.1. Administrative placement and infrastructure 23
   3.2. Physical and urban characteristics 24
   3.3. Population and physical expansion 24
   3.4. Land use transformation 25
   3.5. Industrial land demand in the Ga west municipality 29
   3.6. Overview of employment by industry 30
   3.7. Rationale for selecting the study area 31
4. Methodology and data 33
   4.1. Research approach 33
   4.2. Analyzing AHP questionnaire 36
   4.3. Secondary data justification and variable selection 41
   4.4. Data processing 43
   4.5. Constraints to industrial development 45
   4.6. GIS weighted suitability model 48
5. Results and discussion 49
   5.1. Summary of the analyses with reference to estimating industrial location suitability 49
   5.2. Summary of the Euclidean distance analysis in the research 54
   5.3. Summary of reliability and validity analyses 56
6. Conclusion and recommendations 59
   6.1. Objective 1 59
   6.2. Objective 2 59
   6.3. Objective 3 59
   6.4. Objective 4 60
   6.5. Recommendations 60
   6.6. Strengths of the research 61
   6.7. Limitations of the research 61
   6.8. Directions for future research 62

LIST OF FIGURES

Figure 1. Structure of a standard SDSS........ 11
Figure 2. MADM (a) and MODM (b) models........ 13
Figure 3. Alternatives illustrated in a grid cell........ 14
Figure 4. Decision strategy space in OWA........ 16
Figure 5. A four-level hierarchy of industrial site suitability problem........ 18
Figure 6. Conceptual model describing interrelated concepts........ 21
Figure 7. Ga west municipality in the context of the Greater Accra metropolitan Area (GAMA). 23
Figure 8. Existing land uses in 1897 expressed as percentages of the total land area. 26
Figure 9. Existing land uses in 2003 expressed as percentages of the total land area. 27
Figure 10. Existing land uses in 2017 expressed as percentages of the total land area 28
Figure 11. Employment by industry in 12 localities with manufacturing establishment, 2010........ 30
Figure 12. Explorative sequential mixed methods design........ 33
Figure 13. Research methodology........ 34
Figure 14. AHP analysis........ 37
Figure 15. Cronbach's alpha analysis........ 39
Figure 16. Pearson's correlation analysis........ 40
Figure 17. Hierarchical structure showing general factors and sub factors........ 41
Figure 18. Data processing - independent variables. 44
Figure 19. Development constraints analysis workflow........ 47
Figure 20. Existing developable land in 2017. 52
Figure 21. Final weighted suitability model........ 53
Figure 22a – c. Relationship between reliability, validity and global weights........ 57

LIST OF TABLES

Table 1: Saaty's ratio scale 19
Table 2.: Random Consistency Index 20
Table 3: Projected population comparison between Ga west municipality and Accra metropolis 25
Table 4: Estimated percentage changes in total population 25
Table 5: Historical land use transformation in Ga west from 1987 to 2017 29
Table 6: Changes in industrial land takes among 12 localities with manufacturing establishments 29
Table 7: Summary of datasets, the dates of collection and sources 45
Table 8: Factor weights and ranking 50
Table 9: Factor selection 51
Table 10: Land take by suitable area 53
Table 11: Map statistics 55

ABBREVIATIONS

AHP	Analytic Hierarchy Process
ANP	Analytic Network Process
CBD	Central Business District
CERSGIS	Centre for Remote Sensing and Geographic Information Services
CI	Consistency Index
CR	Consistency Ratio
D - AHP	D - number Analytic Hierarchy Process
DEM	Digital Elevation Model
DSS	Decision Support Models
EPA	Environmental Protection Agency
GAMA	Greater Accra Metropolitan Area
GIS	Geographic Information System
IGF	Internally Generated Funds
LU	Land Use
MADM	Multi-Attribute Decision Making
MCDM	Multi- criteria Decision Making
MCE	Multi – criteria Evaluation
MODM	Multi-Objective Decision Making
MPCU	Municipal Planning Coordinating Unit
OWA	Ordered Weighted Averaging
RI	Random Consistency Index
SAP	Structural Adjustment Policy
SDSS	Spatial Decision Support System
SEZs	Special Economic Zones
SMCE	Spatial Multi – criteria Evaluation
TOPSIS	Technique for Order of Preferences by Similarity to Ideal Solution
UA	Urban Agglomerations
UNECA	United Nations Economic Commission for Africa
WAM	Weighted Arithmetic Mean
WGM	Weighted Geometric Mean
WLC	Weighted Linear Combination

1. INTRODUCTION

The industrial revolution which occurred in the last part of the nineteenth century caused the dramatic economic growth of cities in developed countries. The population in cities such as Manchester, England increased exponentially due to the rapid industrial expansion and technological improvements in the manufacturing of consumer goods (Douglas, Hodgson, & Lawson, 2002) .

Modern day cities have become models of the industrial revolution where still economic prosperity is linked to manufacturing and rapid urbanization. The high population densities in contemporary cities provide support for the production of goods and services. They attract talents and skilled labour which enhances specialization (UN-HABITAT, 2011). In many developing countries, cities are also the places where most of a country's public infrastructure which promote business productivity including highways, telecommunication systems and water treatment is concentrated (Eberts & McMillen, 1999; Vernon, 2009). However, cities undergo various growth cycles. As the economy of a country develops, the expansion of transportation infrastructure to the suburbs coupled with the ever increasing cost of labour and rents in the city compels manufacturing firms to locate or relocate to the suburbs where rents and labour wages are cheaper with areas highly accessible from the core city (Harris, 2015; Vernon, 2009). US cities; Detroit, Philadelphia (Águeda, 2016) and British cities, York and Hull (Sunley, 2015) are examples of cities in this type of transition.

The suburbs do not only become the destination for fleeing manufacturing activities but also for a large number of families who arrive in search of cheaper land for residential purposes. As a result of increasing human activities and rapid population growth, many suburbs present a landscape in a rural – urban transition. This characteristic may be well recognized as the most basic description of suburbs (Forsyth, 2012). However, the suburbs and the related process of suburbanization mean different things globally; this situation has created an overwhelming confusion as to what the actual definition of a suburb or suburbanization is (Forsyth, 2012; Harris, 2010). The problem of finding a universal definition has become a challenge due to the differences in the form and functions of suburban areas (Forsyth, 2012). Some authors define suburbanization from the perspective of the work and home relationship between the suburb and the nearest urban area (Altshuler, Morrill, Wolman, & Mitchel, 1999; Mieszkowski & Mills, 1993), others compare increases in population densities and urban form over time in former rural areas (Zebik, 2011) and many others refer to changes in the type of buildings and land uses (Forsyth, 2012; Harris, 2015). The study area of Ga west municipality is suburban in character, therefore in search of a practical meaning of suburban for the case study, the research agrees with (Johnson, 2006; Leigh & Lee, 2005; Turcotte, 2008) and recognizes the Accra metropolis (including the core area) as the inner ring city and the surrounding suburban municipalities in the GAMA area as the outer ring suburbs. The nuanced nature of the suburban definition is explained further in the literature review.

The primary objective of a firm is to maximize profits and minimize costs, as a result, the decision of where to locate or relocate is seen as a very crucial managerial decision. Poor location can lead to higher costs in the forms of increased transportation costs and higher investments. The operations of the firm can also be affected by inadequate supply of raw materials, shortage of qualified labour, frequent interruption of production and dissatisfied customers and employees (Lee, 2011; Waters, 2002). In selecting a new location for a firm, entrepreneurs aim at choosing the most optimal location with minimum costs (Krzyzanowski, 1927).

The rationality of entrepreneurs means that they are well informed of the comparative advantages that each potential location presents, and understand that not all locations in a particular geographical area are suitable for siting a particular firm.

Because of the economic growth and development that comes along with manufacturing industries, many suburban municipalities in developing countries have drawn up strategies including industrial zoning to attract manufacturing firms (Wang, 2013) . However, drawing up strategies and the enforcement of stringent industrial zoning stifles the industrial development of a municipality (Ferraldo, 2012) . Municipal authorities must recognize that certain important factors and conditions determine whether or not a firm would establish at a particular location.

The literature is rich with theoretical approaches to industrial location using Decision Support (DSS) Models (Rikalovic, Cosic, Labati, & Piuri, 2015) but shows a serious shortage of empirical studies that attempt to explain how specific factors influence the suitability of geographical areas for industrial activities. (Kimelberg & Williams, 2001) .

In many countries of the developing world, municipalities lack spatial information on settlements (Bishop et al., 2000) therefore, studies that evaluate the geographic advantages of different areas in terms of their industrial location suitability would enrich existing spatial knowledge and increase the understanding of how specific spatial factors influence the ranking of industrial locations. This understanding is crucial to improvements in the effectiveness and efficiency of industrial zoning in the municipalities.

1.1. Background and justification

Most commonly, studies of industrial location suitability have hinged on the factors that entrepreneurs' consider whilst selecting locations for industrial firms. However industrial location factors were identified by the early economists who made substantial contributions to the theory of industrial location. von Thunen, "the father of location theorists" was the first economist to attempt to conceptualize the factors that influence the location of industries (Safari & Soufi, 2014). Other theorists like Wilhelm Launhardt further advanced the ideas of the Thunen model (Puşcaciu, 2014) , however, the German geographer, Alfred Weber was the first to add a scientific explanation to the theory of industrial location (Jirásková, 2002). Weber's theory identified primary and secondary factors that caused industries to move from one geographic area to the other. He referred to Primary causes as transport and labour costs and the secondary causes he described as agglomerative and deglomerative factors (Weber, 1929). However, his model attracted a lot of early criticisms from many authors. For instance, according to Predöhl (1928), Weber's theory was more selective than deductive. He posits that the primary and secondary causes of industrial location in the theory are not realistic nor logical and that other factors like "capital costs" and management costs also affect the choice of location for industries thus the factors are not limited to transportation and labour costs. In addition, Predöhl (1928), explains that Weber failed to analyse the technical factors behind agglomeration. He asserts that agglomeration factors such as access to power, water, consumers and specialized machinery are too heterogeneous and that the model fails to identify how much cost can be reduced by agglomeration.

Another notable critic of Weber was S.R. Dennison. According to this critic, Weber's theory was too overburdened with technical considerations; that is; it deviates from two factors "costs" and "prices" and therefore cannot be termed a classic economic theory (Dennison, 1937) .
Irrespective of the criticisms of Alfred Weber's theory, an analysis by Djwa (1960) points to the fact that several early publications recognized the importance of transportation, raw material source, markets, and labour as the most important factors influencing the location of industries.

Advancements on Weber's agglomeration forces did not expire with the outdating of the earlier economists. Hoover (1937) classified agglomeration into large scale economies, localization economies and urbanization economies. In furtherance to the theory of agglomeration, it was Isard (1956) who discovered the relevance of the effects of scale economies, localization economies and urbanization economies on industrial location (Palacios, 2005). Isard (1956) gave a detailed explanation to Hoover's classification, he posited that localization economies occurred when similar firms in the same industry converged at a particular location to benefit from a common resource pool, or common facilities and infrastructure. He further referred to urbanization economies to occur when different firms concentrated in a particular location; that is when firms are "spatially juxtaposed" (Isard, 1960; Palacios, 2005).

Although the earlier theories of industrial location include factors that are still relevant, they do not have a universal application because regions are not identical and different comparative advantages exist in different geographical areas (Martin, 2004). In addition, locational factors vary depending on the type of industry, the target market and employees and so on (Kalantari, 2013).

A practical approach to solving this problem is to model industrial location suitability by assessing location factors based on empirical judgments instead of theoretical data. This approach eliminates the likelihood of including factors which do not necessarily describe the region in question. The approach also assumes a scientific nature which makes it transparent and repeatable (Rauber, Miksa, Mayer, & Proell, 2015).
An empirical approach to industrial location suitability would provide invaluable and accurate locational information to entrepreneurs which would assist them in their future site selection decisions. Accurate locational information on settlements will inform local authorities and urban planners on the comparative advantages of different areas of a municipality which is an indispensable input in industrial zoning.

One of the most powerful methods for assessing industrial location suitability based on empirical information is the spatial multi-criteria evaluation. Spatial multi-criteria evaluation "can be thought of as a process that combines and transforms a number of geographical data (input) into a resultant decision (output)" (Drobne & Lisec, 2009, p.463). The main aim of the method is to determine areas suitable for a specific objective based on several criteria or conditions that the area should satisfy (Eastman, 2005).

Since the late 1980s Geographic information system has been integrated into spatial multi-criteria evaluation to support spatial decision making (Mousseau & Chakhar, 2015). Consequently, GIS based multi-criteria evaluation has been widely used to solve complex industrial location suitability problems (Tienwong, Dasananda, & Navanugraha, 2009; Zhou & Wu, 2012) due to the ability of GIS to combine a variety of geographical data to analyse spatial phenomena (Huang, 2018).

Finding suitable locations for industrial activity is a complex problem whose solution involves the analysis of multiple factors. The most widely used approach is to decompose the problem into simple component parts or hierarchies referred to as the Analytic Hierarchy Process (AHP) (Saaty, 2008). A comparison is made between factors to establish the relative weights of similar location factors in each level of the hierarchy according to a 1 to 9 ratio scale (Song & Kang, 2016) proposed by Saaty (1980) (Thomas L. Saaty). These ratio values are later integrated into the GIS multi-criteria evaluation for further analysis.

AHP was a choice method for this study because of the possibility of incorporating both expert knowledge and subjective judgments in the decision making process (Rahman & Saha, 2008; Store & Kangas, 2001; Ullah & Mansourian, 2016). This approach also supports both quantitative and qualitative data analysis (Rahman & Saha, 2008).

In this research, expert interviews were conducted to identify the most important factors influencing location decisions for large scale manufacturing firms in the Ga west municipality of Ghana. The AHP method was used to compare and measure the subjective judgments of business officials using Thomas Saaty's ratio scale. Spatial data based on subjective judgments were gathered and entered into a GIS-based multi-criteria evaluation to rank areas in the municipality according to their levels of industrial suitability.

To date there is no previous study that has used GIS methods to investigate industrial location in a municipality in Ghana. The present study therefore demonstrates how the integrated GIS based multi-criteria evaluation and human judgements can be implemented for industrial location suitability in a municipality in Ghana. The success of this research is an opportunity to learn more about the municipality in terms of urban planning and economic development.

1.2. Problem statement

Modelling industrial location suitability involves the consideration of complex interactions between multiple technical, social, economic and environmental factors (Badri, 2007; Batista e Silva, Koomen, Diogo, & Lavalle, 2014). The complexity of the interactions arises from the manner that different factors operate to determine industrial location at different temporal and spatial scales. For instance, while general industrial location factors (Badri, 2007) may be appropriate for assessing industrial location suitability, location factors related to manufacturing, construction or hospitality industries are likely to vary.
Similarly, factors within the same socio-economic category may operate at different scales, for instance, “Distance to waste sorting plant” and “Groundwater potential” may operate at different spatial scales (Kelly et al., 2013).

This differences in scales call for a modelling approach that provides a basis to combine multiple information from different sources and different scales as well as expert knowledge into an aggregated model output. Many urban planning decisions in developing countries are ineffective (Ahmed, A., Dinye, 2011; Vaggione, 2013) due to the poor understanding of land use systems among planners and decision makers (Tennøy, Hansson, Lissandrello, & Næss, 2016). The effect of this is that, planners resort to excessive zoning (Vaggione, 2013) and the use of outmoded urban planning practices which do not embrace the changing trends in land use planning. The use of outdated practices and reliance on excessive zoning constrains economic development and impacts the well-being of citizens.

In response to the scale problem arising from the complex interactions between location factors as outlined above, this research utilized an integrated GIS based multi-criteria evaluation and the AHP method to assess the suitability of industrial areas in the Ga west municipality with respect to economic, socio-economic and telecommunication and transportation factors.

An integrated approach to the suitability analysis will enhance entrepreneurs and planners’ understanding of how location-based factors determine prime industrial areas in the Ga west municipality. Furthermore, the model fills an academic research gap as it contributes to empirical research on industrial location suitability.

1.3. Research objective

To develop an approach to understand how location-specific factors determine prime industrial areas in the Ga West Municipality.

1.3.1. Specific objectives

1. To assess the patterns of industrial land use in the municipality for 1987, 2003 and 2017.
2. To identify and evaluate major factors influencing the location of large scale manufacturing industries in Ga west.
3. To determine a suitable method to identify areas that are potentially suitable for industrial development in the municipality
4. To determine which areas in the municipality are prime locations for industrial development.

1.3.2. Research questions

The research questions stipulated below are expected to address the specific objectives of the research;

1. To assess the patterns of industrial land use in the municipality for 1987, 2003 and 2017.

a) Which localities in Ga west experienced an increase in industrial land-take for the three periods?
b) How much additional industrial land area was developed in the localities identified in question 1?

c) Which areas in the municipality indicated a tendency for industrial clustering during the three periods?

2. To identify and evaluate major factors influencing the location of large scale manufacturing industries in Ga west.
a) What factors did business owners consider in selecting the location for their manufacturing plants in the municipality?
b) What factors did business owners consider as most important during the site selection process in question 1?

3. To determine a suitable method to identify areas that are potentially suitable for industrial development in the municipality.
a) What kind of result/output is expected from the method to be identified?
b) What method can be used to identify suitable areas for industrial development in the municipality?
c) Can the method produce the required results/outputs?
d) What are the limitations of the method?

4. To determine which areas in the municipality are prime locations for industrial development
a) Which areas in the municipality are potentially preferred by business owners in locating their manufacturing plants?
b) What area of land is available in the various preferred locations for future industrial development?

1.4. Thesis structure

This thesis report is divided into six chapters; the introduction, literature review, study area, methodology and data, results and discussion and the conclusion and recommendations.

Chapter 1: introduction; gives a background to suburbanization and industrial location decisions. The scope of the research and justification for the topic is described here. The significance of the research is also expatiated in the problem statement in addition to a description of the research's expected contribution to the understanding of industrial location decision making in the Ga west municipality. The chapter also gives an overview of the choice of methods used and presents the general objective, the specific objectives and research questions.

Chapter 2: literature review; evaluates various authors' definition of the suburb, the regional dynamics of manufacturing suburbanization and analyses several dimensions and empirical studies on industrial location in the African region. A background is given on the GIS multi-criteria evaluation concept followed by a discussion on the application of the method in the context of industrial land/location suitability. Evidence of the effects of agglomerative forces in industrial location is established from previous studies and lastly the application of the AHP method is discussed in more detail.

Chapter 3: study area; gives an overview of the Ga west municipality in the context of the Greater Accra Metropolitan Area (GAMA). The location, physical characteristics and the rationale for undertaking the research in this municipality is explained. Population projections for the municipality is analysed in comparison with the Accra metropolis. Land use transformation with emphasis on industrial land use patterns are analysed from 1987 to 2017. An overview of industrial land demand in the municipality is given and localities are compared according to the number of people employed in industry from the 2010 population and housing census.

Chapter 4: methodology and data; outlines how the integrated GIS multi-criteria evaluation and AHP approach was applied in the research .The chapter explains the basis for the selection of the samples for primary data collection. The chapter again describes the methods used for collecting primary and secondary data. The independent variables obtained from the data collection and data processing are furthermore outlined and the rationale and application of the weighted suitability method is also presented.

Chapter 5: results and discussion, in this chapter, all the results of analyses performed in the research are presented and interpreted in response to the research questions posed in the study. Descriptive statistics on respondents' scores; correlations between reliability tests, validity tests and factors' weights, tables showing AHP Pairwise results and the results of the constraints analysis as well as the results of the weighted suitability model itself are all presented and discussed.

Chapter 6: the conclusion and recommendations chapter explains the extent to which the research met the objectives stated in the introduction. The strengths of the research towards achieving the general objective is outlined as well as the limitations faced in executing the research methodology. Some important recommendations to achieve economic growth and to improve on industrial zoning is also expatiated. The chapter suggests various ways to address the limitations identified in the research and recommends new improved ways to undertake the research for better results in the future.

2. LITERATURE REVIEW

This chapter conceptualizes the definition of suburbs and suburbanization as they exist in different regions and under different conditions. The linkage between the spatial expansion of metropolitan areas and manufacturing relocation from inner city areas is analysed in detail. The chapter also explains the nuances of industrial location strategies and demonstrates the influence of agglomeration economies on industrial site selection in Africa's metropolitan areas as they are applicable in the context of Ghana. Lastly, the structure, components and functions of the GIS based multi-criteria decision making methods applied in land suitability analysis is expatiated with special emphasis on the AHP method.

2.1. Definition of suburbs or suburbanization

Despite many popular authors including Clapson and Hutchison (2010), Hayden (2009), Jackson (1985), Nicolaides and Wiese (2017) who have contributed to the history of American suburbanization from the post-World War II, urban scholars have not been successful in establishing a practical definition of the suburban. On one hand, the lack of a clear definition is due to the uninform manner that authors describe the "suburbs" (Forsyth, 2012) . On the other hand, it is due to the different connotations of the term in different regions (Harris, 2010). According to Harris and Larkham (1999), many authors have defined the suburbs by emphasizing on varied combinations of five common dimensions namely; (1) peripheral location; (2) residential character; (3) low density settlements with high levels of over occupation; (4) distinct culture and lifestyle; (5) a separate community identity often embodied in local governments. In what seemed to be an extension of Harris and Larkham's work, McManus and Ethington (2007) expanded the common dimensions of suburbs to include the type of housing and the commuting relationship to the urban core. The contribution of McManus and Ethington (2007) reinforced that the characteristics of suburbs during the medieval periods were still relevant when defining modern day suburbs.

On the evaluation of regional connotations, in Anglo-Saxon countries including the USA, Great Britain and Australia, suburbs are low density residential areas (Grant et al., 2013; Hamel & Keil, 2016; Harris, 2015; Jan & Tom, 2015), often located at the urban fringe (Ekers, Hamel, & Keil, 2012; Hamel & Keil, 2015) . In France, suburbs referred to as "les faubourgs" or "les banlieues" connote low income immigrant housing (Dikeç, 2007; Fourcaut. Annie, 2001). In Spanish and Italian speaking countries, the "los suburbio" or "sobborgo" rather has negative connotations (Harris, 2015).

Mabin, Butcher and Bloch (2011) give an elaborate account of suburbanization in the African context. As the authors unpack the nuances of African suburbs, it is clear that; rapid transition from rural to urban landscapes, densification of peripheries, emergence of new urban cores, the newness of the suburb (Harris, 2010) and the concentration of mixed uses including manufacturing, informal economic activities and even urban agriculture were the themes that feature in the "suburban" descriptions.

China and India have no recognised terms for suburbs (Harris, 2015), however, in the China case, many urban scholars including (Feng, Zhou, & Wu, 2008; Lin, 2014; Zhou & Ma, 2000) refer to the ongoing rapid relocation of industries to the country's urban peripheries also known as "danwei " or work units (Chai, 2014; Xie & Wu, 2008). Furthermore, Sridhar (2004) conducted a study to investigate the suburbanization of population, household and employment in Indian cities, the results of this study confirmed that India's urban agglomerations were rapidly suburbanizing with peripheral areas absorbing large populations resulting in a booming real estate sector. Shaw (1999) also recounts high - tech automobile manufacturing industries, consumer electronics, IT industries, petrochemical industries dotted along the Ahmedabad – Pune corridor, the Bangalore – Chennai-Coimbatore corridor, the Delhi region in the north, and within new suburbs including Hyderabad and Vishakhapatnam in the south. Given these varieties of connotations and characteristics of suburbs or suburbanization, one can understand that imposing a universal definition would not advance the understanding of the phenomenon especially in the local contexts (Harris, 2010). In view of this, a definition of the "suburb" or the suburbanization process is only acceptable in the particular setting that the definition is being used (Harris, 2015). It is necessary to explore the interpretations of the "suburbs" from different environments to increase the reader's understanding of the term as it is used in relation to the study area.

2.2. Analyzing metropolitan expansion and the suburbanization of manufacturing

Metropolitan areas are expanding rapidly, however, the rate of physical expansion is faster in developing countries (Seto, Fragkias, Güneralp, & Reilly, 2011). Seto et al. (2011) reports after a meta-analysis of 326 remote sensing studies on urban growth that globally, metropolitan areas expanded by 58,000 km² from 1970 to 2000 with much of this expansion occurring in India, China and Africa. According to the same study, metropolitan areas are expected to expand further by more than 1,527,000 km² by 2030. Angel, Parent, Civco, Blei and Potere (2011) also used regression techniques and the population projection of 3,646 urban agglomerations worldwide to estimate the urban land cover of all countries by 2050. The study indicated that metropolitan areas in developing countries were expected to increase in land area from 300,000 km² in 2000 to 777,000 km² in 2030 and further to 1,200,000 km² in 2050. According to the same authors, in all countries, metropolitan areas were again expected to increase from 602,864 km² in 2000 to 1,267,200 km² in 2030 and to 1,888,936 in 2050.

A comparison of the two studies reveal that Seto et al. (2011) estimated an approximate increase of 862,664 km² of global urban land area in 2030 more than Angel et al. (2011). Furthermore, metropolitan areas in developing countries were also estimated to increase by more than 70. 7% of the metropolitan land area of all countries by 2030 (Angel et al., 2011).

The world is fast becoming suburban and the peripheries are buzzing with activities (Keil, 2018) ; on the contrary, inner cities are declining. Angel, Parent, Civco, and Blei (2011) analysed and compared historical data on global population, USA population and built up densities. The results of this study indicated that urban densities were declining in every country including developing countries. The study refuted the earlier claims by (Acioly Jr., 2000; Berry, Simmons, & Tennant, 1963; Richardson & Bae, 2000) that developing countries were becoming rather more compact with less expansion at the peripheries than western countries. The analysis pointed out that from 1990 to 2000, out of a sample of 88 cities, built up area densities declined in 75 cities in developing countries whilst all 32 cities in developed countries declined. Furthermore, , Angel et al. (2011) contended that population densities were projected to decline further between 26% and 36 % in 30 years.

Generally, in all countries, as economic development accelerates and public transport improves, central city population is bound to decline giving way to increased suburbanization. Given this background, Seto et al. (2011) observed that the urban peripheries were expanding at a faster rate than the urban population. Cohen (2006) posits two factors accounting for this trend of expansion in developing countries; the suburbanization of core cities and rural- urban migration to the suburbs which is the main cause of urbanization.

Suburbanization and urbanization are two processes that constantly influence the growth of metropolitan areas (Bruyelle & Vieillard-Baron, 2001; Teaford & Harris, 1997), however, whilst the influence of population density has been extensively researched for the two processes, the exodus of manufacturing is still less researched. In most US cities, manufacturing suburbanization in the 1950s and most of the later part of the 20th century was driven by the construction of highways linking suburbs to cities, new telecommunication technology (Rappaport, 2005), availability of land in the suburbs and the change from train to truck as the main means of transporting goods (Hanlon, Short, & Vicino, 2010) . Unlike the US scenario, manufacturing suburbanization in China was mainly state-led. The economic restructuring which started in the 1980s supported the massive industrialization of China's central cities through the establishment of danwei or work units (Huang, 2007) . (Zhou & Ma, 2000) recounted that later in the 1990s, the land reforms which allowed the marketization of land influenced municipalities to relocate many danwei manufacturing firms from the city centres to the suburbs. Evidence of this relocation can still be seen in Beijing, Shanghai and Hangzhou where retail, office and service activities now occupy previous danwei land (Feng et al., 2008; Shen, 2011) . Apart from the reason that municipalities obtained income from the sale of prime land in the city centre, pollution from industries was of grave concern to city authorities. Further improvements in intercity transportation and communication, as well as the availability of inexpensive land in the peripheries further encouraged the flight of manufacturing from the central cities to the suburbs.

A study by Sridhar (2004) revealed some interesting findings on manufacturing relocation in Indian cities. The author estimated employment suburbanization from employment regression models using employment gradients in all of India's urban agglomerations (UAs). According to the results of the study, manufacturing decentralizes to the suburbs due to the attraction from large populations and the availability of labour. Manufacturing again moves away from high rents and high wages in central cities. Lastly, more land available in the suburbs with relatively lower densities implies a lesser impact of pollution serving as a driving force behind the manufacturing flight in Indian UAs. The findings of the study shows a clear contrast between the Indian and Chinese cases, however, Mills and Price (1984) reported similar findings when they studied the effects of crime, high taxes and minority populations on population and employment suburbanization in US cities for 1960 and 1970.

Africa's recent suburbanization is linked to a rapid economic growth in the urban peripheries. Manufacturing, retail and service activities are marching to the suburbs (Attwairi, 2017; Todes, 2014). Contrary to the expansive studies on industrial decentralization in North America and European countries and more recently eastern Asia countries, studies on the nature of the phenomenon in Africa is still limited. Given this challenge however, the available studies identify that Government industrialization policies (Lwasa, 2014), "decentralization initiatives" (Mabin, Butcher, & Bloch, 2013, p.178), post-colonial effects on urbanization (Attwairi, 2017) , foreign investment (Temurcin, Kervankiran, & Dziwornu, 2017) and investment in public transport (Mabin et al., 2011) account for the flight of manufacturing from the urban core to the suburbs in most African cities.

2.3. Dimensions of industrial location in Africa's metropolitan areas

The goal of the recent Agenda 2063 of the African union, is to achieve a sustainable socio-economic transformation of the continent through industrialization and infrastructural development to eradicate poverty, create employment, increase productivity and improve the quality of life of all citizens (African Union Commission, 2015). The agenda is particularly targeted at achieving among other SDG goals, goal 9 and integrates various aspects of this SDG such as increased access to transportation, water, sanitation and ICT infrastructure to promote economic growth especially through manufacturing. Deichmann, Lall, Redding, and Venables (2008) note that in order to achieve equity in the economic development of both urban and rural areas of a country, industrial location decisions that draw on the specific natural resource endowments and comparative advantages of different areas is a necessary requirement. Exploring the dimensions of the location of industrial activities in Africa as a whole would lead to a better understanding of the phenomenon in Ghana.

The 2017 United Nations Economic Report on Africa indicated that the current increasing consumption of the middle class population was a good opportunity for industrialization in Africa. There is a growing demand for manufactured and processed goods in Africa's urban areas. The report argued that spatial targeting would ensure that industrial location strategies were tailored to meet the requirements of different firms. That is; it answers the question of which industries should be located where and which cities and towns to be considered for government infrastructural investments. Spatial targeting evaluates different locations based on their geographic, comparative and competitive advantages to determine the most efficient location with minimum investment costs (UNECA, 2017).

Africa's Industrial development has remained stagnated since the beginning of the structural transformations in the 1970s through to the 1990s and 2000s (Enache, Ghani, & O'connell, 2016) mainly because of the overreliance on extractive industries (oil, gas, and mining) (UNECA, 2013) and the poor management of urbanization and urban form (UNECA, 2017). Special economic zones (SEZs) which are designed to meet the physical location needs of specific industries and to promote productivity have been unsuccessful (Zeng, 2016) because of the location of the zones in what Farole (2011) terms as "lagging" regions or areas which lack access to basic infrastructure such as roads, electricity, ICT, water with long distances to markets, raw materials and shortage of labour. In addition, the colonial legacy of restrictive zoning which is used to segregate land uses does not allow industries to connect with the urban system of metropolitan areas and further deprives manufacturing firms from benefitting from transportation infrastructure and the labour markets. Furthermore, excessive zoning in African cities have prevented firms from establishing in areas that meet their spatial preferences. Different types of industries have different locational preferences; for instance Agro-processing industries prefer to locate in areas endowed with agricultural produce, value added manufacturing firms on the other hand prefer to locate in areas with large urban populations or close to ports and highways (UNECA, 2017).

A less investigated dimension of industrial location in Africa is the effect of agglomeration economies on location choices (Harvey, 2009; Mcgranahan, Mitlin, Satterthwaite, Tacoli, & Turok, 2009). Empirical evidences like the historic work by Isard and Kuenne (1953) prove that at that time, around the New York- Trenton-Philadelphia area in the USA, the availability of a large consumer market became an attraction for many sheet and strip producing plants as well as factories which depend mainly on steel as a raw material. Subsequently as labour increased in the area, more steel fabrication factories were attracted to the Greater New York-Philadelphia urban – industrial region.

Quite a number of more recent studies further confirm the effects of agglomeration economies on the concentration of industries elsewhere. For instance Glaeser and Kerr (2009) found out from analysing US longitudinal business census data that new US manufacturing firms cluster in the same location with other firms which employ the same type of labour or near customers or input suppliers. Rosenthal and Strange (2010) conducted an empirical study using US economic activity data and observed that urbanization effects influence the location of small manufacturing establishments whilst localization effects influenced the location of medium manufacturing establishments. Viladecans-Marsal (2004) analysed employment, output, wages per worker and the number of firms for each manufacturing sector in Spanish cities and observed that location of firms in the IT related manufacturing sector were mostly influenced by urbanization economies whereas location of traditional manufacturing firms such as leather and footwear were influenced by localization economies.

From the above examples, it is clear that the role of juxtaposition or proximity cannot be overemphasized in the agglomeration process. In addition, market and suppliers, raw materials and labour are also important location factors for new firms (Bosma, Van Stel, & Suddle, 2008). Although with limited research, agglomeration effects on industrial location choice exists in Africa (The World Bank, 2010) . These evidences are documented in a number of empirical studies, for instance Pholo Bala, Tenikué and Nafari (2017) estimated the effects of agglomeration on the location choice of French affiliated firms in Africa using French bilateral trade and production data from 1980 to 2006 and the data on French manufacturing firms obtained from the 2006 survey of French affiliated firms in 41 African countries. Their results indicated that the availability of a consumer market influenced the location of French firms in Africa considering the notable effects of location spill overs from other French subsidiaries. Adam and Mensah (2014) assessed the influence of agglomeration effects on the location choice of hotels in Kumasi based on data collected from 153 hotel establishments. The study utilised the x^2 test of independence and binary logistic regression to analyse hotel owners' rating of agglomeration influence and the influence of perceived agglomeration variables respectively on hotel location in the Kumasi metropolis. Their results also revealed that hotel owners preferred to establish in areas with existing hotels of similar scales as theirs and in areas with more clustering of hotels of all scales. The existence of complementary businesses including night clubs and restaurants also produced significant effects on hotel location choice according to the analysis. Nairobi's handicraft production and retail clusters although operating under informality possesses powerful agglomeration forces which attract both new entrant firms and newly trained skilled workers. The clusters are powerful in terms of offering proximal access to a wide variety of production inputs, retail customers and a large labour pool to all firms located within the clusters.

Agglomeration economies is relevant in industrial location as a result of the benefits of reduced transport costs (Marshall, 1920) and the high productivity produced in the clusters (Strjer Madsen, Smith, & Dilling-Hansen, 2003). It is beneficial to the development of metropolitan areas due to the economic growth that is achieved from the highly productive industrial clusters (E. L. Glaeser & Maré, 2001; Henderson, Shalizi, & Venebles, 2000). Regardless of being clouded in informality, agglomeration forces observed in African manufacturing clusters are no different from agglomeration forces existing in other regions. Basic infrastructural investments and spatial targeting are recommended to promote agglomeration economies and industrial development in African cities (UNECA, 2017).

2.4. GIS based multi-criteria evaluation for land suitability

GIS is often recognized as a Spatial Decision Support System (SDSS) because of its powerful capability of analysing relationships between both spatial and non-spatial data (Singh, 2015) and the unique functionality of displaying this data in an understandable form (Cutler & Vandemark, 2002). GIS provides planners with methods to simulate the effects of current urban development situations on future planning decisions. Even though many GIS usage in the real world confirm it as a powerful technology for collecting, manipulating and analysing spatial data, many critics (Jankowski, 1995; Sheppard, 2001; Sieber, 2006; Thomson & Schmoldt, 2001) in recent times have contested the capability of GIS as a Spatial Decision Support System (Keenan, 2006; Sugumaran, V.,2007; Sugumaran, R., 2007). Sultani, Soliman and Al-hagla (2009) argue that one of the key components of a standard SDSS is the "what- if model" used to analyse future urban planning scenarios. Unfortunately, many GIS packages have a rather limited function in terms of modelling, as a result, Keena (2003) referred to Alter (1980) and described GIS as an Analysis Information System instead of a Decision Support System.

Figure 1 illustrates the standard components of a typical SDSS.

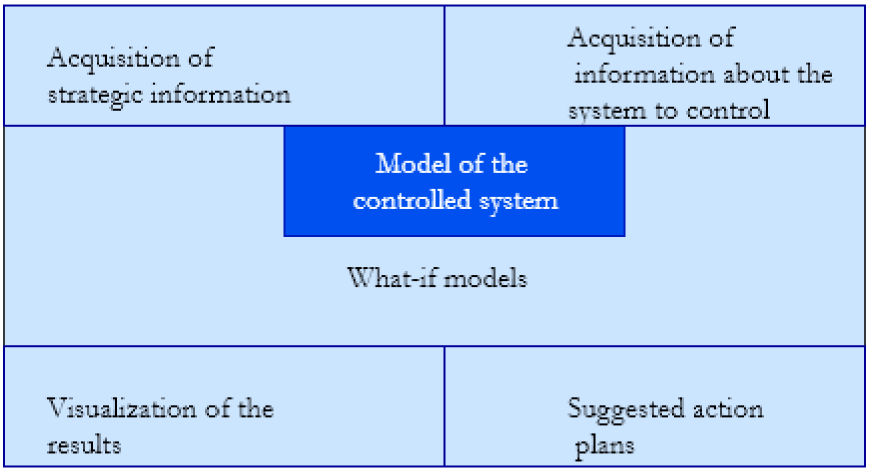

Figure 1. Structure of a standard SDSS.
Adapted from Laurini (2001).

Laurini (2001) defines the various components as follows;

- **Acquisition of strategic information**: refers to the strategic information that emanates from the basic system of the decision problem which is used to evaluate the components of the decision problem toward finding the desired solution.
- **Acquisition of information about the system to control** refers to the information emanating from the individual components of the decision problem. This information can be grouped under different sectors and evaluated using specified techniques and methods.
- **Model of the controlled system:** this represents different urban development scenarios that are forecasted based on historical parameters. That is, any changes to these parameters influences the alternative solutions and the forecasting outcomes.
- **What-if-models for data and system simulation** are used to evaluate historical data and their effects on simulated alternative solutions.
- **Visualisation of the results**: a standard SDSS displays the main variables in the different alternative solutions for proper comparisons.
- **Suggested action plans:** in the standard SDSS, a selected optimal alternative solution is able to be implemented through a series of action plans.

In order to address the modelling challenge of GIS, non-spatial models (Sultani et al., 2009) referred to as Multi-criteria Decision-Making methods (MCDM) have been coupled with GIS to improve its function as an SDSS (Carver, 1991; Matthews, Sibbald, & Craw, 1999). GIS based Multi-criteria Decision Making has been applied expansively in land use suitability studies such as for sustainable urban land use analysis (Adel & Sayed, 2016; Chandio, Nasir, & Matori, 2011; Chen, 2014), conservation ecology for protecting biodiversity (García Márquez et al., 2017; Shalamzari, Gbolami, Sigaroudi, & Shabani, 2018), identifying potential land for Agriculture development (Ahmed, Shariff, Balasundram, & Fikri Bin Abdullah, 2016; Mustafa et al., 2011; Sarkar, Ghosh, & Banik, 2014), identifying suitable sites for private and public facilities (Lukoko & Mundia, 2016; O & Shyllon, 2014; Ohri & Singh, 2010) and so on. The method has gained more popularity in the field of land use suitability due to the introduction of map algebra tools into the traditional overlay mapping operations within the GIS. Overlay mapping procedures for land suitability basically use Boolean Operators and Weighted Linear Combination Methods (WLC). These methods are easy to implement within the GIS and are easily understood by decision makers (Malczewski, 2004).

Because the MCDM approach identifies the most suitable future development scenarios based on a variety of attributes or preferences, the approach is mainly an evaluation process hence a component of evaluation (MCE) is included (Diouf et al., 2017). Additionally, a spatial element added to the MCE (SMCE) denotes that the geographic area under study is occupied by homogeneous instead of heterogeneous land uses (Ferretti & Pomarico, 2013).

According to Malczewski (2006), GIS based Multi-criteria Evaluation is a process that generally involves the use of geographic data, the preferences of stakeholders and the methods by which the data and stakeholder preferences can be combined or aggregated based on a set of predefined decision rules to obtain alternative development solutions.
The increasing application of Multi-criteria Evaluation for different real world decision problems has led to the development of a number of decision rules. Hwang and Yoon (1981) classified these rules (which by definition are the MCDM models) into (1) Multi-objective Decision Making (MODM) and (2) Multi-attribute Decision Making (MADM).

Alternatives are more limited and predefined in the MADM model unlike the MODM model where they are implied through causal relationships between the alternatives themselves and their associated criteria (Malczewski & Rinner, 2015). The main differences between the two models have to do with the general aggregation procedures used to evaluate different solutions. Chakhar and Martel (2006) developed an illustration of these procedures for the MADM and MODM models with inspiration from the general

MCDM model proposed by Jankowski (1995) . The same models are illustrated here in figures 2(a) and 2(b). The illustration shows how different elements of the evaluation processes are linked together towards achieving the optimal solution to a decision problem. For the purpose of keeping the focus of the review on the MADM model, the interpretation for figure 2 concentrates only on the MADM model.

The basic elements of MADM and MODM models are similar however, MODM models arrive at a solution based on the analyses of constraints and mathematical functions relating to more than one objective of the decision making. The MADM approach is more straightforward, in that, feasible solutions are determined from evaluating a discrete set of alternatives and a set of criteria that the solution must satisfy (Chakhar & Martel, 2006). The WLC, Ordered Weighted Averaging (OWA) and AHP Multi- - criteria Evaluation methods are standard examples of the MADM models.

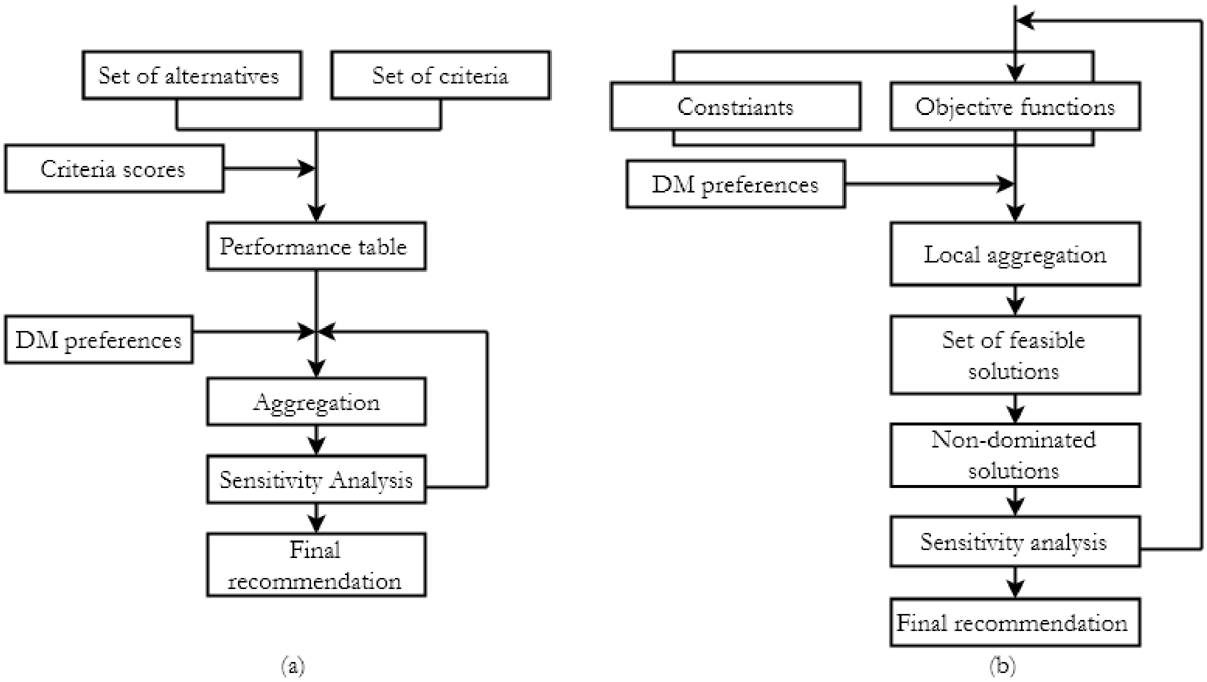

Figure 2. MADM (a) and MODM (b) models.
Adapted from (Chakhar & Martel, 2006; Jankowski, 1995)

The first step in the MADM model is the computation of a performance table based on the evaluation of alternative solutions from a set of criteria scores. Next, an appropriate method is used to aggregate the different criteria scores based on the decision makers' preferences to produce criteria weights. Decision makers' preferences here refers to stakeholders' rating of the performance of alternatives considering a range of numerical values applicable to each criteria. This range of values translates that if an alternative contains values below the numerical range of the proposed final recommended solution, then that alternative is rejected. This means that the ideal alternative is that which exhibits values within the acceptable numerical range of the final solution.

A form of a sensitivity analysis is always required to check the robustness of a solution and to observe any possible differences in the solution should an alternative or a decision makers' preference change. Lastly, the final recommendation for the MADM model is determined by the answers that the final solution is expected to provide to the decision problem in question. The MADM model approach was chosen to solve the decision problem of assessing industrial location suitability due to the advantages associated with the model in terms of its capability to analyse the comparative advantages of different geographic areas and the support for the what - if analysis or the sensitivity analysis. The what-if analysis is necessary in order to determine the effects of alternative solutions on the evaluation. On the other hand, the sensitivity analysis determines the criteria that can be used to measure the accuracy of the decision making (Arh & Blažič, 2007; Jafari & Zaredar, 2010).

2.5. Multi-attribute evaluation methods for land suitability

Multi-attribute (multi-criteria) Decision Making Models offer a number of methods to evaluate alternative development solutions. The purpose of an evaluation method is to determine the most optimal solution or to rank the best alternatives for addressing a problem (Dodgson, Spackman, Pearman, & Phillips, 2009). Although all multi-criteria evaluation methods involve alternatives and preferences, approaches are very different and some methods are more useful in solving a given decision problem than others. Most often, land suitability analysis employs three most common MCE methods, that is, the Weighted Linear Combination method or Simple Additive Weighting (Corona, Salvati, Barbarti, & Chirici, 2008; Diouf et al., 2017) , Ordered Weighted Averaging or the Analytical Hierarchy Process (Bagheri, Sulaiman, & Vaghefi, 2012; Dang Khoi & Murayama, 2010; Mediaty Arief, Yazidun Nafi, Subiyanto, & Hermanto, 2018). Among the methods, the Weighted Linear Combination and Boolean overlay operations are the methods most often used for land suitability analysis (Beedasy & Whyatt, 1999; Jankowski, 1995; Malczewski, 2004). The industrial location problem in all its complex forms means that the process of selecting an MCE method should consider how efficient the method integrates with GIS and the capability of that method to combine a large number of attributes (Rikalovic, Cosic, & Lazarevic, 2014). It is against this background that the common methods namely; WLC, OWA and AHP are hereby discussed.

2.5.1. Weighted linear combination method

The WLC method is a type of multi - attribute decision rule for creating aggregated maps in a GIS environment (Malczewski, 2000). The method is based on a weighted average concept wherein multiple criteria are normalized to obtain a common numeric average (Eastman, 2006a). Attribute map layers are ranked by assigning weights according to their levels of importance. The value of each weighted map is multiplied by the normalized value of the alternative the map it is associated with. The products of each attribute map and alternative are summed up to obtain the total scores for all alternatives. The alternative with the highest score is therefore selected.

Mathematically, the set of alternatives, $X = \{x_{i*} | i = 1,2,3 \dots \dots, m\}$ is represented by cells (vector) or pixels (raster). The symbol i is the location of alternative i in a given geographical area. Assuming the location of alternatives i to m is numbered from 1 on the upper left to m on the lower right, the raster grid cell map will look like below;

1	2	3	4
…	…	…	…
…	…	…	…
…	…	…	m

Figure 3. Alternatives illustrated in a grid cell

The alternatives are described by x and y coordinates as well as their normalized values. If x_{ij} represents the weighted importance of attribute j of alternative i, the "alternatives" function can therefore be illustrated as in equation (1) and the weighted importance of each attribute of alternative i with respect to attribute j can also illustrated in equation (2) (Malczewski, 2000).

$X_{j*} = (x_{j1,}x_{j2,}x_{j3,} \ldots\ldots x_{jm})$ Where i= 1, 2, 3…………m equation (1)
$X_{*j} = (x_{1j,}x_{2j,}x_{3j,} \ldots\ldots x_{nj,})$ Where i= 1, 2, 3…………n equation (2)

Summing the products of weighted importance of attribute j and the normalised value of alternative i, the aggregated map or suitability (S) map is illustrated in equation (3) as follows;
$S = \sum w_j \, x_i$ equation (3); Where w_j is the assigned weight of importance for attribute j and x_i is the normalized value of alternative i (Drobne & Lisec, 2009).

Boolean operators such as intersection (AND) and union (OR) are sometimes used to determine suitable and less suitable alternatives also known as the Boolean constraint method (Drobne & Lisec, 2009; Malczewski & Rinner, 2015). This operation is done by multiplying equation (3) by the product of alternatives and their related constraints' scores as shown in equation (4):
$S = \sum w_j \, x_i \prod c_j$ equation (4); where c is the normalised value of alternative c in terms of constraint j, $\prod$ = product or Boolean operation "AND" (Beinat & Nijkamp, 1998; Malczewski & Rinner, 2015). A more suitable alternative is identified by a high normalized value and a low score for constraints (Malczewski & Rinner, 2015).

The WLC approach is a preferred option for land suitability analysis because the procedure can easily be implemented in GIS (Malczewski, 2004). It also supports the use of both raster and vector data models within the GIS (Eastman, 2006a) and is able to integrate a large number of alternatives (Dodgson et al., 2009).

By way of examples, Al-Hanbali, Alsaaideh and Kondoh (2011) used raster and vector layers of constraints to develop alternative suitable locations for potential land fill sites in Mafraq, Jordan. The study reclassified the location constraints based on weights obtained through consultations with local experts and the use of the author's local knowledge of the area. Jiang (2007) estimated the location - cost of suitable industrial locations in Panzhihua, China. Several map layers including green areas, water bodies, existing factories, highways and elevation were processed using multiple buffers. The WLC method was used to rank suitable industrial areas by integrating with Boolean constraints. The final results is the quotient of a standardized suitability map and location cost map.

Despite the advantages and wide application of the WLC methods, Jiang and Eastman (2000) identified a number of limitations associated with the method. The first limitation is the problem of trade-offs or substitutability. Whereas in the WLC, a low normalized value of an alternative can be compensated for by a higher value of another alternative in the suitability map, the Boolean operators (Boolean constraints) uses strict classifications, meaning that, an area in the suitability map which does not have a value greater than the normalized value of an alternative is excluded from the result. This problem has caused differences other than similarities in the outcomes of the same analysis involving the use of raster in the WLC method and vector data in the Boolean constraints method. The second limitation relates to the simple linear transformation technique of reclassifying alternatives to common numerical values (thus the normalization of alternatives). This technique is not applicable in all cases as in some cases a non-linear transformation is rather more useful (Drobne & Lisec, 2009; Eastman, 1999). The third limitation has to do with weights; since most of the values originate from local experts or local informants, there is a problem of inconsistencies or the poor validity of expert judgements. The fourth limitation is referred to as the decision risk; in the case of the Boolean constraints method, it is possible that the suitability result may be wrong as a result of an incorrect decision rule from the choice of Boolean operators "AND" or "OR", therefore some suitable areas may be left out or unsuitable areas may find their way into the final result (Eastman, 2005).

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Furthermore, in the case of the WLC method, the normalization of the values of alternatives may lead to unlimited number of areas being included or excluded from the result leading to further uncertainties in the suitability output (Erdoğan & Zwick, 2016). As a result of these limitations of the WLC , Jiang & Eastman (2000) adopted the fuzzy measures (Dubois & Prade, 1982) or the Ordered Weighted Averaging Approaches (OWA) as a solution to the map combination problems of many multi-criteria evaluation methods.

2.5.2. Ordered weighted averaging

OWA refers to a set of approaches used to combine geographic data and the preferences of decision makers or stakeholders in an MCE (Malczewski, 2006b). It is an extension to the conventional methods used to combine maps in MCDM models (Jiang & Eastman, 2000). The difference between the OWA and the conventional methods is that with the OWA, decision making is regarded as an imprecise set problem that resembles the natural behavioural approach to the process (Dodgson et al., 2009; Drobne & Lisec, 2009). On the contrary, the conventional methods like the Boolean or WLC are based on hard and crisp decision rules (Dodgson et al., 2009; Jiang & Eastman, 2000) . Conventional methods are able to integrate a large number of finite alternatives however, land suitability problems are known to involve series of infinite alternatives with complex interrelationships. As such, suitability under this condition is influenced by some degree of natural language quantifiers such as “at least 4”, “about 10”, “most”, “many”, “a few”. These quantifiers are difficult to implement with conventional methods (Malczewski, 2006b).

The OWA approach, involves two types of weights, the importance weights and order weights. An attribute is assigned an importance weight (based on human judgements) which applies to all locations in the study area. These weights are also assigned with respect to the alternative that the attribute is associated with. Order weights are assigned to a location’s attributes in a decreasing order not influenced by the values of any particular attribute (Eastman, 2006a). This weight is the central idea in the OWA methods, it determines whether an area satisfies at least one acceptable attribute value referred to as the degree of ORness or the degree of trade-off. Decreasing degrees of ORness automatically means a decreasing degree of trade-off or substitutability among attributes. This means that a large number of locations may become suitable with decreasing ORness or unsuitable with decreasing ORness depending on how order weights are defined in terms of suitability (Malczewski, 2006b). This logic is shown in the decision strategy space in figure 4, adapted from Jiang and Eastman (2000).

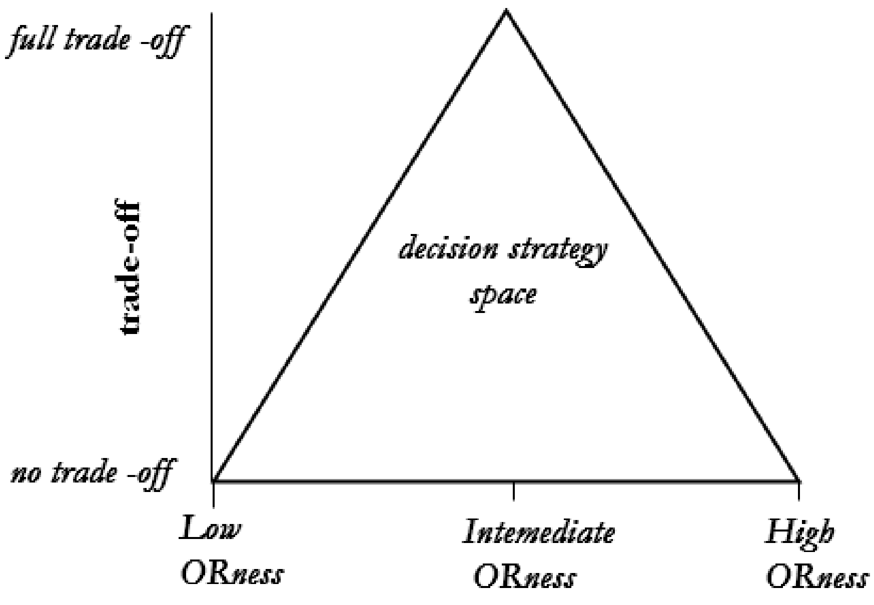


Figure 4. Decision strategy space in OWA.
Adapted from Jiang and Eastman (2000).

OWA has many advantages in land suitability analysis. The method provides decision makers with a wide range of development strategies depending on the number of OWA combination rules applied. It is able to evaluate a large number of attributes with complex relationships (Malczewski, 2006b). Furthermore, the OWA approaches can be carried out in the GIS-IDRISI software developed by the Clark Labs at the Clark University, Worcester, USA (Eastman, 2006b) .

Examples of the application of the OWA approach to land suitability include Mokarram and Hojati (2017) who evaluated soil fertility in west Shiraz, Fars province; Iran based on the inverse distance of locations in the study area to the location of six mineral elements of soils found at 45 sample points. Six alternative maps or fuzzy maps were generated and six sets of order weights of the alternatives were classified with increasing weights representing increasing soil fertility. Six quantifiers and the six sets of order weights were used to generate 6 different fertility patterns for the area.
Malczewski (2006b) used the OWA approach to find out the most suitable land for housing development in the Villa Union area on the pacific coast of Mexico. The evaluation criteria or attributes used included proximity to airport, proximity to city, and proximity to major roads, proximity to rivers and distance to wetlands. An area was deemed suitable when it was located close to the first four attributes and unsuitable when located close to the last attribute (maximization criterion). The attributes were ranked from the most important to the least important attribute that is; proximity to major roads, proximity to city, proximity to the airport, proximity to rivers and distance from wetlands. Finally seven fuzzy quantifiers namely; "at least one", "at least a few", "a few", "identity", "most", "almost all", and "all" were used to develop seven land suitability patterns for housing development in the area. The results of the analysis which was carried out using the GIS-IDRISI software showed that the most suitable areas for housing development were located far from the wetlands.

Boroushaki and Malczewski (2008) undertook a study on the OWA approach and indicated that the combination procedure used in the OWA are similar to the Analytical Hierarchy Process (AHP), however, OWA ordered weights are determined by multiplying each attribute's importance weight by the ordered weight for different sets of attributes. Going by this procedure, a wide range of combination rules can be obtained including a full trade-off among attributes which is a condition associated with the WLC and Boolean overlay methodology illustrated in equation (3) that is, $S = \sum w_j \, x_i$.

2.5.3. AHP

AHP is a Multi-attribute Evaluation method and a variant of the weighted linear combination methods. The method was developed by Saaty (1980) in response to his observation of a lack of a straightforward and easy to understand methodology for making complex decisions whilst directing research projects in the US Arms Control and Disarmament Agency (Saaty, 2004). Since then, AHP method has been widely applied in a large number of fields worldwide such as in healthcare, education, ecology, supply chain management, energy sector and manufacturing (Emrouznejad & Marra, 2017). In the process of analysing location suitability, Banai-Kashani (1989) and Saaty (2004) recounted that many conventional models utilize expert judgements to determine the relative importance of attributes and preferences for several alternatives towards reaching a particular suitability objective. During this process, factors including zoning, land values and existing urban developments are also evaluated, however, none of the conventional suitability methods employed in Multi-criteria Decision Making includes a strategy to check for inconsistencies in human judgements or uncertainties in the evaluation of factors. As a result, errors are introduced into suitability decision making and forecasting. Erdoğan and Zwick (2016) point out that the AHP method was developed to address these uncertainties inherent in the conventional suitability models.

Boroushaki and Malczewski (2008) argue that AHP is an effective method for solving complex decision problems involving multiple factors connected by complex interrelationships. Furthermore, the method is easy to use even under conditions of limited data and can integrate both qualitative and quantitative factors within a site suitability problem (Banai-Kashani, 1989). The AHP method is capable of incorporating expert judgements whilst checking for inconsistencies in the evaluation of attributes and criteria (Benítez, Delgado-Galván, Gutiérrez, & Izquierdo, 2011).

The evaluation procedure of AHP involves the ranking of a set of alternative suitable sites and selecting the best out of these alternatives. The ranking is done by structuring the suitability problem into a hierarchical framework that shows the relationship between goals, criteria and alternatives (Mateo, 2012). Stated differently, AHP involves a paired comparison in the lower level of a hierarchical structure and then, in the higher level of the same hierarchy (Sabaei, Erkoyuncu, & Roy, 2015). Boroushaki and Malczewski (2008) identified three main steps involved in the AHP that is (1) developing the hierarchy (2) a pairwise comparison of the elements of the hierarchical structure and (3) rating of priority alternatives.

What follows is a summary of theoretical application of the AHP procedure with respect to the industrial site suitability problem.

In the step (1) that is; developing the hierarchy; the decision problem is decomposed into a hierarchy made up of elements that are important in making the decision. The first level in the hierarchy is the overall goal of the problem. In this case, "To identify suitable locations for industrial development in the Ga west municipality". The second level is the general location factors on which the evaluation of the study area would be based and the third, the sub factors identified from the general location factors. Normally, the hierarchy descends from the more general goal to more specific elements however some discrepancies exist depending on the decision problem in question (Saaty, 1980). This description is illustrated in figure 5.

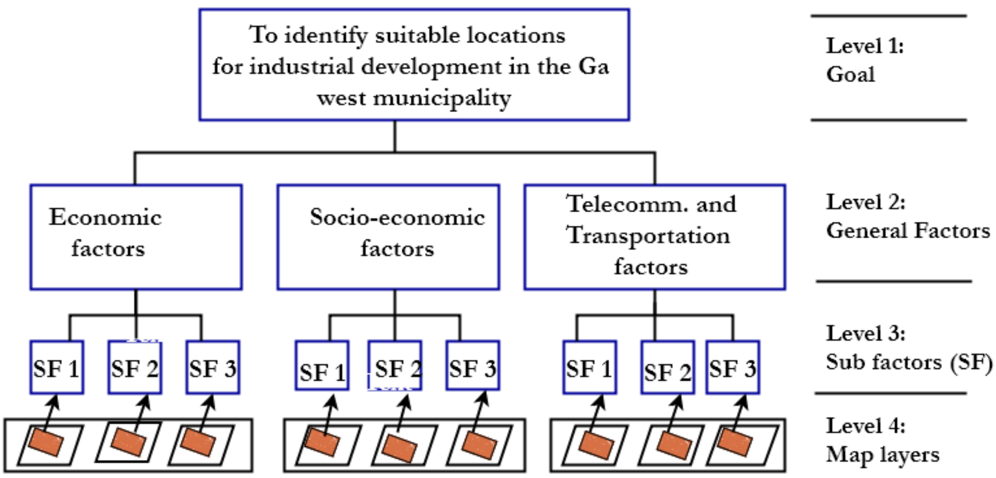


Figure 5. A four-level hierarchy of industrial site suitability problem.
Adapted from Boroushaki and Malczewski (2008).

The hierarchical structure simplifies the decision problem and makes it easy to understand. In a GIS based multi-criteria evaluation, a fourth level, the alternatives are stored as vector or raster map layers. Each alternative map bears the values of sub-factors which denote suitability.

Assuming the set of m number of alternatives is denoted by A_i = 1, 2……..m. Alternatives are to be evaluated based on a set of p number of general factors; where "general factors" is represented by O_q, then $O_q = 1,2 \dots \dots p$.

The general factors are again measured based on a set of n number of sub factors, where the sub factors; C_J= 1, 2…n with an associated p number of general factors. In effect, a subset of a number of sub factors $k,$ belonging to the qth general factor is represented by $C_{k(q)}$ where k =1, 2……l and $l \leq n$.

In order to illustrate the importance of a sub factor, two sets of weights (local weights);
$W_q = (w_1, w_2 \dots \dots \dots w_p)$ and $W_{k(q)} = (w_{1(q)}\ w_{2(q)}\dots\dots w_{l(q)})$ are assigned to general factors and sub factors respectively. The two weights therefore can be said to have the following mathematical properties that is:

$W_q \in [0,1],\ \sum_{q=1}^{p} w_q = 1$ and $W_{k(q)} \in\ [0,1],\ \sum_{k=1}^{l} W_{k(q)} = 1.$

The suitability performance of alternative set A_i with respect to sub factors C_J can be described by a set of normalized values of general factors thus; $X = [x_{ij}]_{mxn}; x_{ij} \in [0,1]$ where j=1, 2…..n.

Step (2), which refers to "a pairwise comparison of the elements" simplifies the computation of the hierarchy since only two elements can be compared at a time. Still with respect to the industrial site suitability, three steps need to be undertaken at this stage, that is (a) developing a comparison matrix for each level in the hierarchy starting from the top to the bottom. (b) determine the weights for each element in the hierarchy and (c) estimate the consistency ratio.

We begin with step (a) in this respect; the pairwise comparison is conducted with reference to the ratio scale developed by Saaty (1980). This scale is described in table 1.The scale ranges from 1 to 9 and denotes how raters compare and score general factors and sub factors.

Table 1

Saaty's ratio scale

Level of importance	Verbal judgement of preference
1	Equally important
3	Moderately important
5	Strongly important
7	Very strongly important
9	Extremely important
2, 4, 6 , 8	For intermediate judgements between importance values

Note: Adapted from (Boroushaki & Malczewski, 2008; Saaty, 1980).

A straightforward approach to comparing and scoring the general location factors; is described by the matrix:
$A = [a_{qt}]_{pxp},$ Where a_{qt} is the pairwise scores for general factor q and general factor t.

Matrix A is a reciprocal matrix which means that $a_{tq} = a_{qt} = 1$ Where $q = t$.

The same technique is applied to the sub factors, similarly, sub factors' comparison matrix is constructed for each general factor under which a set of sub factors can be found in the hierarchy.

The sub factors matrix is hereby described as $A_q = [a_{kh(q)}]_{lxl}$ Where q = 1, 2……p and $a_{kh(q)}$ is the pairwise score for sub factor k and sub factor h which is associated with the general factor q from the hierarchy.

In the next step (b); "determine the weights for each element in the hierarchy"; after constructing the pairwise matrices, relative weights are assigned to the elements in the hierarchy. The weights are used to represent the preferences of stakeholders in numerical terms. In other words "how general factors and sub factors performed after rating".

Two vectors are computed for weights associated with the general factors and sub factors respectively that is: $\omega = [w_1 w_2 \ldots\ldots\ldots\ldots\ldots w_p]$ for general factors and
$\omega_q = [w_{1(q)}, w_{2(q)} \ldots\ldots\ldots w_{l(q)}]$ for sub factors associated with the qth general factor.

The procedure for computing these vectors is to calculate the normalized Eigen vector using the maximum Eigen value related to the pairwise comparison matrix in question. The normalized Eigen vector is then used to calculate the principal Eigen vector or priority vector for each of the general factors or sub factors.

The principal Eigen vector now becomes the relative weight of importance among the general factors and sub factors. A sequence of processes are involved in the computation. These processes are shown in the steps below; the first step is to compose the matrix $\hat{A}$ by normalizing the columns of matrix;
A: $\hat{A} = [a^*_{qt}]_{pxp}$, Where $a^*_{qt} = \frac{a_{qt}}{\sum_{q=1_2}^{p} a_{qt}}$ when all $t = 1, 2\ldots\ldots\ldots n$ (1)
Then $\hat{A}$ is computed and normalized as $\hat{A}_{2j}$, next $\hat{A}_3 \ldots\ldots \hat{A}_z$ are computed until all the columns are identical. This column becomes the vector of the general factors ω: The vector for this column is $\omega_q = \hat{a}^*_{qt(z)}$; where $q = 1, 2\ldots\ldots\ldots\ldots p$. (2)

The weights for sub factors $w_{k(q)}$ are calculated using the same procedure; that is:
$a^*_{kh(q)} = \frac{a_{kh(q)}}{\sum_{k-1}^{l} a_{kh(q)}}$ Where all $h = 1,2 \ldots\ldots\ldots l$ (3)
Then the weights for sub factors is given by;
$w_{k(q)} = \hat{a}^*_{kh(q)}$; Where all $k = 1,2 \ldots\ldots\ldots l$ (4)

Step (c): Because of the inconsistencies associated with all human judgements, it is necessary to measure how inconsistent the pairwise comparison matrix A is, from computing the consistency index (CI) where
$CI = \frac{\lambda - P}{P-1}$ (5)
The consistency ratio can further be obtained by computing $CR = \frac{CI}{RI}$ where RI is the random consistency index composed by Saaty (1980). The RI table is shown in table 2 below. To look up the RI table, we use the number of elements in the pairwise matrix.

Table 2.

Random Consistency Index

Number of elements (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Note: Adapted from Saaty (1980).

An acceptable consistency ratio should be $CR \leq 0.10$ which indicates that human judgements or scores are consistent in the pairwise. If $CR \geq 0.10$, then the scores are inconsistent, therefore, the sub factors need to be revised (Boroushaki & Malczewski, 2008).

Having undergone through the entire procedure for implementing the AHP, one can deduce that the simplification, aggregation, human judgement component, the consistency checks, the ease of implementation and ease of understanding capabilities of the method has well been demonstrated. However like any other Multi-criteria Evaluation method, the AHP has not been spared from criticisms.

Kazibudzki and Grzybowski (2013) contend with the ability of pairwise comparison matrices and their accompanying principal Eigen vectors to compute the true rankings of suitability factors. In line with Kazibudzki and Grzybowski (2013), Tomashevskii (2015), argues that there is also the phenomenon of rank reversal where an addition of a new "unsuitable" alternative has the tendency of changing the ranking of alternatives. The critics pointed to the effects of these situations on the reliability of the AHP results. Brunelli and Fedrizzi (2014, 2015) also raised concerns about the use of consistency indices in the AHP as a measure of the degree of inconsistency in human judgements. The authors implied that the measure overlooks the actual properties of inconsistency.

Zhu and Xu, (2014) identified a similar limitation as the previous critics and proposed a method known as hesitant multiplicative programming .This method considers human judgements to be a hesitant decision making and so cannot be aggregated. Several other methods have been proposed to deal with many supposed limitations of the AHP such as D-AHP (Deng & Deng, 2017) and TOPSIS (Pavić & Novoselac, 2013; Zadeh Sarraf, Mohaghar, & Bazargani, 2013), ANP (Saaty & Vargas, 2013).

Irrespective of the limitations, AHP application is still on the increase most especially in the field of suitability analysis. For instance, in resettlement site selection (Shibru, Suryabhagavan, Mekuria, & S, 2014), location of urban facilities (Parry, Ganaie, & Sultan Bhat, 2018) and industrial site suitability (Lukoko & Mundia, 2016; Muhsin, Ahamed, & Noguchi, 2017; Sarath, Saran, & Ramana, 2018).

2.6. Conceptual model

The main concepts underpinning this research is derived from the literature review and applied to the empirical situation in the Ga west municipality. Suburbanization has been seen to exhibit itself in different forms under different geographical settings (Harris, 2010). In the conceptual model, suburbanization caused by declining densities in the Accra Metropolis agrees with the global trends described by Angel, Parent, Civco and Blei (2011). Apparently, population decline in the Accra metropolis is also caused by increasing rents (Vernon, 2009). Subsequently, the city's population moves to the peripheral Ga west municipality, however in this case, manufacturing accompanies the relocation (Temurcin et al., 2017).

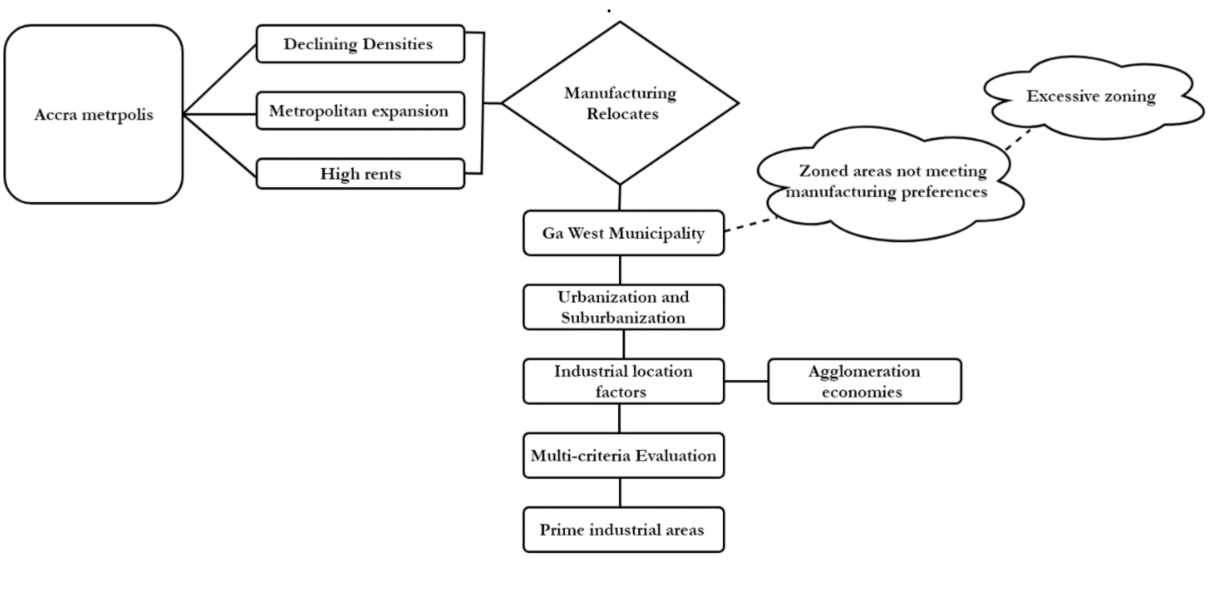


Figure 6. Conceptual model describing interrelated concepts.

This creates a mixture of urbanization and suburbanization influences on the municipality (Bruyelle & Vieillard-Baron, 2001; Teaford & Harris, 1997).Furthermore, the relocating agenda of manufacturing is faced with the challenge of rigid industrial zoning which do not meet the natural location preferences of manufacturing (UNECA, 2017). In order to achieve some flexibility and improve efficiency in the zoning, areas with the tendency of agglomeration economies in the municipality need to be considered (Harris, 2014).

Lastly, industrial location factors specific to the Ga west municipality is central to identifying future industrial sites. This process can only be implemented by selecting the appropriate MCDM method (Rikalovic et al., 2014). The GIS based AHP Multi-criteria Evaluation method is effective in combining spatial data of different scales. This makes it an appropriate method for achieving the overall objective of the research, that is, to identify prime industrial locations which will in turn promote the industrial development and economic growth of the municipality (African Union Commission, 2015; UNECA, 2017).

3. STUDY AREA

This chapter positions the Ga west municipality in terms of its demarcation and describes the character of the municipality in relation to existing infrastructure, population, natural resources and industrial development. The chapter explains the rate of physical expansion of urban land uses with focus on industrial land expansion from 1987 to 2017. An overview of the current and future workforce of the municipality is also described in the chapter.

3.1. Administrative placement and infrastructure

Ga west municipality is one of 10 municipalities comprising the Greater Accra Metropolitan Area (GAMA) (Oduro, Adamtey, & Ocloo, 2015). Until 2008, the municipality existed as the Ga district which was created in 1988 during the implementation of the government decentralization and local government policy. In 2004, the Ga district was divided into Ga west and Ga east, later in 2008, it was divided into Ga west and Ga south. In 2018, the municipality was further divided into Ga west and Ga north with Amasaman, the former capital of the Ga district still remaining as the capital for the new Ga west municipality. The municipality is located at about 25 km west of the Accra's CBD and covers a total land area of approximately 24100 ha with about 201 communities (CERSGIS, 2018; MPCU, 2018).

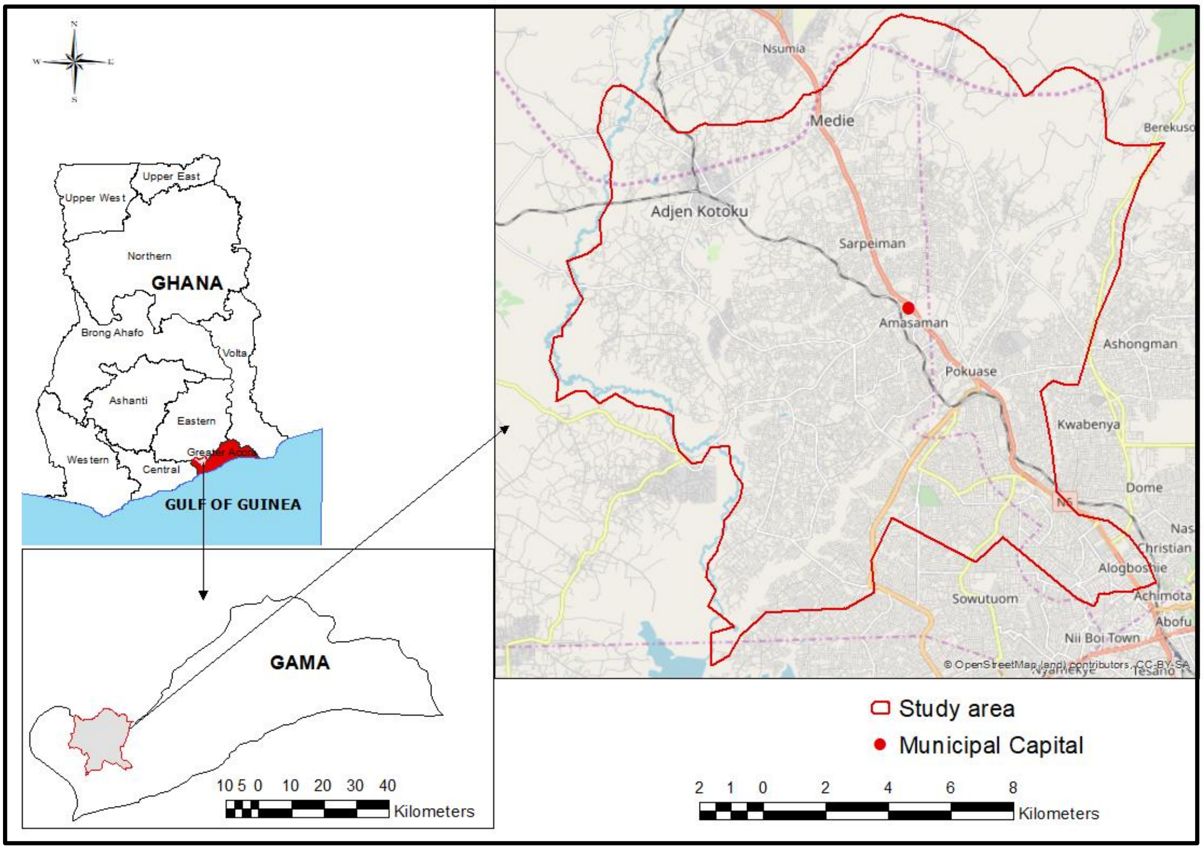


Figure 7. Ga west municipality in the context of the Greater Accra metropolitan Area (GAMA).

The municipality is well connected to the Accra-Kumasi highway and the Accra- Nsawam railway line which makes it accessible to major transportation facilities like the Tema port and Kotoka international airport as well as other social facilities in the Accra metropolis. The major public health facility in the municipality is the municipal hospital located at Amasaman. The location of this facility makes it accessible

to a large number of surrounding communities. Other lower order health facilities including Government health centres and (CHPS) compounds are also well distributed in the municipality (MPCU, 2018) .
Recently, three tertiary institutions have been established at Pokuase (KNUST –IDL campus), Amasaman; (Heritage University college) and (Samjet media institute) (Nai, 2018a). In terms of electricity, the municipality is connected to the national grid however, some areas experience erratic supplies due to several reasons. Fixed telecommunication network coverage in the municipality is low as it is now outdated, however private mobile networks like MTN, Airtel, Vodafone and Tigo are available in majority of the communities with only a few ones not having access to these networks. There is a high level of security in the municipality, however the issue of land ligation problems exists in some fast urbanizing areas (Armah Tagoe & Aryee, 2014; MPCU, 2018; Oduro & Adamtey, 2017).

3.2. Physical and urban characteristics

Ga west municipality lies within latitude 50°48' N, 5°39' N and longitude 0° 12' W, 0°22' W. It shares common boundaries with the Ga East municipality and Accra metropolitan Assembly to the east, Akuapem South Municipality to the north and Ga South Municipality to the south and west (MoLGRD, 2014).

The municipality falls within the coastal savannah agro-ecological zone with most areas having an elevation of less than 5% except the area around the "Samsam" hills at the north-eastern part (MPCU, 2018). Voltaian sandstone, granite and mixed quartzite soils dominate in the area (CERSGIS, 2018). These soils are rich in sandstone and limestone that are good raw materials for the construction industry (Armah Tagoe & Aryee, 2014). Four major rivers drain the municipality that is; the Densu, Onyansia, Nsaki and Dorblo rivers. The Onyansia River drains from the centre of the municipality into the Accra metropolis where it enters the Odaw River and Korle lagoon respectively. The Densu river drains from the eastern region through the municipality to Weija where it is dammed for water treatment (Armah Tagoe & Aryee, 2014; MPCU, 2018).

Despite the location of the municipality close to the Weija water treatment plant, only 3% of the population in the municipality are served by the Ghana water company (GWCL) otherwise termed as "municipal water supply". The remaining majority depend on treated underground water which is relatively cheaper and can be sourced with the latest well drilling technologies. This system is encouraged by the abundance of underground water in the municipality especially at the north western part. Major food crops produced in the municipality include pineapple, maize, cassava, yam, plantain and vegetables in the Samsam – Dedeiman area; Maize, cassava and vegetables around Pokuase, Amasaman, and Nsakina areas; rice, maize and vegetables around Katapor, Kpobikope, Ayikai dorblo, Medie and Kojo Ashong areas.

50% of the municipality is urban according to the classification of localities by their total population, that is; a locality with more than 5000 persons is classified as urban. 30% of the localities are peri-urban and 20% rural (Armah Tagoe & Aryee, 2014; MPCU, 2018). Four major towns directly linked by the Accra – Kumasi highway serve as the CBDs of the municipality. These towns are; Amasaman, Sapeman, Adjen-Kotoku and Medie.

3.3. Population and physical expansion

According to the 2010 national population and housing census report, the population of the municipality stands at 219,788 inhabitants. The projection from 2010 to 2020 as shown in tables 3 and 4 reflects an increasing population since the last national population census. This increasing trend was expected to continue into 2020 (Ghana Statistical Service, 2019). The most significant population increase in the municipality was estimated to occur from 2010 to 2015 (11.6%) and the lowest from 2019 to 2020 (2.3%).

Comparing the projections for Ga west and the Accra metropolis, it is evident that the population of the metropolis was expected to follow a similar trend like the Ga west Municipality; the highest population increase in the metropolis was anticipated to take place from 2010 to 2015 (13.4%) and the lowest from 2019 to 2020 (2.5%). From 2010 to 2020, the population in the Accra metropolis was estimated to increase by a margin of 28.5% whilst Ga west was to increase by 24.9% for the same period. It is worth noting that the two areas were expected to experience a slowed population growth from 2015 onwards. However Ga west was to undergo a more stable population increase than the Accra metropolis.

This projection can be interpreted that migration from Ga West to the Accra Metropolis was anticipated to be more intense than the migration from the Accra metropolis to the Ga west municipality. Another possible reason has to do with the number of neighbouring suburban municipalities absorbing the spill over from the metropolis such that migrants from the metropolis are spread over more than a single neighbouring suburban municipality. The third probable reason is that whereas migration from the suburbs to the Accra metropolis mainly involve people, migration from the Accra metropolis to the suburbs depicts a suburbanization of manufacturing and employment and not necessarily people.
This notwithstanding, the anticipated slowed growth of the city's population is a situation that follows a trend from the early 1980s during the implementation of the Structural Adjustment Policy (SAP). The policy supported the liberalization of many sectors of the economy including the housing sector. Following the liberalization, the rent control system became weakened and unregulated resulting in high rents in the metropolis.

The SAP was faced with several challenges which deepened poverty in the inner areas of Accra. These developments compelled both low income and middle income households to flee from the city into the adjoining fringe areas in search of cheaper residential accommodation. Although the population of Accra metropolis at that time increased, the growth was not as high as in the past periods (Yankson & Bertrand, 2012) . Apart from the effects of the liberalization programme on population decline in the Accra metropolis, Williamson (2011) noted that during the SAP period, the extension of transportation and electricity infrastructure to peripheral municipalities and the decentralization that took place in municipalities such as the former Ga and Tema districts led to the diffusion of many manufacturing establishments from the Accra metropolis.

Table 3

Projected population comparison between Ga west municipality and Accra metropolis

	Census, 2010	Projected population					
Year	2010	2015	2016	2017	2018	2019	2020
Ga West Municipality	219,788	245,224	250,915	256,703	262,585	268,557	274,617
Accra Metropolis	1,665,086	1,887,780	1,936,836	1,986,580	2,036,889	2,087,668	2,138,833

Ghana Statistical Service (2019)

Table 4

Estimated percentage changes in total population for Ga west and Accra metropolis from 2010 to 2020

Percentage increase in population	2010 -2015	2015 - 2016	2016 - 2017	2017 - 2018	2018 - 2019	2019 - 2020
Ga west municipality (%)	11.6	2.3	2.3	2.3	2.3	2.3
Accra Metropolis (%)	13.4	2.6	2.6	2.5	2.5	2.5

Ghana Statistical Service (2019)

3.4. Land use transformation

The expansion of the Accra metropolis into suburban municipalities have had a considerable impact on the land use pattern in the Ga west municipality. The historical simulation of land uses in the municipality illustrated in figures 8 - 10 and table 5 confirms that industrial land use is gaining more importance in the landscape of the municipality. The maps show that the municipality has transformed from a predominantly agricultural landscape to more urbanized land uses within the last 30 years. Industrial land use occupied only 0.4% of the total land area of the municipality in 1987, however by 2017 industrial space had expanded by 448.1 % of the same size recorded in 1987. The built up area evidently has been the fastest growing land use in the municipality. The proportion of land dedicated to residential use as it is the dominant land use in the municipality's built up area was less than 12% in 1987. By 2017, the size of the built up area had ballooned to more than 50% of the municipality's land area. Following closely is commercial land use which also expanded by adding 2,398 hectares from 2003 to 2017. Agricultural land use has been mostly affected by these transitions. The area of Agricultural land reduced significantly during the three periods, an indication of the combined effects of urbanization and suburbanization.

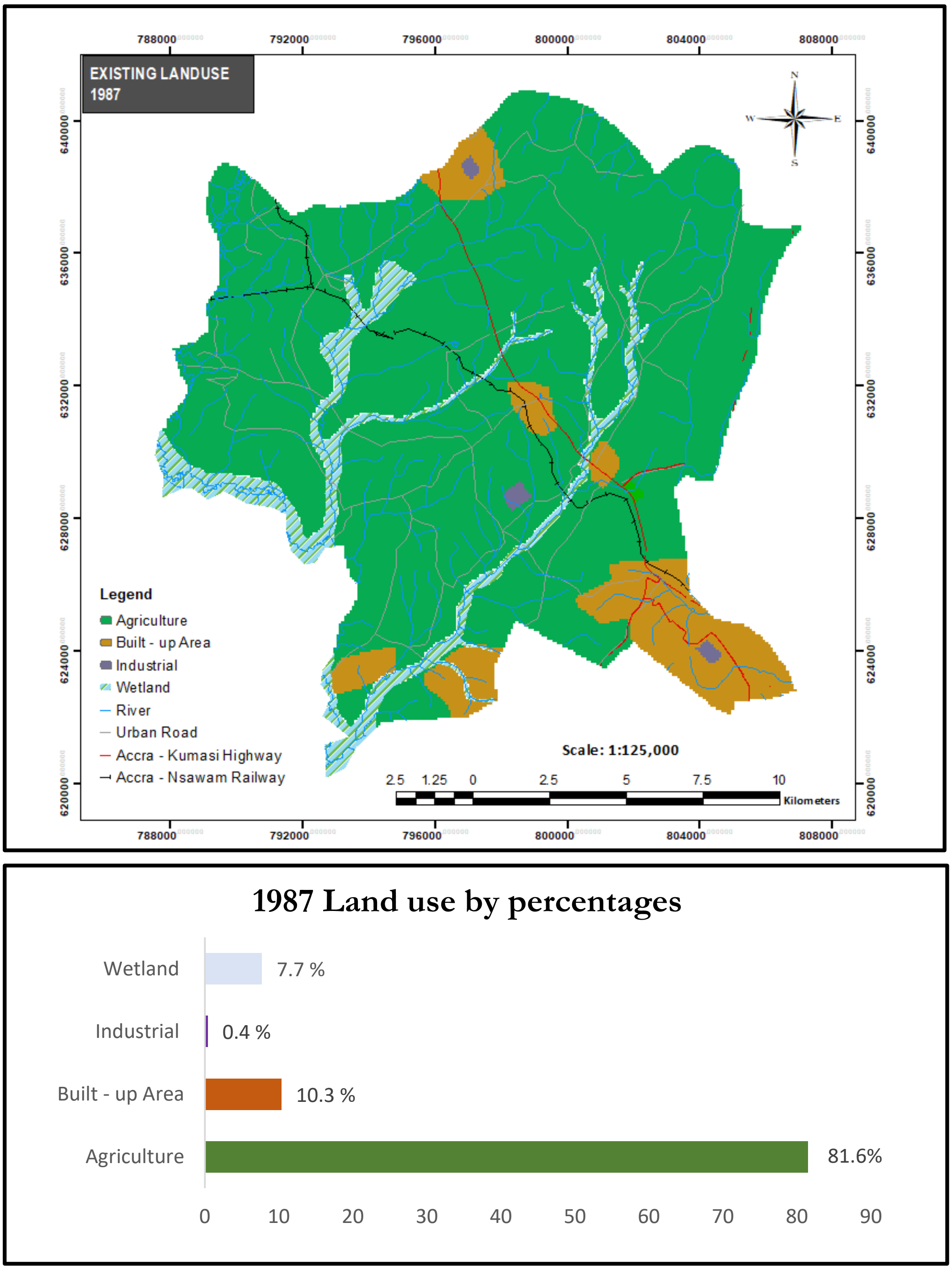


Figure 8. Existing land uses in 1897 expressed as percentages of the total land area.

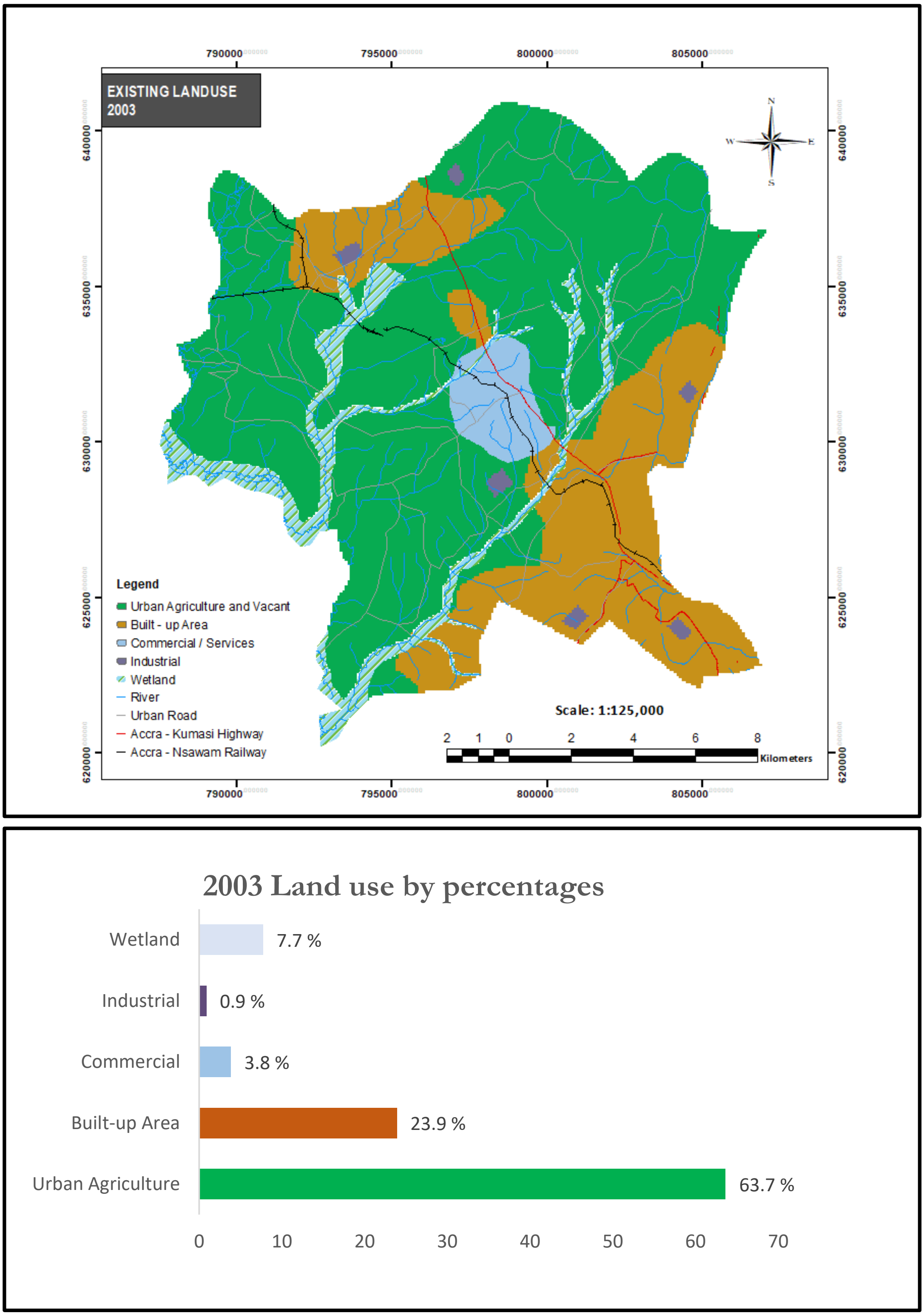


Figure 9. Existing land uses in 2003 expressed as percentages of the total land area.

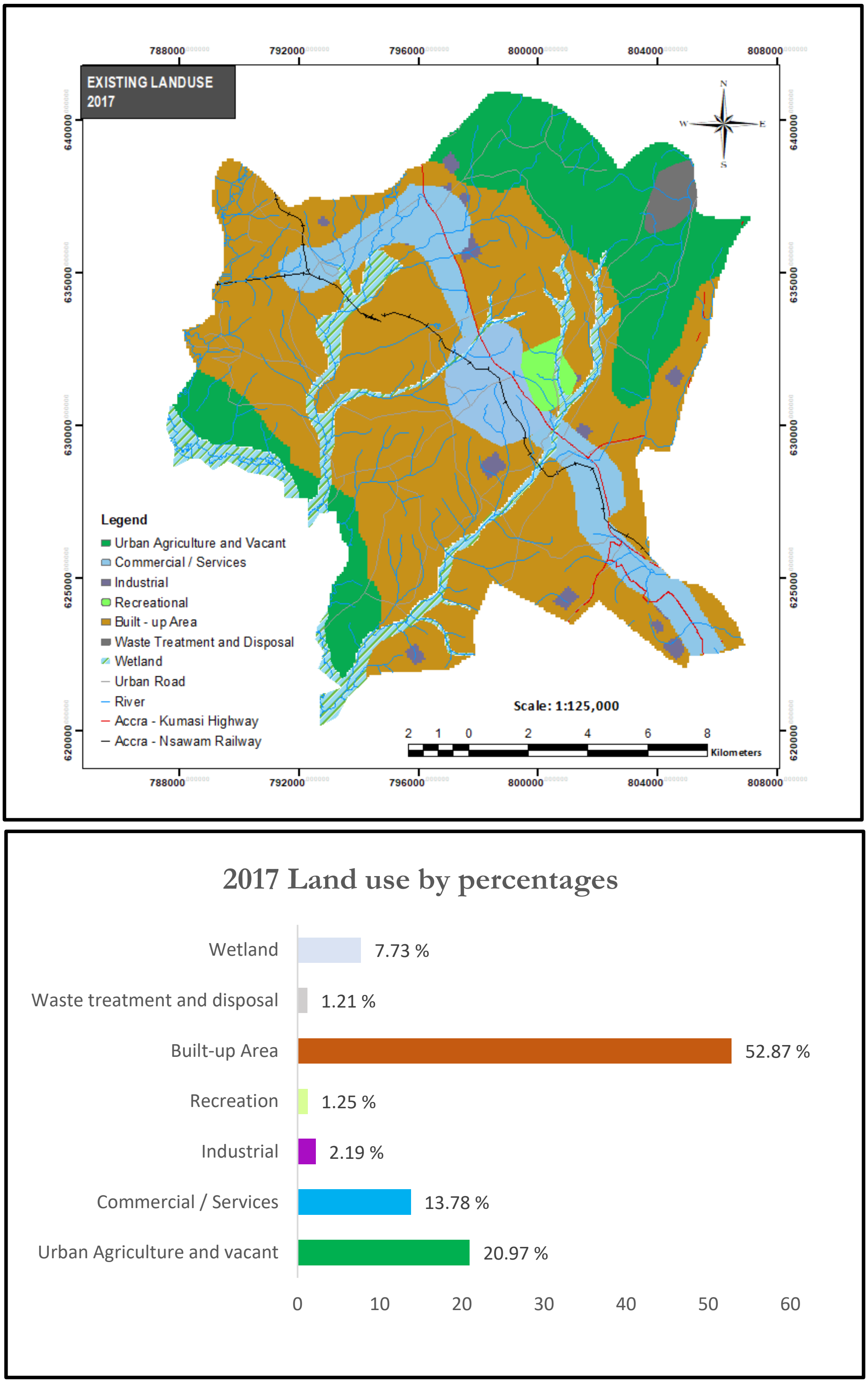


Figure 10. Existing land uses in 2017 expressed as percentages of the total land area

Table 5

Historical land use transformation in Ga west from 1987 to 2017

Land use (LU)	1987 (ha)	2003 (ha)	2017 (ha)	Change 1987 – 2003 (ha)	Change 2003 – 2017 (ha)
Agriculture and vacant	19,648.1	15,341	5053	-4,307.1	-10,288
Commercial	-	924	3,322	924	2,398
Industrial	96.33	210	528	114	318
Recreation	-	-	301	-	301
Built - up Area	2,492.57	5,762	1,2741	3,269.43	6,979
Waste treatment and disposal	-	-	292	-	292
Wetland	1,863	1,863	1,863	0	0

Source: CERSGIS (2018)

Table 6 shows the distribution of industrial land takes among 12 localities in the municipality from 1987 to 2017. Adzen Kotoku, Hebron, Kutunse, Medie and Toman had the largest manufacturing concentrations in 2017. Akotoshie, Adzen Kotoku, Hebron, Toman and Kutunse were the localities that saw significant increases in the number of manufacturing firms from 2003 to 2017.Two urban localities; Tantra hill and Ofankor which share boundaries with the Accra metropolis recorded a significant reduction in industrial land take for the same period. In consequence, industrial development can be seen to be taking place in the more peri-urban localities in the municipality than the urban areas.

Table 6

Changes in industrial land takes among 12 localities with manufacturing establishments from 1987-2017

Locality	1987 (ha)	2003 (ha)	2017 (ha)	Change 1987 – 2003 (ha)	Change 2003 – 2017 (ha)
Achimota- Mile 7	16.03	27	11	10.97	-16
Adzen Kotoku	6	64	126	58	62
Akotoshie	0.3	0	39	-0.3	39
Hebron	0	4	56	4	52
Kutunse	14	35	74	21	39
Medie	0	39	52	39	13
Ofankor	23	15	13	-8	-2
Pokuase	17	8	23	-9	15
Samsam	3	0	10	-3	10
Sapeman	5	5	21	0	16
Tantra Hill	12	13	41	1	28
Toman	0.	0	62	0	62

Source: CERSGIS (2018)

3.5. Industrial land demand in the Ga west municipality

Ga west municipality has become a preferred destination for manufacturing in recent years. Many manufacturing firms have relocated from Accra city and new ones are being attracted to the municipality due to the availability of land and the natural resource endowments of the area. Mineral water producing companies such as Voltic Ghana Limited, Le country mineral water Company and Ideal bottling company limited are located in the groundwater endowed areas in the municipality. Food and beverage producing companies such as Blue skies Ghana limited, Vintage Pineapple Juice Company, Agya Appiah Bitters, Srighan farms Limited and Fresh and Tasty Farms Limited obtain most of their raw materials from the municipality (MPCU, 2018; Nai, 2018a). Construction Pioneers and Sonitra Ghana Limited engage in the production of concrete materials from large deposits of sand, stone, clay and laterite available in the municipality (MPCU, 2018). Data from the municipality indicates that a total of 65 large scale manufacturing companies are currently operating in the municipality with numerous undocumented small and micro scale manufacturing taking place in the localities. The Physical Planning Department in the municipal assembly indicated that, the number of industrial building permit applications were on the rise. As a result, more industrial zoning was needed to absorb the newcomer industries (Nai, 2018a). This type of zoning required the municipality to allocate separate areas for manufacturing to restrict other urban land uses from the effects of pollution and to protect the environment (Department of Town and Country Planning - Ghana, 2011) .

3.6. Overview of employment by industry

Figure 11 refers that manufacturing is the leading employer of the working population in the Ga west municipality. Data from the 2010 population and housing census shows that Tantra hill, Pokuase, Ofankor, Adzen kotoku and Achimota - Mile 7 have the highest workforce employed in manufacturing (Armah Tagoe & Aryee, 2014). The construction industry is the second largest employer followed by Agriculture then, mining and quarrying. With reference to available empirical information, many of the employees of manufacturing firms located in the peri-urban areas of the municipality reside in urban localities such as Tantra-hill, Pokuase, Ofankor and Achimota –Mile 7 and commute to work on daily basis. Since the census was a housing and population type, the industry where a person was employed was recorded relative to his or her residential location and not the location of employment.

A large number of the workforce employed in construction reside in Pokuase and Ofankor where residential construction is in high demand. There is an abundance of labour in the municipality due to the arrival of new migrants and “relocators” from the Accra metropolis. This labour provides support to many of the, manufacturing firms located around the Medie- Adzen kotoku - Kutunse corridor. More manufacturing establishments arriving in the municipality, means that a large size of the future workforce would be absorbed into the industry. However with the automation of production, many unskilled labour would have to obtain some form of training in order to operate machines effectively.

Number of persons employed in industry by locality

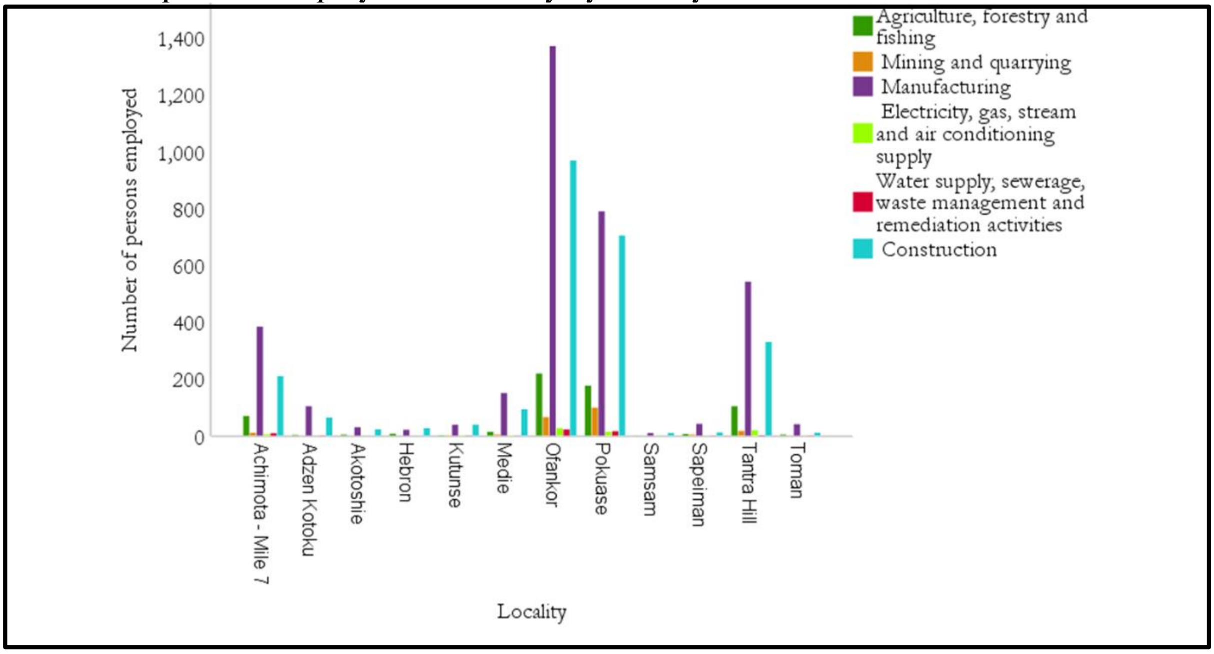


Figure 11. Employment by industry in 12 localities with manufacturing establishment, 2010.
Source: Armah Tagoe and Aryee (2014).

3.7. Rationale for selecting the study area

Three reasons account for the selection of Ga west for this research;

- Firstly, the industrialization of the municipality was a phenomenon that was still new and ongoing. This setting was a good one to implement the research methodology and to interpret the results.
- Secondly, zoning had become ineffective and many unauthorized industrial developments were taking place on the blind side of the municipal authorities, an example was where the database on the number of small and micro scale industries was incomplete. This research provides a good option for the municipality to introduce some flexibility in the industrial zoning to reduce the number of recalcitrant developers.
- Thirdly, the Ga west hospitality facilitates research. The subjects show a lot of interest in research studies and are readily available to undertake surveys whilst adding their own views on particular subjects that affect them.

4. METHODOLOGY AND DATA

This chapter justifies the mixed methods approach and the methodology implemented in the research. The chapter describes the purposive and quota sampling strategies used with descriptions of how primary data was collected and analysed. Secondary data collection and processing as well as all the processes leading to the constraint analysis and ultimately to the weighted suitability model are explained in detail.

4.1. Research approach

Research approaches exist in three forms, namely; quantitative, qualitative and mixed methods. Qualitative approaches basically involve the collection of non-numerical data to analyse individuals or groups of people's perceptions about a particular problem. Quantitative approaches collect and analyse numeric data by finding statistical relationships between variables to test the relevance of a predetermined theory or hypothesis. The mixed method approach is an integrated version of the qualitative and quantitative methods. Mixed methods are essentially useful in making inquiries into a research problem that involves the collection and analysis of both quantitative and qualitative data (Creswell, 2013).

The study was undertaken using the mixed method research approach for three reasons; firstly, a method was needed to integrate expert judgements and numerical ratings of industrial location factors. Secondly, a sample frame of 65 large scale manufacturing industries was likely to create type II errors (Columb & Atkinson, 2016) which could potentially affect the interpretation of AHP results. As a result, a mixture of semi-structured interviews and qualitative observations needed to be integrated into the data collection and analysis process to offset the limitations of the small sample size. Thirdly, the research was bound to involve a number of variables which operate under conflicting scales. Therefore both quantitative and qualitative techniques were needed to ensure a common level of measurement for all the variables (Najmaei, 2016).

The mixed method approach is more suited for complex research problems because it offers the researcher the flexibility of choosing from different methods and data sources to examine a situation for better understanding. The focus of the mixed method approach is on "what works" at a particular time rather than a one size fits all approach (Creswell, 2013). The strength of either quantitative or qualitative methods can be used to compensate for the weakness in both methods. For instance, qualitative outcomes can be used to explain the results from quantitative research while quantitative outcomes can compensate for the biasness in qualitative results.
This research employed the explorative sequential mixed method design to integrate different qualitative and quantitative methods design to integrate different qualitative and quantitative methods. . Validity and reliability analyses were performed to check for possible inaccuracies in expert judgements. Figure 12 describes the explorative sequential design procedure followed in the research

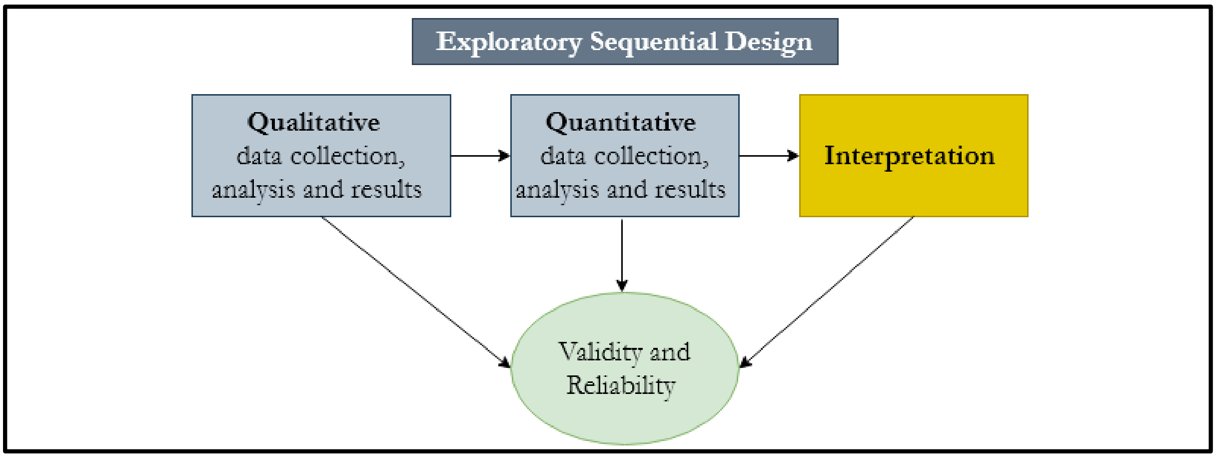


Figure 12. Explorative sequential mixed methods design.

4.1.1. Research methodology

The mixed method approach applied in the research integrated both quantitative and qualitative methods during the data collection, analysis and interpretation phases. This implies that some specific qualitative and quantitative processes were involved in the three stages of the research. The purpose of the research methodology is to identify the processes as they contributed to answering the research questions. Figure 13 describes the overall research methodology categorized under the themes that informed the literature review, the instruments and methods used for the primary and secondary data collection, the techniques used to analyse and process primary and secondary data and the themes that were focused on during the evaluation process. The direction of the arrow shows the sequence in which the main processes were executed in the research.

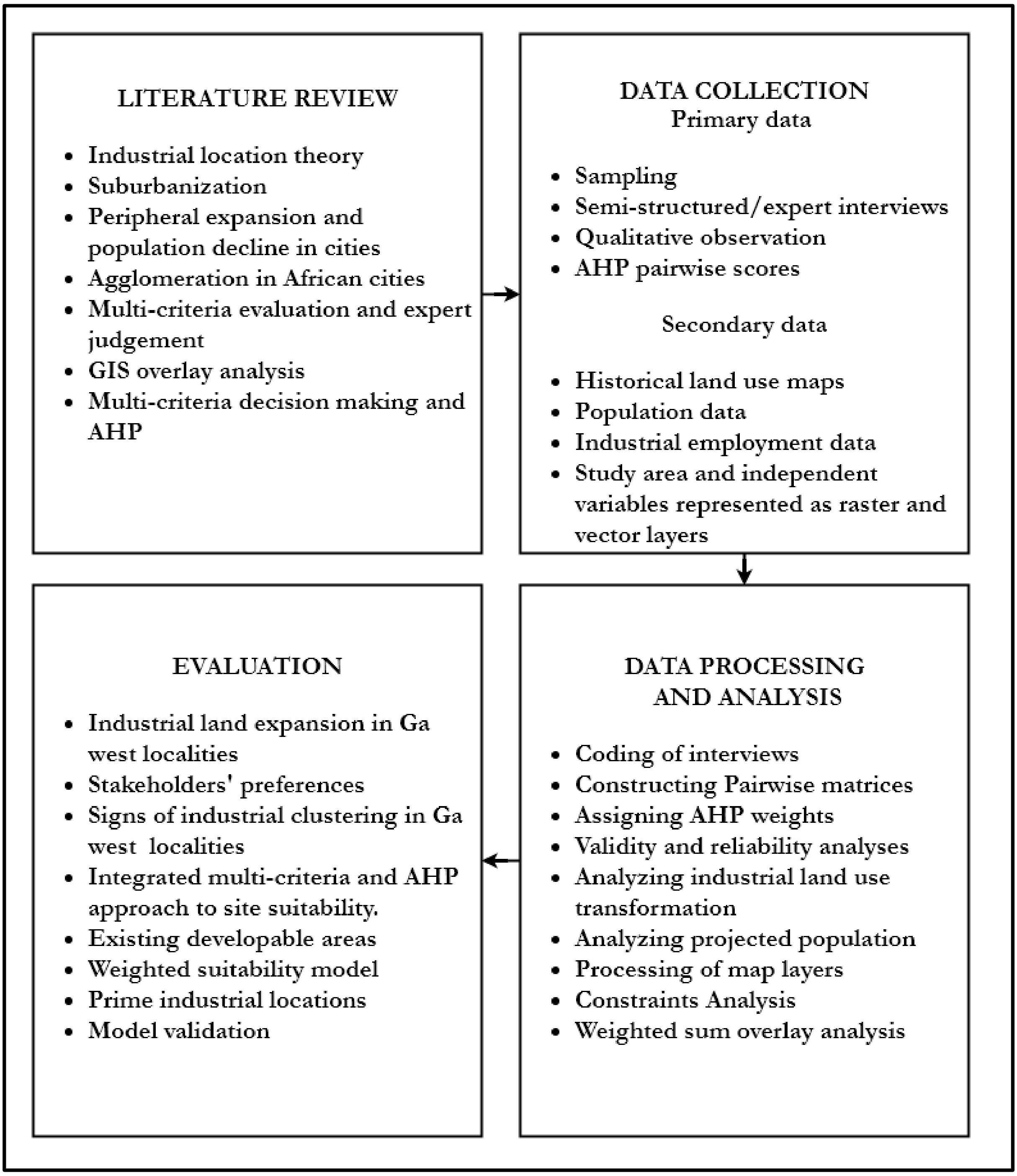


Figure 13. Research methodology.

4.1.2. Sampling strategy

The underlying objective for a sampling strategy in the research was to determine two appropriate samples to conduct expert interviews and administer the AHP questionnaire. The purpose of sampling for expert interviews was to obtain information from people with direct experience in industrial site selection in the Ga west municipality. An expert in this research was defined as an upper level business official in a large scale manufacturing firm having worked with the same firm for at least 10 years.

The purpose of sampling for the AHP questionnaire was to determine how business officials of large scale manufacturing firms in the municipality perceived the importance of specific location factors in the site selection decision making process. The reason for the selection of large scale manufacturing firms for the sampling was because their operations and management are more formalized with their top level officials highly skilled and knowledgeable in particular fields. In Ga west, large scale manufacturing firms are registered with a business operating license from the municipal Assembly. Moreover a manufacturing firm in Ghana is classified as large scale if it employs more than 100 persons (Osei, 2017).

Mixed method sampling allows for flexibility in the choice of sampling techniques. The researcher can combine or select from either probability or non-probability sampling techniques (Teddlie & Yu, 2007). In this research, firstly, the purposive sampling technique was used to select the experts, secondly, the quota sampling technique was used to select large scale manufacturing firms for the AHP questionnaire administration. Both techniques belong to the larger group of non-probability sampling techniques. This type of sampling technique is advantageous in a way that it is time and cost effective and suitable for small samples involved in explorative research (Alvi, 2010). A description of how the techniques were applied in the research is documented as follows;

Purposive sampling: A total of 5 experts consisting of CEOs, human resource and operations managers from 5 of the largest manufacturing firms in Ga west were selected based on the researcher's subjective judgment (Alvi, 2010). All 5 experts were investigated to ensure that they met the definition of "experts" adopted in the research.

Quota sampling: The total number of manufacturing establishments according to the Ga west municipal Assembly was estimated at 163. The total number of large scale manufacturing firms was 65 (Nai, 2018b) (sampling frame), this means that 39.8% of the total number of manufacturing firms in Ga west were classified as large scale. On the quota sampling, an approximated total of 46 large scale manufacturing firms were selected out of a sample size of 115 industries, (at 95% confidence interval and 5% margin of error) that is; 39.8% of 115. Fourteen (14) firms out of the 46 had seized operations, this reduced the sample to 32.

4.1.3. Instrument construction

Data collection was of crucial importance in the research because it was the basis for understanding the complexity of industrial location decisions and the source of the main inputs for the intended suitability model. Both primary and secondary data were used in the research. After a thorough consultation with the literature, semi-structured interviews and AHP questionnaires were selected for the primary data collection. Secondary data was also found to be obtainable from relevant government institutions and the Municipal Assembly. The interview guide was designed with the objective of allowing the expert to express his or her opinions on the reasons for the current location of the firm they were employed in and how he or she perceives other locations in terms of site suitability and infrastructure. The guide was designed to be flexible at the same time making sure that the interview remained focused on the factors influencing site selection (Adams & Cox, 2008).

The AHP questionnaire is basically a likert scale type of questionnaire (Kallas, 2011). The input for the instrument was derived from the location factors dataset generated from the expert interviews. Interviews were analysed by transcribing and coding the phrases that give hints of the location factors, the codified phrases from all the experts were grouped into themes, then the most common location factors from the themes were deduced and labelled according to economic factors, socio-economic and telecommunication and transportation factors referred to as "general factors". The entire interview analysis was done manually in Microsoft word. Fifteen (15) industrial location factors (sub factors) were found to be common to all the interviewees.

The AHP instrument consisted of 40 questions. A participant in each selected firm was assisted to compare and rate general factors and sub factors in separate pairwise comparison tables. The comparison tables used can be found in appendix 5. The questionnaire was highly self-explanatory with all the needed information for a participant to understand and do the rating with little assistance. Calibri fonts were used for readability and some colour was added to the tables to increase the interest of participants in the survey.

An additional set of semi-structured interview guides was developed for interviewing the Chief Executive of the Ga West Municipal Assembly and the Municipal Physical Planning officer respectively (Appendices 7 and 10). The process of selecting the two participants was generally by purposive sampling with the objective of validating the results of the expert interview and increasing the understanding of the industrial location in the Ga west context.

4.1.4. Instrument administration for primary data collection

Semi-structured interviews: The interviews were conducted by the researcher with the help of three observers from the Ga west municipal assembly. Prior to the interviews, the informed consent form and interview guide was sent to the selected firms (Appendix 1). Letters of invitation (Appendices 6 and 9) were added to the consent form and interview guides (Appendices 7 and 10) and sent to the Municipal Assembly officials. All the participants participated fully in the interviews. In the case of the firms, the individual candidates meeting the expert definition criteria were provided by the firms themselves. In order to ensure effectiveness, the interviews were conducted at the premises of the firms and the Municipal Assembly respectively. Before the interviews commenced, the researcher briefed participants on the format and purpose of the interview. A thorough explanation was given on the intended use of the data to be collected and the confidentiality of the participants. The researcher was available to answer questions on the objectives of the interviews and other personal concerns of participants such as voice recording, freedom to opt out and taking of photos (Adams, 2015) . Following the preliminary question and answer session, the participant was issued with a certificate of consent.

The research placed a great deal of emphasis on confidentiality as a result, each participant was interviewed individually (Coffelt, 2018), this strategy produced more in-depth responses from the participants.

AHP questionnaire: The questionnaire was administered in the same fashion as the interviews. Officials of 32 large scale manufacturing firms partook in the questionnaire however, in this case, under the guidance of three data collection assistants. The assistants were national service persons drawn from various departments of the Ga west municipal assembly. The researcher's choice of national service persons was due to their prior experience from other surveys and their own academic research. This condition facilitated their training which resulted in a 100% response rate (Fincham, 2008).

4.2. Analyzing AHP questionnaire

The practical application of the AHP analysis shown in figure 14 is based on the theoretical description of the method elaborated earlier in the literature review.

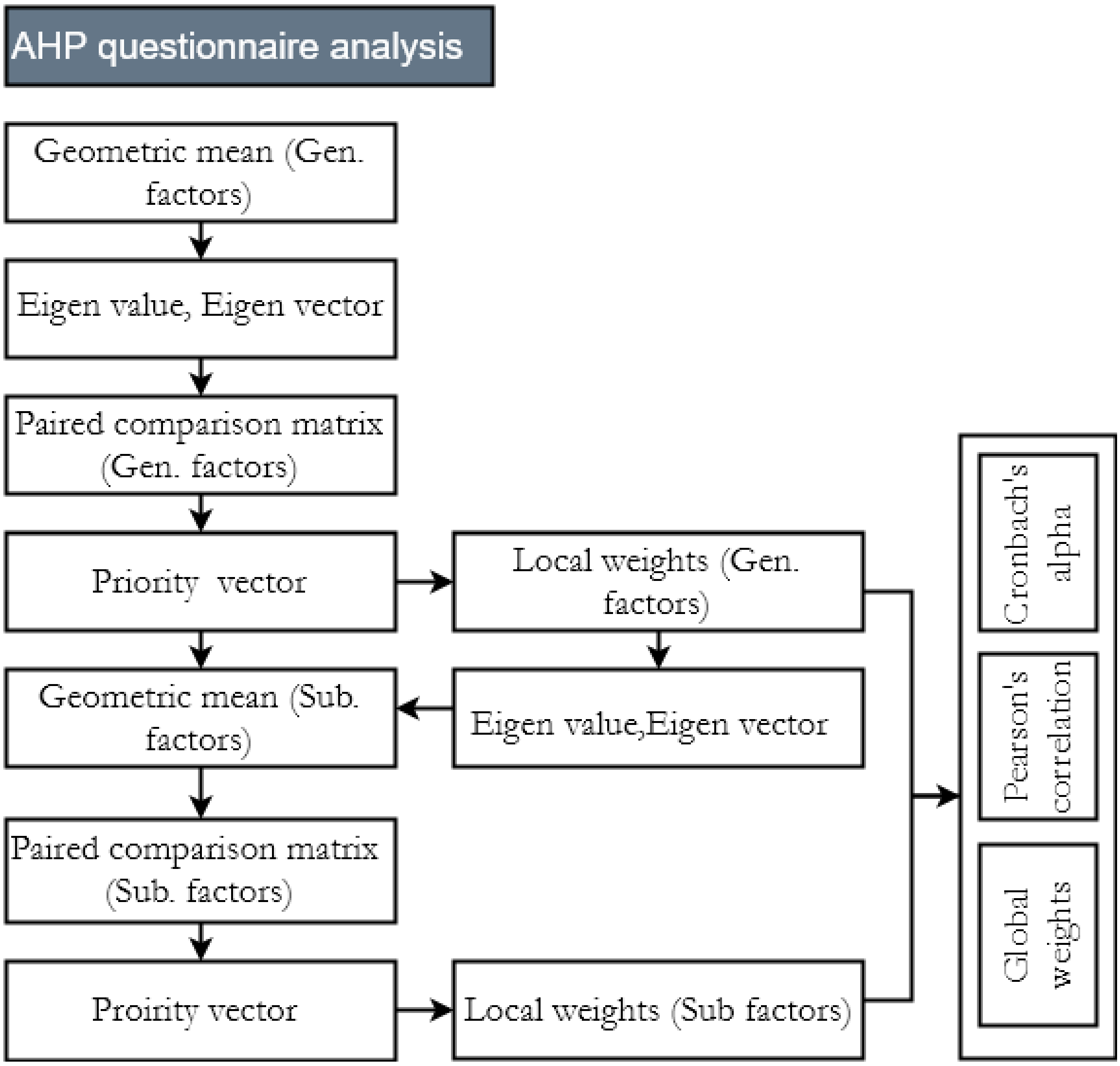


Figure 14. AHP analysis

The literature review demonstrated the decomposition of the elements of industrial site suitability into hierarchies and the computation of the principal Eigen vectors or priority vectors. It also demonstrated the computation of weights representing stakeholder preferences and the checks for consistency in the scores.

The number of scores obtained from administering the 40 pairs of questions with 32 participants was very voluminous. Adding to this volume were the values generated from the computation of the reciprocal matrices. This means that an analysis of the scores on individual basis was simply impossible unless an aggregation procedure was utilized. In view of this challenge, the geometric mean (Crawford & Williams, 1985) was computed for every pair of pairwise questions across all 32 participants. Several authors contend that the Weighted Geometric Mean (WGM) is a better way of aggregating AHP scores than the Weighted Arithmetic Mean (WAM). The geometric mean by its computation is able to preserve the reciprocal capability of the scores unlike the arithmetic mean. According to Krejčí and Stoklasa (2018),the problem of rank reversal is more likely when arithmetic mean is used.

Eigen value refers to the inverse of the total number of general factors and sub factors. Principal Eigen vectors for the three general factors; economic, socio-economic and telecommunication and transport were computed from multiplying the Eigen value that is, 1/3 with the horizontal sum of the normalized

Eigen vector. The process was repeated for the three sets of sub factors classified under the general factors. Subsequently, the computations resulted in one Principal Eigen vector for general factors (respondents' relative weights for general factors) and three other principal Eigen vectors for sub factors (respondents' relative weights for sub-factors). The Eigen vectors were referred to as local weights as shown in figure 14.

Having obtained the two sets of local weights, a technique was needed to merge the local weights generated from the general factors with the local weights from the sub factors. To perform this computation, the local weight of each sub factor was multiplied by the local weight of the associated general factor. The values obtained from this computation were now the global weights of importance for each individual sub factor. All computations were performed in Microsoft excel spreadsheet. The tool helped in simplifying the cumbersome processes involved in the analysis. Excel also has a ranking function which was used to rank the global weights from the most important to the least.

4.2.1. Reliability and validity analysis

The analysis proceeded to check for inconsistencies in the scores so that early measures could be taken to prevent any errors from jeopardising the final results. Instead of the conventional consistency ratio used in most AHP analysis, another measure, the Cronbach's alpha was used to check for the internal consistency of the scores also referred to as inter-rater reliability (Mohajan, 2017). The AHP consistency ratio has been criticised for its failure to measure actual forms of inconsistencies in scores hence many researchers now resort to more efficient measures of reliability (Brunelli, 2015). The measurement was performed by transferring the respondents' scores (scores in the columns, pairwise in the rows) from Microsoft excel to SPSS to run the reliability test. The closer the value of Cronbach's alpha was to 1, the more reliable the scores were.

Next, an analysis was performed to check the validity of the pairwise comparisons. The difference between the reliability and validity checks was that whereas the reliability sought to identify how similar respondents' scores were, validity looked out for how well the pairwise comparisons measured respondents' perception about the importance of location factors. This type of validity measurement is also referred to as criterion- related validity (Mohajan, 2017). There are many different methods for measuring the validity of constructs, one of the methods is the Pearson's correlation coefficient used in this research (Swank & Mullen, 2017). Similar to the reliability test, the pairwise scores already entered in Microsoft excel was transferred to SPSS, however this time, the pairwise comparisons (constructs) were in the columns and the scores in the rows. The last column in the SPSS was the sum of scores across all pairwise comparisons for each of the 32 respondents, next, a bivariate correlation was run in SPPS. To determine whether a pairwise comparison was valid or invalid, the significant p values were crosschecked with the look up value from the Pearson product moment correlation coefficient (r table). A pairwise comparison was valid if its significant p value was greater than the value from the r table that is, 0.349 associated with a df (degree of freedom) of 30.

The researcher was further interested in investigating the extent of correlation between the variables; Cronbach's alpha; Pearson's correlation and the global weights for the sub factors. In the previous reliability analysis, the scores were checked for inconsistencies, however for the purpose of this investigation, the pairwise comparisons were instead analysed for inconsistencies.

Since the results of the first two variables were presented in aggregated formats, a method was formulated to disaggregate the values into sub factors to support the investigation using scatterplots. Figures 15 and 16 illustrate the derivation of the Cronbach's alpha and Pearson's correlation coefficients for the sub factors.

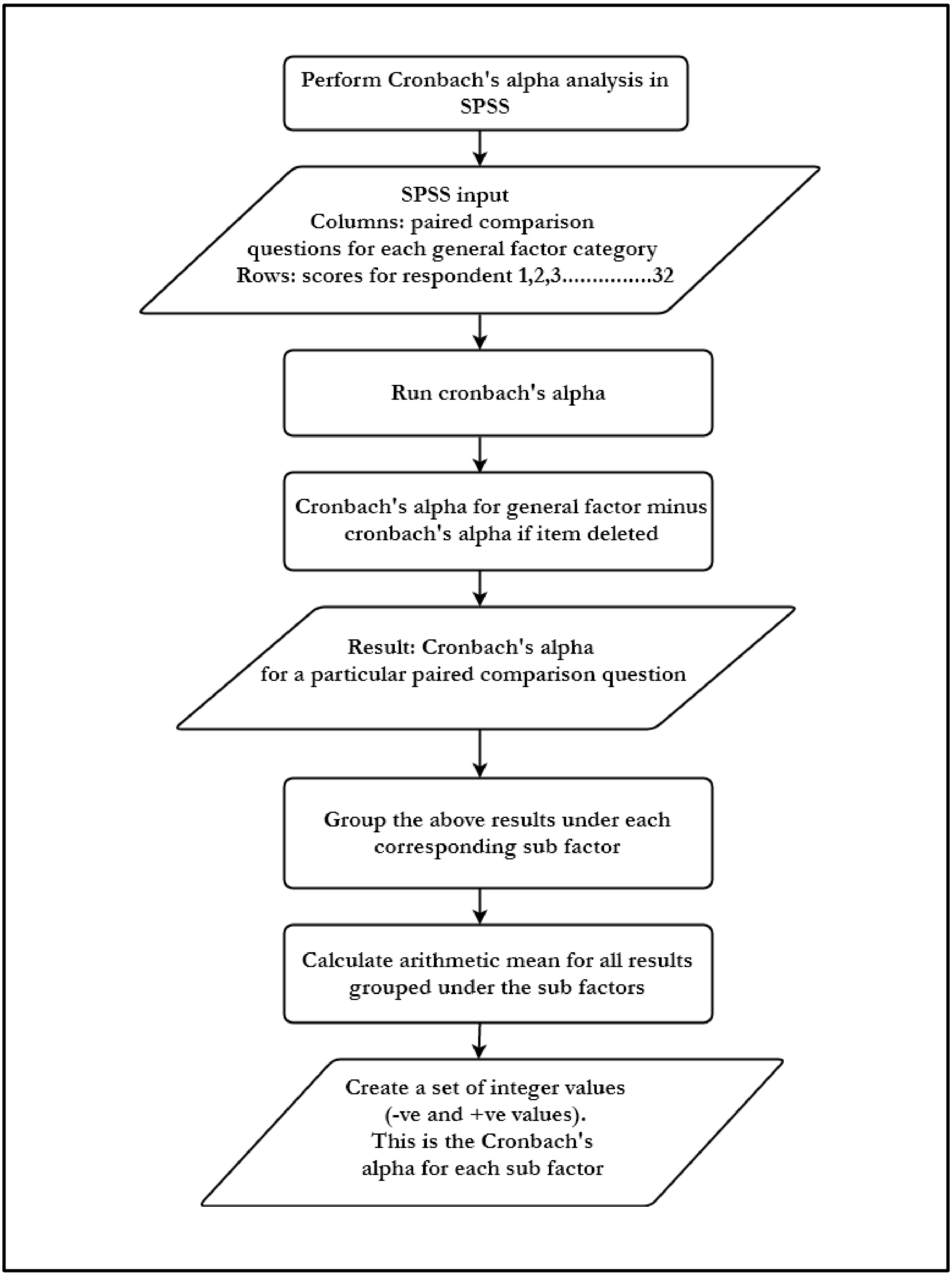


Figure 15. Cronbach's alpha analysis

Cronbach's alpha computation: As shown in figure 15, the Cronbach's alpha was computed for three sets of pairwise comparisons associated with the three general factors. The results of this computation in the SPSS was an overall Cronbach's alpha value for each of the three general factors. From the SPSS results, the value of "Cronbach's alpha if item deleted" was subtracted from the overall Cronbach's alpha value for each general factor, thus "Cronbach's alpha if item deleted" - overall Cronbach's alpha(economic , socio-economic, telecommunication and transportation). Then the results from the subtraction was grouped under the individual sub factors where they were associated with. Furthermore, the arithmetic mean was calculated for each group of new Cronbach's alpha values. Finally, a set of integers (-ve and +ve) representing the mean values for individual sub factors was created for the scatterplot analysis.

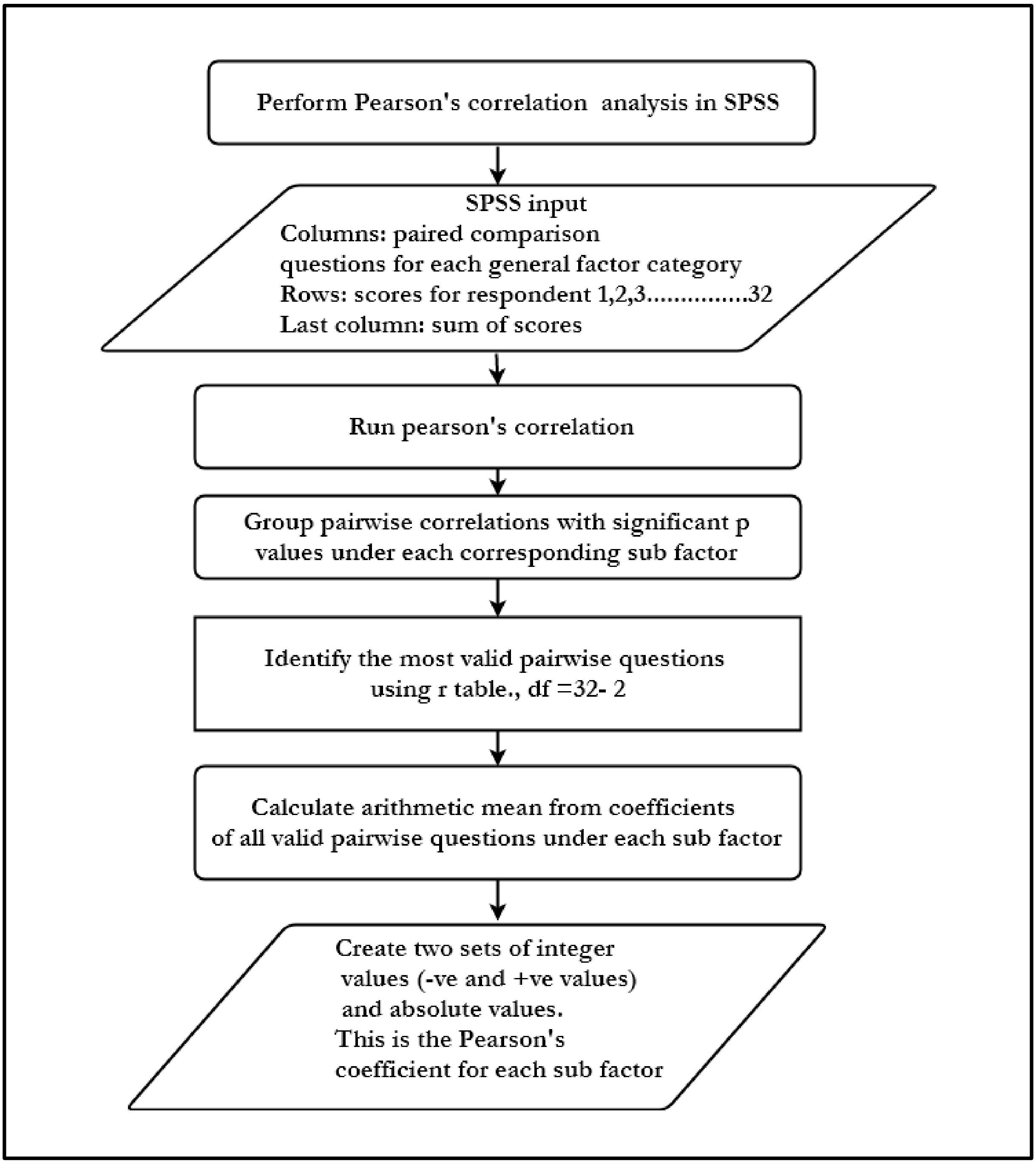


Figure 16. Pearson's correlation analysis.

Pearson's correlation computation: With reference to figure 16, the results from the Pearson's correlation was presented in three correlation tables. The last column in each table was the significant p value for each respondent's scores. The computation commenced with the selection and grouping of only pairwise comparisons or questions with significant p values as they correspond to the individual sub factors. Then groups of valid questions were selected using the r table. The arithmetic mean of the coefficients were calculated for each group of selected valid pairwise questions. Two sets of integer (-ve and +ve values) and absolute mean values were created for further analysis with the scatterplots.

4.3. Secondary data justification and variable selection

The data collection phase of the research was basically about integrating primary and secondary data which is a major dimension of the mixed methods research approach (Schoonenboom & Johnson, 2017). In view of this, the main source of the secondary datasets used for the GIS weighted suitability model was from the AHP global weights rankings. The rankings provided the opportunity for the selection of the most important factors for the suitability analysis.

The first part of this section of the report justifies the three general factors and the 15 most critical sub factors collated from the expert interviews as shown in the three–level hierarchical structure in figure 17.

The second part oof this section describes the proceedure used for selecting the secondary data inputs for the suitability analysis.

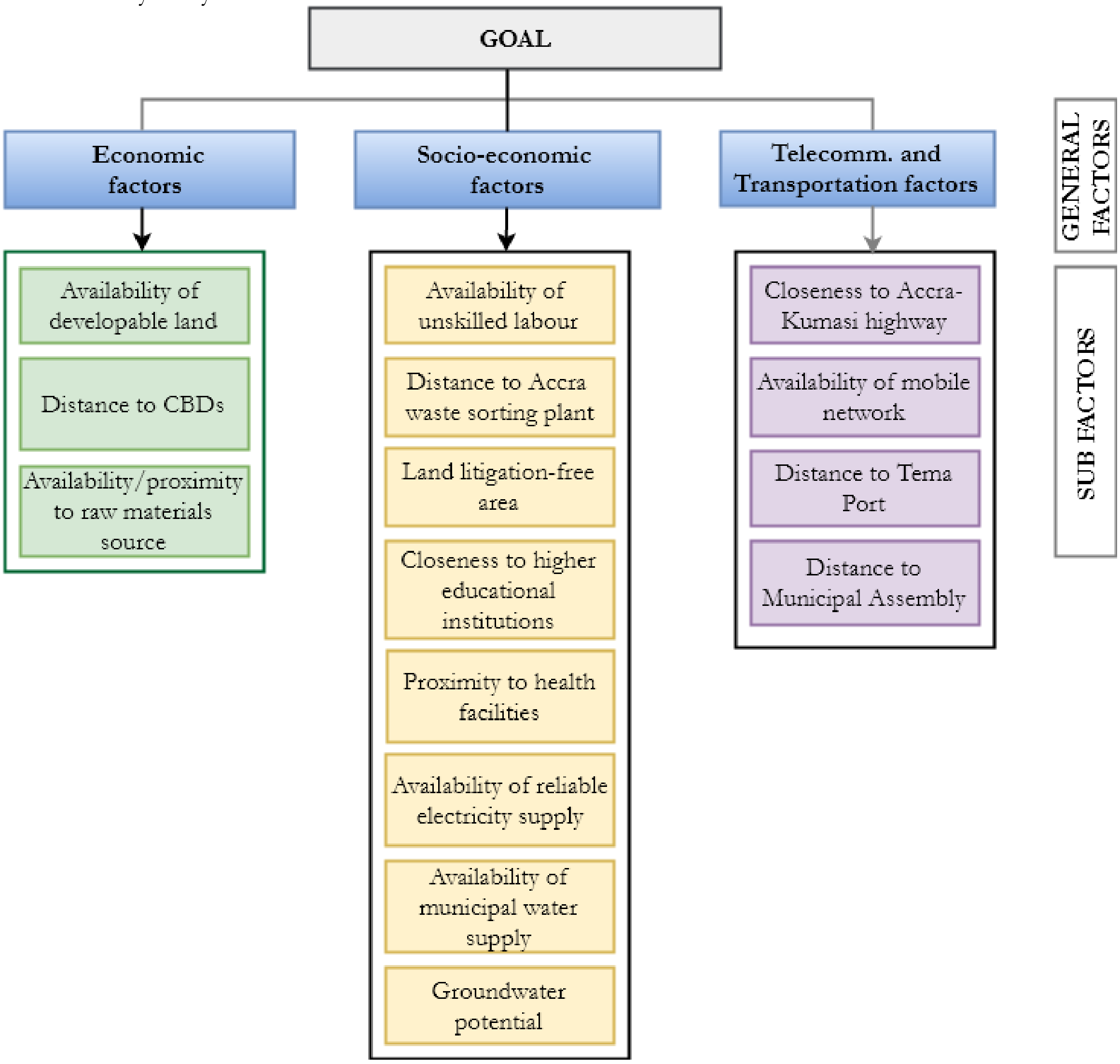


Figure 17. Hierarchical structure showing general factors and sub factors.

4.3.1. Justification of location factors

The hierarchical structure (figure 17) identifies the relevance of the general factors influencing industrial site selection in the Ga west municipality. The economic factors outlined in the hierarchy are very crucial considerations in industrial site selection, for instance, adequate space is needed for the location of the plant and for future expansion, the environmental considerations during the site selection and the cost of the proposed industrial sites can also not be overlooked in the decision making process. The 5 experts agreed that the industrial site should be at a proximal distance to markets which are often located in the CBDs. Proximity to CBDs ensures that customers can readily purchase a firm's products within a short distance from the main market location thus reducing transportation and distribution costs (ASEAN, 2014). It is more cost effective to locate the site close to the source of raw material depending on the type of firm. Footloose industries such as mobile phone and electrical manufacturing companies may not consider the distance to raw materials as very important however firms such as cement and sugar production need to locate close to raw materials to reduce transportation and storage costs. It is also better for food producing firms to be located close to their raw materials sources due to the perishable nature of the inputs.

The socio-economic factors under listed in the hierarchy were very relevant since they represent the actual picture of industrial location factors at play in the municipality. All the experts emphasized that, business owners and entrepreneurs were attracted to the presence of unskilled labour who are highly mobile within the municipality and attracted comparatively lower wages than other municipalities in the metropolitan area. This type of labour was mostly employed in the concrete production firms or food processing firms as casual workers. Furthermore, the experts considered the distance to the waste sorting plant as crucial due to the long distance that firms were previously required to travel to access landfill sites in the Accra metropolitan area. This situation had the tendency of increasing transport costs and impacting negatively on the firm's profits. Like many other fast urbanizing municipalities in the GAMA area, Ga west is not free from pockets of problems related to land ownership, as a result, the experts indicated that the potential industrial site should be free from all manner of land litigations. The proximity to higher educational institutions were considered as very important in the municipality due to the advantage of a large population of customers created through the urbanization effects of universities and colleges. The experts recognized that the industrial site selection process considered sites which were located at a proximal distances to health facilities to reduce the cost of transportation and the time employees spend while accessing medical treatment.

Manufacturing firms in Ga west look out for areas with a reliable supply of electricity to support their production hence it was necessary that the industrial site be located in an area with a constant supply of electricity from the national power grid. The experts explained that intermitted power cuts disrupted production and increased a firm's operating cost especially if it resorted to electric generators. According to the experts, municipal water supply was available in the Amasaman, Adjen Kotoku and Medie areas of the municipality therefore food and beverage producing industries which use large amounts of fresh water in their production processes can be found in those locations. However, the availability of groundwater was also an important attraction for mineral water manufacturing firms whose main raw material was water.

The experts identified four telecommunication and transportation factors which were significant considerations in the site selection process namely; "Closeness to Accra – Kumasi highway", "Availability of mobile network", "Distance to Tema Port" and the "Distance to the Municipal Assembly". Entrepreneurs mostly preferred sites closer to the Accra- Kumasi highway to facilitate the transportation of finished products to customers and the Tema port. Telecommunication and internet is very essential for any business nowadays. However, because some areas in the municipality do not have good mobile phone network, the firms selected the sites where private mobile networks were available. Although not a major priority for investors, the expert interviews indicated that some firms were located closer to the Municipal Assembly in order to reduce the cost of transportation and time spent whilst travelling to pay taxes at the Assembly and attend meetings.

4.3.2. Secondary data selection process

Since the GIS based spatial multi-criteria evaluation uses geographical data in the form of map layers as inputs, it is the responsibility of the user to select the highest ranking sub factors to be translated into map layers for the suitability analysis. The most popular approaches to this selection is based on the user's subjective judgement and the availability of data (Ayehu, Besufekad, Ayehu, & Besufekad, 2015; Ullah & Mansourian, 2016). This practise leads to several biases in the analysis (Montibeller & Von Winterfeldt, 2015).

The aim of the researcher was to conduct a selection free from biases. In view of this, a technique was devised by using the Pearson's correlation coefficients for sub factors and the validity tests illustrated in table 9 (results and discussion chapter). The correlation coefficients obtained in figure 16 for each sub factor was tested for validity using a df of 30 from the r table. If the Pearson's coefficient (r) for a sub factor was greater than the r table value of 0.349, the sub factor was said to be valid, if the Pearson's coefficient (r) was less than 0.349, the sub factor was invalid. To effect the selection, the first 10 set of highest ranking factors were identified; from this set, 8 valid sub factors were selected for the data processing. Invalid sub factors within the first 10 were in effect omitted from the selection.

4.4. Data processing

Data processing was very crucial in the suitability analysis because the map layers represented the extent to which alternative locations in the Ga west municipality met the respondents' criteria for selecting optimal locations for firms. The first step in the data processing was to gather the relevant maps according to the selected sub factors. Next, several ArcGIS tools were used to analyse the map layers and to present them in the appropriate raster formats for the suitability analysis. Figure 18 explains the process followed in the data processing. 7 map layers with the exception of "Developable land" were obtained from the Land Use and Spatial Planning Authority, the Centre for Remote Sensing and Geographic Information Services and the Municipal Assembly. A summary of all data inputs for the research, their dates of acquisition, the original file formats and sources are documented in table 7. All selected datasets for the suitability analysis were processed in the Esri ArcGIS software version 10.6.1.

Figure 18 shows that the input data analysis generally entailed proximity operations and data display operations. To begin with, the most common raw materials in the municipality which had been the source of attraction for manufacturing firms were (1) agricultural produce (2) groundwater (3) sandstone and limestone rich soils. To analyse the "raw material source layer" (with a rank of 3), firstly, the point locations of 13 most notable food producing areas were identified, using the point layer as the input source locations , the processing extent was set to the study area, then the Euclidean distance tool was run. For the purpose of ensuring that the analysis was confined to the study area, the raster output was masked using the extract by mask tool. Lastly the resulting raster data set was classified into 5 classes with 5 being the most suitable location in terms of distance to food producing areas (Appendix 13). Secondly, groundwater potential was treated as a "raw material source" data and not as a location factor as is seen in tables 8 and 9. Using the symbology operations in ArcGIS, the polygon layer was classified into 5 classes with 5 showing the best area with large amounts of groundwater in the aquifers (Appendix 13) (Kebede, 2013). A similar procedure was used for the geology map layer; the layer was classified from 5 to 1, however, the classification was interpreted as areas with the voltaian sandstone formation were the most suitable (category 5) raw material sought by the concrete products manufacturing firms. The next favourable formation was granite then mixed quartzite and sandstone and so on (Appendix 13).

With respect to the "Availability of unskilled labour" layer, a dataset describing the number of unemployed and inactive persons 15 years and older was obtained from the Ghana Statistical Service in excel format (table 7). This dataset was used as a proxy for the spatial distribution of unskilled labour in the municipality. To process this data, the sum of unemployed and inactive persons was computed for 5 zones in the municipality. This sum was the total number of unskilled labour for each of the 5 zones.

Consequently, the output map was ranked from 5 to 1 according to the zone with the highest population of unskilled labour (Appendix 12).

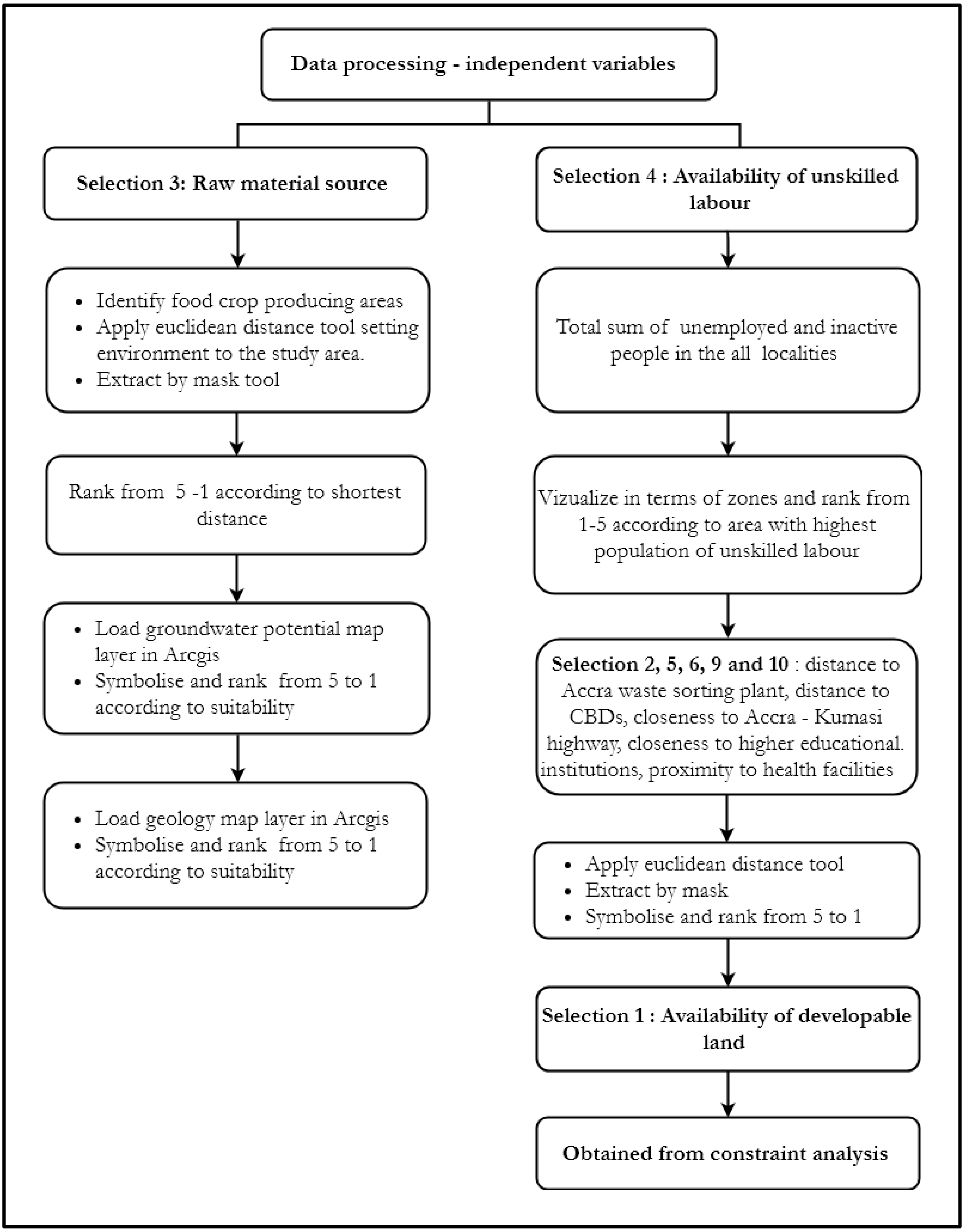


Figure 18. Data processing - independent variables.

As can be seen from figure 18, the map layers namely; “Distance to Accra waste sorting plant”, “Distance to CBDs”, “Closeness to Accra - Kumasi highway”, “Closeness to higher educational. Institutions” and “Proximity to health facilities” were processed with the Euclidean distance tool and ranked from 5 to 1 just as was done for the food producing areas. The final and most important map layer, “Developable land” was the output map from the constraints analysis discussed in the next section. All datasets produced were projected in WGS 84/UTM zone 30N.

Table 7

Summary of datasets, the dates of collection and sources

Description	Format	Year	Source
Land use maps (LU)	Vector	1987, 2003, 2017	CERSGIS, University of Ghana
Projected population - Ga West Municipal	Excel	2010, 2015, 2016, 2017, 2018, 2019	Ghana Statistical Service
Projected population - Accra Metropolis	Excel	2010, 2015, 2016, 2017, 2018, 2019	Ghana Statistical Service
Employment by industry	Excel	2010	Ghana Statistical Service
Economic activity of persons 15 years and older	Excel	2010	Ghana Statistical Service
Transcribed interviews	Text	2017	Field work
AHP pairwise scoring	Numerical ranking	2017	Field work - AHP questionnaire
Distance to food producing areas	Vector	2017	1. Land Use and Spatial Planning Authority 2. ARCGIS spatial analyst tools
Geology	Vector	2017	CERSGIS, University of Ghana
Groundwater potential	Vector	2017	CERSGIS, University of Ghana
Unskilled labour distribution	Vector	2010	Ghana Statistical Service
Distance to highway	Vector	2017	1. Land Use and Spatial Planning Authority 2. ARCGIS spatial analyst tools
Distance to CBD	Vector	2017	1. Land Use and Spatial Planning Authority 2. ARCGIS spatial analyst tools
Distance to health facilities	Raster	2017	CERSGIS, University of Ghana
Distance to higher educational institutions	Raster	2017	CERSGIS, University of Ghana
Distance to Accra waste sorting plant	Raster	2017	1. Ga West Municipal Assembly 2. ARCGIS spatial analyst tools
Floodable areas	Raster	2017	CERSGIS, University of Ghana
DEM	Raster	2017	CERSGIS, University of Ghana
Rivers and streams	Vector	2017	CERSGIS, University of Ghana
Developable industrial land, Ga West	Raster	2017	1. CERSGIS, University of Ghana 2. ARCGIS analysis tools

4.5. Constraints to industrial development

The physical environment is significantly impacted by industrial development projects. When large parking areas and access roads to industrial sites are constructed, the impervious surfaces (Schueler, 1994) created as a result, prevents the infiltration of rainwater into the ground, this increases runoffs containing hazardous substances from roads and parking areas into nearby rivers and streams (Kim, Jeong, Jeon, & Bae, 2016).Some pharmaceutical industries, paper manufacturing (Regional Activity Centre for Cleaner Production (RAC/CP), 2005) and plastics manufacturing firms release sulphur dioxide and nitrous oxide into the immediate atmosphere, the gases later react with rain water and are deposited into rivers and streams. The combined effects of these processes results in the loss of natural habitats, reduced water quality, the loss of wetlands and flooding (Martina, 2010). This means that proper industrial location decisions must ensure that rivers and wetlands are preserved to mitigate the impacts of industrial activities on biodiversity and to prevent flooding.

The Ghana Environmental Protection Agency, prohibits any form of development in areas prone to flooding, hilly areas with critical slopes, sacred groves, water bodies in use for domestic purposes, water bodies in protected areas and water bodies which protect wildlife and fishery activities (Environmental Protection Agency, 1999) . As a requirement, developers are to obtain an EPA permit before the commencement of an industrial project. Any proposed industrial site which violates the regulations does not warrant a permit. Apart from developments being prohibited in these areas, industrial construction on steep slopes are challenging due to site stability issues, the cost of transporting goods from slopes are also higher compared to flatter terrains (Sarath et al., 2018). As a result, slopes above the grade of 15% were considered as steep slopes and not appropriate for industrial development. Sacred groves in Ghana are important for conserving the original species of certain plants and animals and as a source of medicinal plants. Groves such as the nature reserve in the study area is protected by law (Nganso, Kyerematen, & Obeng-Ofori, 2012) therefore industrial development are not permitted in these forests (Environmental Protection Agency, 1999).

4.5.1. Constraint analysis

The purpose of a constraint analysis in the site suitability model is to identify the most important environmental restrictions to industrial development (Abbaspour, Mahiny, Arjmandy, & Naimi, 2011). The results of the constraints analysis was to assist the user to determine areas that are likely to be suitable for selection as an optimal industrial location in the model. In view of this, a GIS based constraint analysis was conducted by gathering map layers on the four environmentally sensitive areas identified namely; Rivers and streams, floodable area, the sacred grove and slopes greater than 15%. The analysis was effected with the support of ArcGIS geoprocessing and spatial analyst tools.

Figure 19 provides a summary of the workflow used for the constraint analysis. The final map obtained from the process was what remained after environmentally sensitive areas and other land uses (assumptions) had been removed from the study area.

As can be seen from the workflow, the cells in the DEM for the study area was first classified into percentage slopes. The measurement of slopes using percentages was found to be more convenient and easy to relate to the actual steepness of the landform than in degrees. The objective of the constraint analysis was to analyse all layers in their vector forms, therefore since the DEM was a raster layer, the conversion to polygons could only be effected by converting the floating values of the cells into integer values. This was done using the INT tool. Prior to the conversion, the raster was multiplied by 1000 so that the decimals in the floating raster were not lost during the conversion. Next, the Raster to Polygon tool was run with the new DEM integer raster, all slopes greater than 15% were selected from the attribute table and saved as a new map layer.

Because the datasets for rivers, streams and floodable areas were already in vector formats, the Feature to Polygon tool was a convenient way of converting the two datasets each into polygons. A subset of the built-up area in 2017 and the sacred grove were also created from selecting by attributes and were saved separately. The same process was performed for the Accra waste sorting plant polygon.

Following that all constraints and assumptions had been identified, the geoprocessing tool; "merge" was used to combine all the polygon layers into one output dataset. This dataset was then erased from the Ga west study area to have an area free from physical constraints and lands use assumptions.

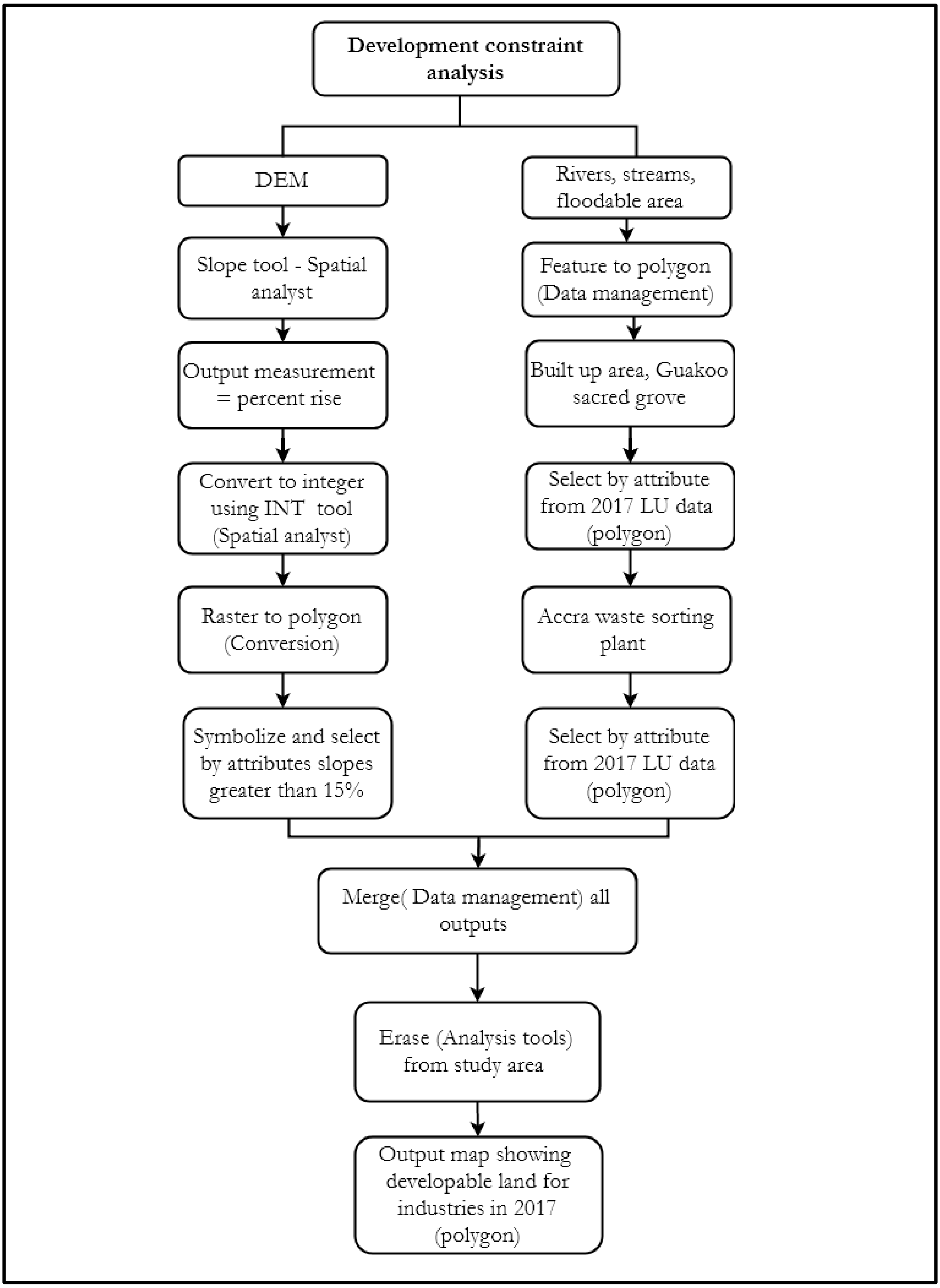


Figure 19. Development constraints analysis workflow.

4.5.2. Assumptions

Five main assumptions were made in the constraint analysis, that;

a. There was no expectation of land parcels in the built-up area to convert to industrial land use in the short to medium term.

b. The waste treatment site would not become an optimum location for industries in the short to medium term.

c. Industries would only locate on previous agricultural and vacant land in the municipality.

d. Land use zoning did not influence the size of developable industrial land in 2017.

e. There were no restrictions left after the constraint analysis

4.6. GIS weighted suitability model

A GIS weighted suitability model is a type of suitability analysis that allows candidate locations to be ranked according to a predefined criteria. The advantage of this technique is that all input map layers have relative importance in the model and users have the chance of selecting the next suitable location after the best has already been selected (Briney, 2014). The technique used for a weighted suitability model is based on the Weighted Linear Combination methods. Usually, individual raster map layers referred to as independent variables are reclassified or ranked, weighted and aggregated using ArcGIS weighted overlay tools, weighted sum or map algebra. However, since in this analysis, the AHP method had already been used to assign weights to the industrial location factors, the suitability model proceeded to reclassify the independent variables and to apply the weighted sum overlay tool to aggregate the map layers.

This methodology implies that two Multi-criteria Evaluation methods from the group of the WLC approaches were integrated into the weighted suitability model. The “raw material source” layer was developed by merging the three raw material sources, next all other independent variables including “Developable land” were reclassified from 5 (most suitable) to 1 (least suitable). Following the reclassification, the weighted sum tool was used to aggregate all the layers by multiplying each layer by its associated global weight (table 8 in the results and discussion chapter). In order to ensure that only the areas earmarked as developable industrial land were ranked, the result of the weighted sum model was again intersected with the “Developable land layer”. Subsequently, the final weighted suitability model was the 2017 developable industrial land in Ga west duly ranked from the most highly rated area to the lowest rated area (figure 22 , results and discussion).

4.6.1. Assumptions

5. The GIS weighted suitability model made two main assumptions; (1) that the experts and participants in the AHP survey were rational decision makers and (2) prime industrial locations referred to the most ideal locations for siting manufacturing type of firms.

4.6.2. Results validation

The results from the suitability analysis was validated to assess how accurate the interpretations were. The validation approach used was a comparison of ground truth location characteristics of suitable areas and the results from the ranked model. The source of the ground truth location characteristics was Google earth images and qualitative observations during field work.

5. RESULTS AND DISCUSSION

The research developed an integrated MCE approach to understand how specific industrial location factors determined future prime industrial areas in the Ga west municipality using 2017 as the base year. As demonstrated in section 4.1.2 of the methodology chapter, two samples consisting of 5 experts and 32 respondents were selected from 37 large scale manufacturing firms in the municipality for the primary data collection. The 5 experts were each engaged in a 30 – minute semi-structured interview to elicit their knowledge about the factors that entrepreneurs in the Ga west municipality mostly considered during their industrial site selection decision making process. The factors obtained from the expert interviews were further developed into an AHP questionnaire made up of 40 pairwise comparisons for rating. In view of this, the second sample of 32 respondents participated in rating the AHP questionnaire by assigning a value from 1 to 9 to represent how they perceived the importance of one location factor over the other in the pairwise comparison.

The scores from the AHP ratings were duly analysed to identify the most important location factors applicable to the Ga west municipality, furthermore, several methods were used to process the factors into spatial data inputs for an industrial site or location suitability analysis. The output of this analysis was then used to determine the most prime industrial areas in the municipality.

This chapter is organized into three sections grouped under the following themes identified from the literature review and research questions; (1) estimating industrial site or location suitability,(2) Euclidean distance analysis and (3) reliability, validity and global weights. The first sections presents a summary of the various analyses conducted on a particular theme, the second sections present the results obtained from the analyses in the first section whilst the third sections interprets the findings in the light of previous research and discusses its implications on the MCE approach and industrial location in the Ga west municipality.

5.1. Summary of the analyses with reference to estimating industrial location suitability

In this research, the geometric mean was used to aggregate the pairwise scores obtained from the AHP questionnaire survey. Principal Eigen vectors were calculated from the normalized relative weights of sub factors as expatiated in the section 4.2 of the methodology and data chapter. To obtain the global weight of each sub factor, the local weight of the sub factor was multiplied by the local weight of its corresponding general factor. The objective of this analysis was to determine the degrees of importance that respondents attached to various industrial location factors in the context of the Ga west municipality. A method using the global weights and validity test results was developed and used to select the most significant location factors out of the total of 15 (please refer to section 4.3.2 in the methodology and data chapter). The selected factors were transformed into map layers or independent variables for the weighted suitability model. The purpose of this approach to selecting sub factors was to avoid biases transferred from the selection procedure into the final suitability analysis.

A total of 8 map layers were processed using either data display operations or the Euclidean distance analysis or the constraints analysis (please refer to section 4.4 and 4.5 of the methodology and data chapter). On performing the actual suitability analysis, the raster versions of the individual map layers were first reclassified from 5 which was the most suitable locations to 1, the least suitable locations. However, prior to the reclassification, rivers and streams, floodable areas, the nature reserve and slopes greater than 15% classified as environmentally sensitive areas were removed from the study area during the constraint analysis . The actual suitability analysis assumed that the built-up area and the waste sorting site were not likely to be converted into industrial land use in the short to medium term periods, therefore these two land uses were also removed from the study area.

With respect to the method for aggregating the reclassified map layers and the global weights (described in section 4.6 of the methodology and data chapter), the weighted sum tool in ArcGIS was chosen among the weighted overlay and map algebra tools. Because the map layers consisted of both floating point and integer rasters, the weighted sum tool was appropriate for the aggregation instead of the weighted overlay tool which accepts only integer rasters or the map algebra technique that uses mathematical operators to combine the layers.

5.1.1. Results of the analyses with reference to estimating industrial location suitability

The geometric mean computations produced a common average value for the scores across the 32 respondents who answered each of the pairwise comparisons. Four Principal Eigen vectors, one for the general factors and a set of three for sub factors were obtained from the normalized relative weights. As a matter of fact, the global weights were ranked accordingly as documented in table 8.

Table 8

Factor weights and ranking

General factor	Local weight	Sub factor	Local weight	Global weight	Ranking by importance
Economic	0.673	Availability of developable land	0.70	0.47	1
		Availability/proximity to raw material source	0.22	0.15	3
		Distance to CBDs	0.09	0.06	5
Socio-economic	0.227	Availability of unskilled labour	0.34	0.08	4
		Distance to Accra waste sorting plant	0.19	0.23	2
		Litigation-free area	0.15	0.04	7
		Closeness to higher educational institutions	0.11	0.02	9
		Proximity to health facilities	0.08	0.02	10
		Availability of reliable electricity supply	0.06	0.02	12
		Availability of Municipal water supply	0.05	0.01	13
		Groundwater potential	0.03	0.01	15
Telecommunication and Transportation	0.099	Closeness to Accra -Kumasi highway	0.52	0.05	6
		Availability of mobile network	0.26	0.03	8
		Distance to Tema Port	0.15	0.02	11
		Distance to Municipal Assembly	0.07	0.01	14

The results portrayed in table 8 means that economic factors were the most important considerations for Ga west entrepreneurs in their site selection, as a result, the economic general factor attained the highest local weight from the analysis. One can deduce from the table that the global weights are directly related to the local weight of a general factor. For instance, because economic general factor attained the highest local weight, the economic sub factors had the highest global weights followed by socio-economic sub factors then, telecommunication and transportation. Among the economic sub factors, respondents perceived the "Availability of developable land" as the most important factor hence it attained the highest local weight in that category followed by the "Availability or proximity to raw material source". Among the Telecommunication and transportation factors, "Closeness to the Accra – Kumasi highway" was perceived to be the most important factor also in that category. The global weight ranking is basically the arrangements of the weights of all sub factors from the highest to the lowest value. Overall, the respondents found the "Availability of developable land" to be the most important industrial location factor in the municipality, followed by the "Distance to the Accra waste sorting plant".

Interestingly, although many of the manufacturing firms depend on groundwater for their operations, the factor attained the lowest weight among the sub factors likewise the "Distance to the Municipal Assembly" and the "Availability of Municipal water supply".

Respondents prioritized land very high in the scoring, the reason being that land had become very scarce in the Accra metropolis, as a result, Ga west municipality which was the most relatively undeveloped municipality in the Greater Accra Metropolitan Area was a major attraction for most manufacturing firms in search of large spaces for their plants (Nai, 2018a).

A considerable number of the firms that participated in the questionnaire dealt with the production of goods for international exports however, "Closeness to the Tema port" was not a very important priority once the selected site was close to the Accra – Kumasi – highway. Respondents also did not find the "Closeness to the Municipal Assembly" as a significant location factor due to the fact that the municipality's revenue collectors and the EPA officers embarked on periodic site visits, as a result, the firms paid their taxes and benefitted from the recommendations of the EPA officials without having to travel to the Municipal Assembly for these services (Nai, 2018a).

The factors which met the selection criteria for the suitability analysis are hereby presented in table 9.

Table 9

Factor selection

Sub factor	Pearson's (r)	d.f	r-table test	Validity	Ranking by importance	Selection
Availability of developable land	0.583	30	> 0.349	valid	1	selected
Availability/proximity to raw material source	0.706	30	> 0.349	valid	3	selected
Distance to CBDs	0.551	30	> 0.349	valid	5	selected
Availability of unskilled labour	0.523	30	> 0.349	valid	4	selected
Distance to Accra waste sorting plant	0.454	30	> 0.349	valid	2	selected
Litigation-free area	0.222	30	< 0.349	invalid	7	not selected
Closeness to higher educational institutions	0.391	30	> 0.349	valid	9	selected
Proximity to health facilities	0.536	30	> 0.349	valid	10	selected
Availability of reliable electricity supply	0.466	30	> 0.349	valid	12	not selected
Availability of Municipal water supply	0.530	30	> 0.349	valid	13	not selected
Groundwater potential	0.426	30	> 0.349	valid	15	not selected
Closeness to Accra -Kumasi highway	0.626	30	> 0.349	valid	6	selected
Availability of mobile network	0.128	30	< 0.349	invalid	8	not selected
Distance to Tema Port	0.024	30	< 0.349	invalid	11	not selected
Distance to Municipal Assembly	0.585	30	> 0.349	valid	14	not selected

From the table, the following factors namely; "Availability of reliable electricity supply ", "Availability of Municipal water supply ", "Groundwater potential " and "Distance to the Municipal Assembly" did not qualify for selection because their global weights positioned them outside the 1 to 10 ranking (section 4.3.2 methodology and data chapter). In addition, even though the factors; "Litigation free area" and "Availability of mobile network" were ranked among the first 10 factors, because the r table test had considered them to be invalid, they were also not selected. Lastly the factor; "Distance to Tema port" was on the one hand invalid and on the other hand not among the first 10 factors. This condition automatically disqualified it from the selection.

With respect to the results of processing the raster map layers, the datasets namely; "raw material source", "unskilled labour" and "developable land" were processed into categorical raster datasets and they appear in appendix 12. The remaining datasets; "Distance to CBDs", "Distance to Accra waste sorting plant", "Closeness to higher educational institutions", "Proximity to health facilities" and "Closeness to Accra – Kumasi highway" were also processed into continuous raster datasets and are also included in appendix 12.

The results of the constraint analysis revealed that only 4,384 ha of land was available for industrial purposes as at 2017 depicted in figure 20. The purple areas show that any future form of industrial development would head towards the north eastern and south western parts of the municipality since the central portions which was mainly built –up was not likely to undergo any large scale change of use from residential or commercial to industrial land use in the short to medium term.

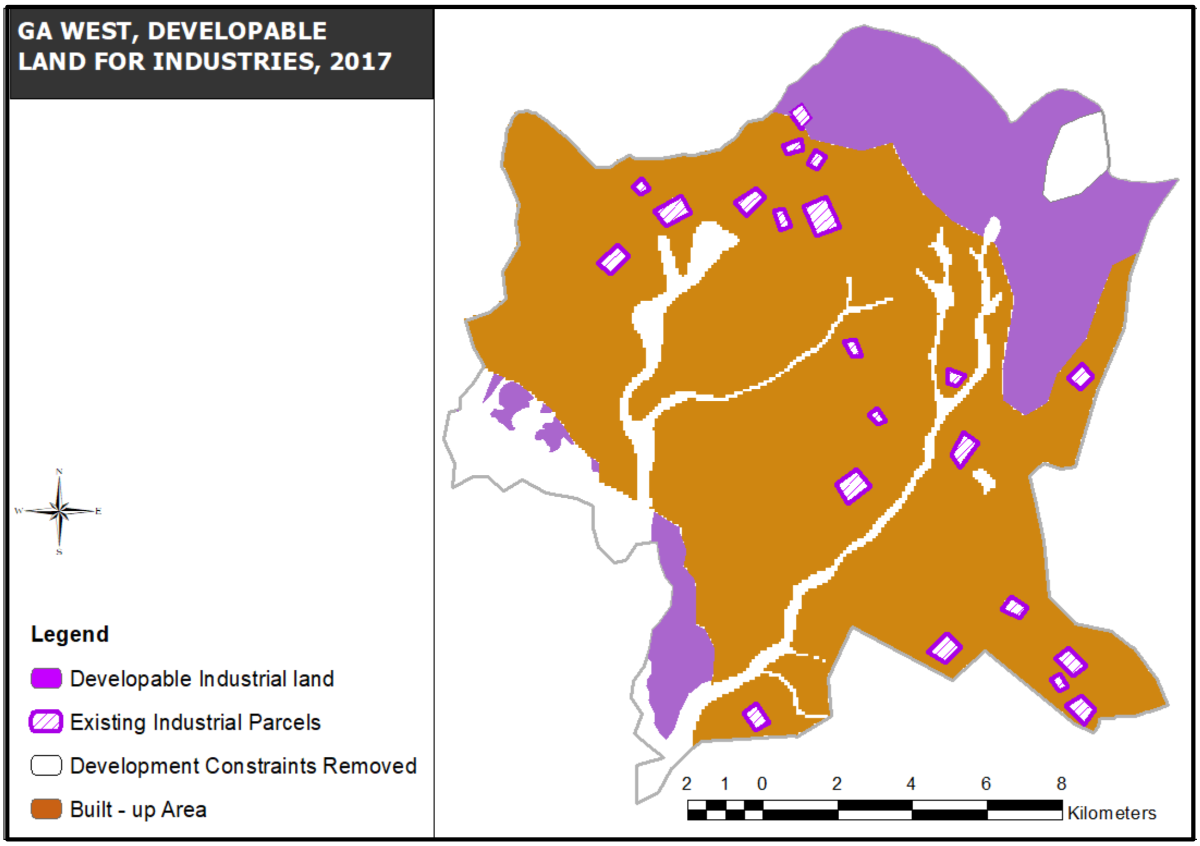


Figure 20. Existing developable land in 2017.

The results of the final weighted suitability model is hereby presented in figure 21. .As demonstrated, the availability of developable land had a significant influence on the pattern of suitable industrial locations in the municipality. This means that only areas that fell within the developable land area were assessed for suitability. From the illustration in the figure, one can notice that the most highly rated area was the Doboro - Mpehuasem area (Area 1) followed by the Hebron – Korleman - Gonse area (Area 2) then Adusa (Area 3), Mayera - Katapor (Area 4) and the Afuaman- Manhia and Okushiebiade enclave (lowest rated area).

The model identified the first two highly rated areas as the future prime industrial locations in the municipality. By way of a validation, a qualitative observation of the actual positions of these areas confirms that the Doboro – Mpehuasem and Hebron – Korleman areas are situated close to the highway and the CBD at Medie. These areas are also among the most rural in the municipality with large tracts of Agriculture or vacant land (Nai, 2018b).

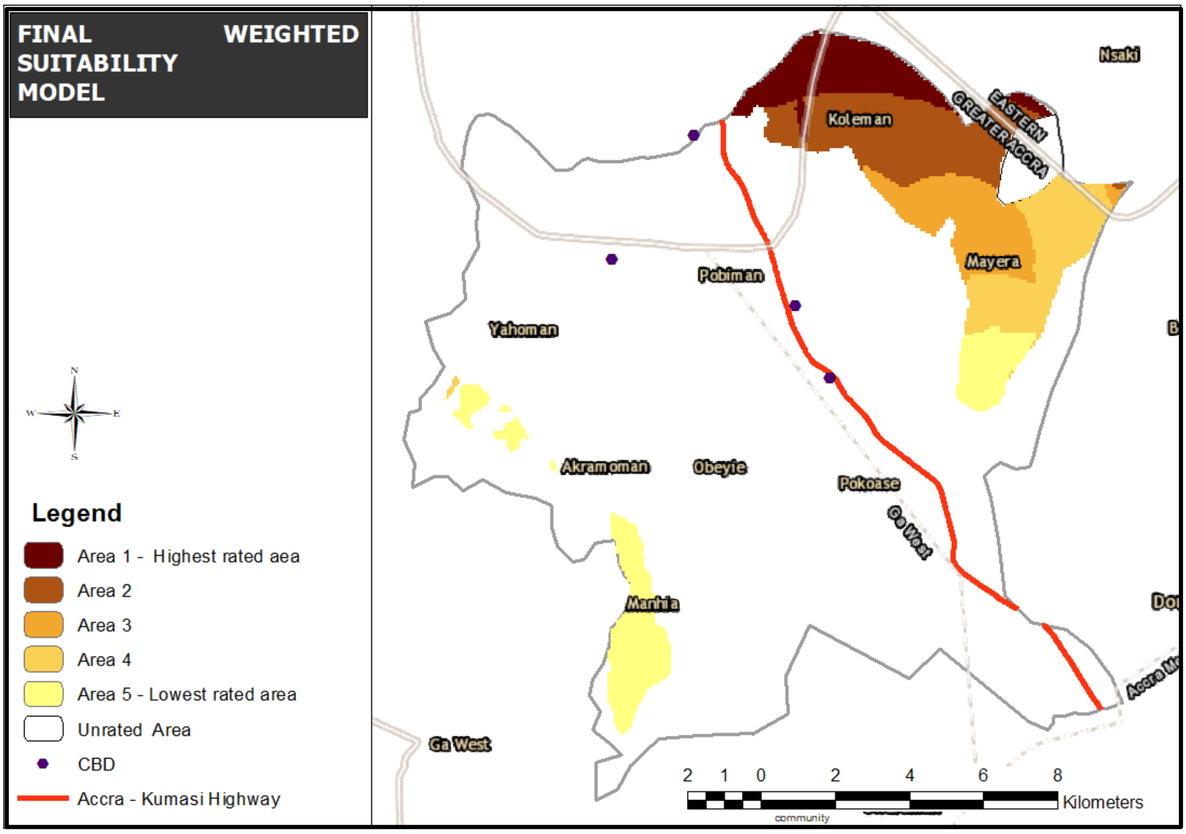


Figure 21. Final weighted suitability model

Table 10 gives a summary of the estimated industrial land take for the various suitable areas deduced from the model. As can be seen, the Hebron – Korleman – Gonse area presented the largest land area available for industrial development followed by Afuaman- Manhia and Okushiebiade; however, in terms of industrial clustering, the Dodoro – Mpehuasem area was the next expected hotspot after the Medie - Adjen Kotoku area (figure 20). In the situation where respondents did not prioritize the availability of land or the model did not make any land use assumptions, it was possible that the Medie - Adjen Kotoku corridor would experience more industrial clustering in the coming years.

Table 10

Land take by suitable area

Suitable Area	Land area (ha)	Percentage of total (%) approximated
1.0	718	16
2.0	1181	27
3.0	735	17
4.0	796	18
5.0	954	22
Total	4384	100

5.1.2. Discussion of the findings from estimating industrial location suitability

The research showed that industrial location in Ga west is motivated by comparative advantages rather than agglomeration forces. All 8 location factors used for the suitability analysis assessed location specific characteristics. The results from the final weighted suitability model suggests that assuming that developable land was available in the built – up area of the municipality, then, there was a possibility that agglomerative driving forces were significant during the analysis; because in 2017, the distribution of industrial land parcels in the municipality (figures 10 and 20) signified some form of clustering around the Adjen Kotoku, Medie, Hebron and Kutunse area which is located within the built- up area of the municipality.

In many developing countries including Chinese metropolitan areas and Mumbai in India, manufacturing have moved out of big cities to the suburbs and the hinterland due to the attraction from low cost industrial land and the infrastructural developments occurring in some of these areas . As a result, entrepreneurs begin to prioritize land once the factor becomes costly in the big cities (Henderson, 2014).

In the Ga west municipality, entrepreneurs become attracted to the suburbs in their search for cheap land however, because the costs that firms incur do not only emanate from land rents but from other important factors such as transportation and labour, the entrepreneur considers potential sites that would complement the cheap rents and further reduce the firm's cost of operation. For instance, manufacturing firms such as Nsawam cannery, Komenda sugar factory and Pwalugu tomato factory in Ghana are located close to their raw material sources (Owoo & Lambon-quayefio, 2017) to reduce the cost of transportation and to maintain the quality of perishable raw materials which can also translate into a cost to the firm.

The research expected that since a large number of mineral water and beverage manufacturing firms were operating in the municipality, the survey would place a lot of importance on groundwater potential as a location factor; on the contrary, this factor recorded the lowest global weight among the factors. One possible reason for this result could be that respondents did not find groundwater to be significant due to its wide availability in the municipality or that economic factors such as land, raw materials and markets (CBDs) were more important in municipality.

The "Distance to waste sorting plant" came tops among the socio-economic factors because solid waste management had been a topical issue in the Accra metropolitan area after the shutting down of three major landfill sites in the area (Amaniampong, 2015). Manufacturing firms were required to transport their solid waste all the way to the Kpone landfill site situated at the eastern part of Accra. Due to the high cost of transportation to Kpone, the Accra compost and recycling plant at Adjen- Kotoku came in handy for the manufacturing firms located in the Ga west municipality (Cofie, Rao, Paul, & Fernando, 2014) .

Infrastructural developments in many developing countries is characterized by spatial inequalities; the more urbanized areas in the municipalities are more favoured in terms of proximity to transport, large markets, health and educational facilities than the rural areas (McKay & Perge, 2015). More so, natural resources used as raw materials are not evenly distributed in the municipal areas. Some authors argue that advantages in industrial location is no longer important as a result of globalization and the competitive advantage sought by firms (Palacios, 2005; Porter, 1998), however, Deichmann, Lall, Redding and Venables (2008b) recognize their relevance under certain situations.

5.2. Summary of the Euclidean distance analysis in the research

The Euclidean distance method was used to analyse the concept of closeness or proximity or distance to location factors in the research. Factors analysed in this respect were the "food producing areas" defined as a raw material source (Appendix 13.), CBDs, waste sorting plant, higher educational institutions, health facilities and the Accra –Kumasi highway. The original formats of the factors for the analysis were points and lines. These inputs produced different raster maps each measuring the geometric distances between the source factors and all the locations within the study area. Since the purpose of this analysis was to determine how close a location was to the nearest location factor mentioned, each of the resultant maps were accompanied by a minimum and maximum distance to either a raw material source or CBD and so on. In addition to the minimum and maximum distances, other statistical information including the mean and standard deviation were also computed in the GIS to provide a better understanding of the different spatial extents of the map layers. Table 11 presents the statistics conveyed in the raster maps.

5.2.1. Results of the Euclidean distance analysis

The longest distance travelled to a source factor was to the waste sorting plant followed by the CBDs and the highway. The mean values in the table implies that the distances from all locations to higher educational institutions were the shortest. Although the waste sorting plant recorded the longest distance from a location in the study area, the mean values explain that average distances to this source factor were shorter than the average distances to the CBDs or the highway.

Table 11

Map statistics

Factor	Minimum (km)	Maximum (km)	Mean (km)	Standard deviation (km)
Distance to food producing areas	0	8.5	2.2	1.4
Proximity to CBDs	0	15.6	6.1	3.4
Distance to Accra waste sorting plant	0	24.3	1.2	5.4
Closeness to higher educational institutions	0	2.1	1.1	0.5
Proximity to health facilities	0	11.4	3.8	2.2
Closeness to Accra-Kumasi highway	0	13.8	4.1	3.3

The table further demonstrates that the three higher educational institutions in the municipality were more accesssible from all locations than the health facililities. Different spatial extents associated with the factors meant that a common measurement scale through a reclassification or standardization process was necessary in order to produce meaningful results in the suitability model and to avoid the situation where "apples were being compared to oranges". In view of this , the technique used in the suitability model was to aggregate the weights of all the raster map inputs with their standardized values and to rank candidate locations from the best to the worst..

5.2.2. Discussion of findings from the Euclidean distance analysis

The Euclidean distance analysis assumed that the standardized distances for the source factors represented by values from 5 (shortest distance) to 1 (longest distance) were equivalent, however, in reality, for instance, the shortest distance to the nearest higher educational institution was not equal to the shortest distance to the CBDs. In general, the distances were dependent on the origin of the source factor. The factors which were concentrated at the north-eastern (waste sorting plant) and the eastern sections (higher educational institutions) were more accessible within the shortest distance than the factors with their origins at the north western (CBDs) and central sections of the municipality (Accra - Kumasi highway).

The results of the analysis in table 11 was found to be in line with Yazdani, Monavari, Omrani, Shariat and Hosseini, (2015) who recommended that waste disposal sites should be located not less than 0.08 km from industrial sites to avoid the contamination of industrial water and other nuisances (Moses, Iwara, Gbadebo, Olubukola, & Omin, 2018). The results again agrees with Sarath et al. (2018) that potential industrial sites should be located at a permissible distance of between 0.05 – 0.5km from state and national highways. Furthermore, Badri (2007) recognized that higher educational institutions and health facilities were critical to industrial location.

According to some authors, the Euclidean distance approach to measuring travel distance is faced with many errors. Shahid, Bertazzon, Knudtson, and Ghali (2009) pointed out that Euclidean distance underestimates road distance and travel time. Furthermore, the notion of travelling in a straight line is unrealistic because people and vehicles avoid obstacles and natural features in order to move from one origin to a destination (Sander, Ghosh, van Riper, & Manson, 2010) . However, Buczkowska, Coulombel, and Lapparent (2016) compared the effects of Euclidean distance and network distance on the location choices of businesses in Paris and found out that the Euclidean distance measurement was very strongly correlated with road network distance.

The technique used for standardizing the Euclidean distances in this research identified the shortest distances to the source factors as the most suitable and the farther distances as less suitable. As a result, different locations in the study area were assessed based on their relative distances. This means that the analysis did not involve computations with absolute distance values hence the Euclidean distance method was justified as appropriate for the research.

Whilst the Euclidean distance was a relevant spatial distance measurement in the research, the land use regulations in Ghana stipulates that large scale and heavy industries are not permitted close to mixed use developments and agricultural zones (Department of Town and Country Planning - Ghana, 2011). This implies that although entrepreneurs may favour locations that are nearest to a location factor, there is a limit to how close they can site their plants to these factors.

5.3. Summary of reliability and validity analyses

The tests for reliability and validity had been performed in two parts, in the first part, the reliability analysis checked for inconsistencies in respondents' scores whilst the pairwise comparisons were assessed for validity. In the second part, the pairwise comparisons were assessed for both reliability and validity.

In both cases, the reliability analysis was performed using the Cronbach's alpha test. On the other hand, the Pearson's correlation coefficient (r) was used for the validity analysis. The two computations were conducted using the SPSS software.

As a matter of importance, the purpose for the first part of the accuracy tests was to check for any errors were likely to have been introduced into the scores from the pairwise rating (reliability) and to determine how well the pairwise comparisons measured the relative importance of the location factors (validity).

The second part of the accuracy tests was to provide a basis for comparing the relationship between Cronbach's alpha, Pearson correlation coefficient and the global weights for the all location factors.

To ensure that this comparison was made feasible, the Cronbach's alpha and Pearson correlation coefficients for the individual location factors were disaggregated from the overall Cronbach's alpha values and aggregated from the p values respectively as expatiated in section 4.2.1 of the methodology and data chapter. A comparison of the accuracy tests and the weights was necessary to provide more understanding of the underlying mechanism behind the tests and the global weights.

5.3.1. Results of the first part of reliability and validity analysis

The results of the reliability analysis in the first part of the accuracy test appears in the Appendix 15. As can be seen from the Cronbach's alpha values, the scores for all the factors (economic, socio-economic , telecommuniction and transportation factors) contained minimal errors from across all the 32 respondents who participated in the questionnaire. Among the factors, the economic scores were the most reliable having attained an alpha value of 0.989. The socio-economic scores followed with an alpha value of 0.983 and lastly telecommuniction and transportation with a value of 0.981. These results imply that respondents understood the location factors thoroughly during the questionnaire administration.

On the other hand, the results of the validity analysis in the first part of the accuracy test is included in table 9; the r table test results describes the factors; "Litigation free area", "Availability of mobile network"and the " distance to Tema port" as invalid factors. This result indicates that relatively, these factors do not determine entrepreneurs' choice of industrial site in Ga west as much as the remaining valid factors (table 9.).Irrespective of the insignificance of the three factors in Ga west, their scores had a minimal adverse impact on the reliability of the socio-economic and telecommunication and transportation scores.

5.3.2. Results of the second part of reliability and validity analysis – comparing accuracy test results and global weights

The second part of the reliability and validity analysis recognised that firstly, there existed some form of relationship between the level of significance of a location factor and the global weight associated with that same factor (figure 22a), secondly there was also a relationship between the level of significance of a location factor and the level of consistency of the scores from that factor across all respondents (figure 22b), thirdly there existed a relationship between the level of consistency in the scores associated with a location factor and the global weight of that factor (figure 22c).

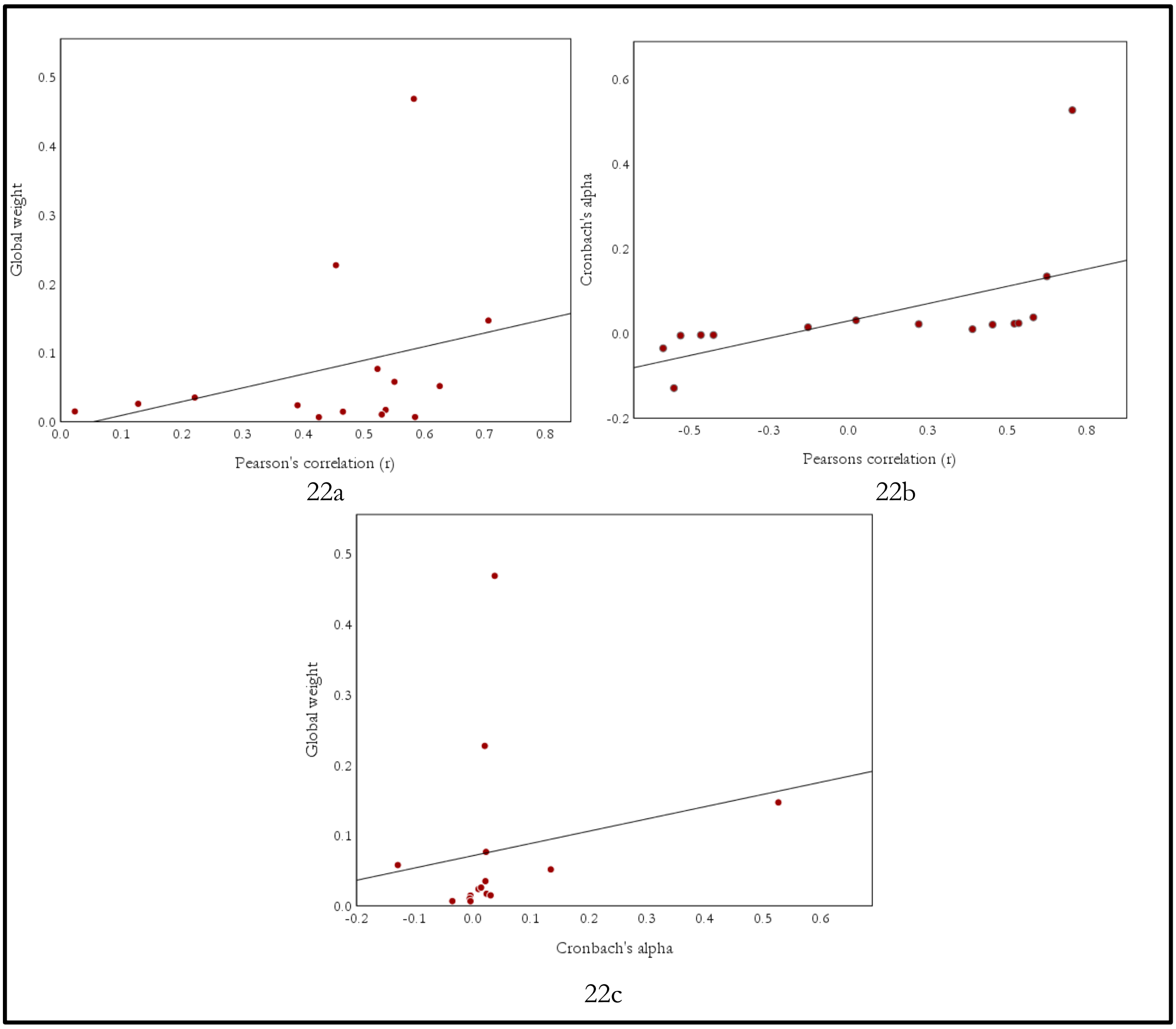


Figure 22a – c. Relationship between reliability, validity and global weights

The scatterplots in figure 22a – c describes these underlying relationships based on the Cronbach's alpha, Pearson's correlation coefficients and the global weights for all the location factors used in the suitability analysis. The figure reports (1) a strong positive correlation between the global weights and the Pearson's correlation (r). (2) A weak positive correlation between Cronbach's alpha and Pearson's correlation (r). (3) A weak positive correlation between the global weights and the Cronbach's alpha. Figure 22a – c further indicates that the more valid a factor was in the research, the higher the probability that it would attain a high global weight (figure 22a). The factors which were significant or valid did not necessarily mean they produced consistent scores across the respondents (figure 22b) and the scores which were very reliable or consistent were not necessarily associated with the factors with the highest global weights (figure 23c). In summary, although some form of relationship can be found among all three variables, the strongest relationship was observed between the global weights and the degree of validity of location factors (figure 23a). The poorest relationship was the one between the global weights and the reliability (figure 22c).

5.3.3. Discussing the effects of expert interviews on the accuracy tests

The use of human experts in the research had a great impact on the accuracy of the scores. The location factors obtained were satisfactorily applicable in the context of the Ga west municipality therefore only 3 out of the 15 factors were relatively invalid. The remaining 12 valid factors used for the questionnaire is an indication that respondents did not rate factors that were insignificant and that the global weights were not computed for factors which were invalid.

The ability of an expert to exhibit good judgement depends on whether he/she has mastery in the subject the researcher is investigating (Bolger & Wright, 1994; Rowe & Wright, 2001). Therefore in this research, as experts with direct experiences in industrial site selection in the study area were selected, it is inarguable that their experiences reflected in their responses to the interview questions. Additionally, the responses were accurate because these experts having worked with the same firm for ten years or more had more knowledge about the firms including the reasons for their current location.

After analysing the relationship between the Cronbach's alpha and the Pearson's correlation (r) in figure 23b, one can understand that the correlation is in line with (John, 2015; Thatcher, 2010) who argue that a factor can be invalid but produce reliable scores or a valid factor can produce scores which are not reliable. The pattern in this scatterplot implies that whether a location factor exhibited a weak or strong validity, it was reliable and therefore still relevant in the study area.

A general finding from figure 22a - c was that the factors exhibited a very uniform reliability, which indicates a high inter-rater reliability among the respondents. To this end, the respondents were sensitized on the actual meaning of the location factors used in the AHP questionnaire, as a result, the understanding of the pairwise comparisons were uniform across the board.

Expert interviews have been rarely used in multi-criteria evaluation and AHP site or land suitability analysis. Most often, researchers have derived the evaluation factors from the literature or their own local knowledge of the study area (Bagdanavičiute & Valiunas, 2013; Kihoro, Bosco, & Murage, 2013; Kumar, Luthra, Haleem, Mangla, & Garg, 2015; Memarbashi et al., 2017). Only a few studies such as Abushnaf (2014), Bunruamkaew & Murayama (2011) and Muhsin et al., (2017) have obtained the evaluation factors from the expert interviews. Apart from ensuring the accuracy and consistency of the suitability assessment, eliciting factors from experts increases the applicability of the recommendations from the research in the given study area. This research therefore supports the argument for expert-based MCDM and AHP industrial site suitability analysis.

6. CONCLUSION AND RECOMMENDATIONS

This chapter evaluates the research objectives with respect to whether they were met or not with evidence from the thesis. Suggested recommendations are also presented for consideration by the Municipal Assembly. The chapter further outlines the strengths of the research and the limitations of the methods used and lastly provides directions for other researchers who may be interested in undertaking the same research in the future.

6.1. Objective 1

To assess the patterns of industrial land use in the municipality for 1987, 2003 and 2017.

The effects of suburbanization and urbanization have led to rapid changes in the land use patterns of the Ga west municipality. Industrial land use has especially seen a remarkable increase in area in recent years. However, from 1987 to 2017, industrial developments have been concentrated in some 12 localities. It was important to analyse the historical distribution of industrial land take in the municipality as a basis to identify which locality showed signs of clustering and therefore indicated the existence of agglomeration economies. This objective was fully met as can be seen from table 6 in section 3.4 of the study area chapter. The localities where manufacturing activities had been ongoing from 1987 to 2017 were identified, then the industrial land takes in the localities for the three periods were extracted from the LU maps to calculate the changes in land areas. Adzen Kotoku and Medie were the two localities identified as existing industrial hotspots from the assessment.

6.2. Objective 2

To identify and evaluate major factors influencing the location of large scale manufacturing industries in Ga west.

This objective was an intermediate requirement for the weighted suitability analysis. It basically referred to the results of the expert interviews and the AHP analysis. The objective was fully met on the one part through the identification of the location factors namely; the availability of developable land, availability/proximity to raw material source, distance to CBDs, availability of unskilled labour, distance to Accra waste sorting plant, litigation – free area, closeness to higher educational institutions, proximity to health facilities , availability of reliable electricity supply, availability of municipal water supply, groundwater potential, closeness to Accra – Kumasi highway, availability of mobile network, distance to Tema port and distance to municipal Assembly. On the other part it was met through the computation of global weights from the scores (section 4.2 of the methodology and data chapter) and from the reliability and validity analyses (section 4.2.1 of the methodology and data chapter). All the factors identified were found to be relevant in the study area.

6.3. Objective 3

To determine a suitable method to identify areas that are potentially suitable for industrial development in the municipality.

The above objective was the central concept in the research. It sought to identify the most appropriate multi-criteria evaluation method that was able to integrate into the GIS and had the capability to combine a large number of different map layers. As a result, the overall expected outcome of the research was dependent on achieving this objective. In view of this, the objective was fully met. Evidence of this achievement can be found in sections; 2.5.1, 2.5.2 and 2.5.3 of the literature review chapter. The WLC, the OWA and AHP methods are three of the most commonly used MCE methods for land suitability that have been well expatiated in the literature review. The advantages as well as the limitations of the methods have been included in the aforementioned sections to demonstrate why one method was a better option than the other. The AHP which is also a type of the WLC methods was the choice method for the suitability analysis. The major reason for selecting this method was its ability to integrate human judgments and the ease of implementation in the GIS.

6.4. Objective 4

To determine which areas in the municipality are prime locations for industrial development.

The goal of this objective was to evaluate the best and the worst rated areas identified from the final weighted suitability model. This was the overall aim of the research. The objective was fully met as can be seen from table 10. The area of each suitable zone in the final model was determined using the zonal geometry as table (spatial analyst tool) in ArcGIS. The first two best rated areas (figure 22) were evidently the most prime industrial areas in the municipality due their proximity to the highway and the CBD at Medie as well as their endowment with large areas of developable land. The area with the largest land available for future industrial development was Area 2 as can be seen from (figure 22). Area 1 indicated the most limited land area for industries from the suitability rating.

6.5. Recommendations

The findings of the research suggested that some recommendations were needed to ensure that the prime industrial areas promoted the economic growth of the municipality. Since the research approach was very practical, some recommendations are also given for the integration of some aspects of the findings with current zoning practices.

6.5.1. Recommendations for achieving economic growth

The research findings revealed that, the future prime industrial areas that is; the Doboro - Mpehuasem and Hebron – Korleman - Gonse are rural and lagging areas. As a result, the two areas are currently not well positioned in terms of transport infrastructure and the requisite social facilities that would support the survival of manufacturing firms (Nai, 2018a). It is recommended that in order to upgrade these areas to increase their attractiveness to prospective investors, the Municipal Assembly should consider directing its efforts towards achieving the following four strategies generated from the findings of the research. Firstly, the Assembly should consider improving the conditions of feeder roads in the area by undertaking asphalt paving to increase their accessibility during the rainy season. Secondly, the Assembly should extend its coverage of health facilities to the two areas to increase access to healthcare in the communities. Thirdly the Assembly is encouraged to create a land bank for the municipality by acquiring land within the prime areas specifically for the purpose of industrial development. Finally additional market centres should be created in the northern part of the municipality to reduce the potential cost of transporting finished goods to consumers and to attract more labour to these areas. All of these strategies can be implemented when they are incorporated into the composite budgets of the Municipal Assembly.
The above recommendations are of utmost importance to the Assembly because investing in the industrial development of the municipality would reduce unemployment by creating more jobs especially for the youth. It would also increase the Internally Generated Funds (IGF) of the Assembly and finally accelerate the economic growth of the municipality.

6.5.2. Recommendations for zoning

The literature review chapter has pointed to the shortcomings of the industrial zoning approach in the municipality. The approach has been said to stifle industrial development in the introduction chapter due to its rigid nature. Current zoning has separated industrial land use from other urban land uses following the idea that industries are polluting in nature, they generate noise or release noxious substances into the atmosphere. This idea although relevant has not encouraged manufacturing to locate in their preferred areas. The research has demonstrated that different geographical areas impact manufacturing firms differently as a result of their comparative advantages. The findings have also confirmed that the expert interviews produced accurate location factors tailor-made for the Ga west municipality. In view of this, it is recommended that the concept of comparative advantages and expert interviews be integrated into the zoning to increase its flexibility and effectiveness. Implementing this recommendation means that the municipal planning authority should elicit the location factors from experts that it deems appropriate for the interviews. The sample size should be expanded to include all types of industries in the municipality. From the acquired factors, a spatial database can be created for all the settlements. The contents of the database would be the comparative advantages of the settlements stored in the appropriate format with the accompanying metadata. In order to effect the integration with the zoning, the planner and her team compares the settlements in terms of their comparative advantages based on some particular industrial land use criteria. The most suitable settlements conforming to the criteria are zoned taking into consideration the appropriate buffering distances from other conflicting land uses. This recommendation would ensure that firms respect the zoning laws whilst their productivity is being promoted.

6.6. Strengths of the research

This research presents some major strengths which explains why it is important for achieving the overall objective of understanding prime industrial locations in the Ga west municipality.

- It has used supportive literature from different sources to help the reader understand the physical expansion of metropolitan areas and the reasons for the flight of manufacturing to the suburbs. It has synthesised the processes leading to manufacturing suburbanization in the Ga west municipality for a better understanding.
- Specific forces that attract manufacturing entrepreneurs to the municipality have been explained in detail to inform the reader about the location advantages in the area.
- The research has pointed to the ineffectiveness of the current industrial zoning practice in the municipality and has suggested the integration of the principle of comparative advantages into the zoning process.
- The research focuses on the location factors identified through the expert interviews and AHP assessments to recommend the expansion of public infrastructure and social facilities to lagging areas in the municipality.
- Some important considerations are highlighted in the research which can assist the Municipal Assembly in the location of industrial parks. Some of these considerations include; the geographic distribution of agricultural products in the municipality, the natural resource endowment of different areas in the municipality, availability of labour, availability of land, topography and conservation areas, transport infrastructure and compatibility to adjoining land uses.

6.7. Limitations of the research

Like every other study, the methodology applied in this research was limited in certain aspects;

- The research has been primarily concerned with the comparative advantages of potentially suitable locations in the municipality with no emphasis on agglomerative forces even though there was a possibility of its existence in the municipality.
- Because of the problem of data availability, the number of map inputs for the suitability analysis was limited to 8. Additional data inputs could have been the “availability of reliable electricity supply “and the “availability of municipal water supply”. These factors could improve the suitability model further by creating the opportunity to evaluate candidate locations based on the combined effects of all the valid location factors.

It was observed during the fieldwork that 14 firms had halted their operations in the municipality. As a result the sample for the questionnaire was reduced from 46 to 32.

6.8. Directions for future research

The following suggestions are hereby recommended to address the limitations of the research and to advance the field of industrial location suitability modelling.

- The samples used in the research were selected from large scale manufacturing firms because the analysis attempted at making generalizations based on the opinions and perceptions of subjects from large scale manufacturing firms. As a consequence, the outcome of the expert interviews and AHP scores were homogeneous with respect to the population (manufacturing firms). However, future research should consider increasing the population to include medium and small size manufacturing firms that is; if the research intends to analyse location factors applicable to all types of manufacturing firms or to make inferences from a large number of varied factors.
- Buffers (variable distances) are recommended as an alternative to the Euclidean distance analysis (Mu, 2008) to ensure that the suitability analysis does not extend to areas prohibited from heavy industrial developments such as mixed use developments.
- The effects of agglomeration economies on industrial location was not assessed due to the manner that the expert interview questions were formulated. Further research should consider incorporating agglomerative forces into the interview guide.

LIST OF REFERENCES

Abbaspour, M., Mahiny, A. S., Arjmandy, R., & Naimi, B. (2011). Integrated Approach for Land use Suitability Analysis. *International Agrophysics*, *25*(1993), 311–318.

Abushnaf, F. (2014). *A Land Evaluation Model for Irrigated Crops using Multi- Criteria Analysis*. Sheffield Hallam University.

Acioly Jr., C. C. (2000). Can Urban Management Deliver the Sustainable City? Guided Densification in Brazil versus Informal Compactness in Egypt. In M. Jenks & R. Burgess (Eds.), *Compact cities: Sustainable urban forms for developing countries* (pp. 127–140). London, UK: Spon Press. https://doi.org/10.1103/PhysRevD.64.077501

Adam, I., & Mensah, E. A. (2014). Perceived Spatial Agglomeration Effects and Hotel Location choice. *Anatolia*, *25*(1), 49–60. https://doi.org/10.1080/13032917.2013.822818

Adams. (2015). Conducting Semi-Structured Interviews. *Handbook of Practical Program Evaluation: Fourth Edition*, (August 2015), 492–505. https://doi.org/10.1002/9781119171386.ch19

Adams, A., & Cox, A. L. (2008). Questionnaires , In-depth Interviews and Focus groups. In P. Cairns & A. L. Cox (Eds.), *Research Methods for Human Computer Interaction* (pp. 17–34). Cambridge University Press.

Adel, M., & Sayed, E. (2016). Land Suitability Analysis as Multi-criteria Decision Making to Support the Egyptian Urban Development. *Proceedings of Science and Technology*, (Khalifa 2011), 1–11.

African Union Commission. (2015). *Agenda 2063: The Africa We Want*. https://doi.org/978-92-95104-23-5

Águeda, B. F. (2016). Urban Planning in Industrial Cities: the Reversibility of Decay.

Ahmed, A., Dinye, R. D. (2011). Urbanisation and the Challenge of Development Controls in Ghana: A Case Study of Wa Township. *Journal of Sustainable Development in Africa*, *13*(7), 210–235. https://doi.org/1520-5509

Ahmed, G. B., Shariff, A. R. M., Balasundram, S. K., & Fikri Bin Abdullah, A. (2016). Agriculture Land Suitability Analysis Evaluation Based Multi criteria and GIS Approach. In *IOP Conference Series: Earth and Environmental Science* (Vol. 37, p. 12044). https://doi.org/10.1088/1755-1315/37/1/012044

Al-Hanbali, A., Alsaaideh, B., & Kondoh, A. (2011). Using GIS-Based Weighted Linear Combination Analysis and Remote Sensing Techniques to Select Optimum Solid Waste Disposal Sites within Mafraq City, Jordan. *Journal of Geographic Information System*, *03*(04), 267–278. https://doi.org/10.1016/j.isatra.2011.10.006

Alter, S. L. (1980). *Decision Support Systems: Current Practice and Continuing Challenge*. *Reading, MA: Addison-Wesley*. https://doi.org/10.1371/journal.pone.0066043

Altshuler, A., Morrill, W., Wolman, H., & Mitchel, F. (1999). *Governance and Opportunity in Metropolitan America*. Washington, D.C: National Academy of Sciences.

Alvi, M. H. (2010). A Manual for Selecting Sampling Techniques in Research. *MPRA*, (21465), 6–53. https://doi.org/10.3109/15368378209040332

Amaniampong, S. B. (2015). *Developing an Option for Sustainable Plastic Waste Management in Ghana: A case Study of Sunyani Municipality, Ghana*. Kwame Nkrumah University of Science and Technology.

Angel, S., Parent, J., Civco, D. L., & Blei, A. M. (2011). *Making Room for a Planet of Cities*. Cambridge , MA.

Angel, S., Parent, J., Civco, D. L., Blei, A., & Potere, D. (2011). The Dimensions of Global Urban Expansion: Estimates and Projections for all Countries, 2000-2050. *Progress in Planning*, *75*(2), 53–107. https://doi.org/10.1016/j.progress.2011.04.001

Arh, T., & Blažič, B. J. (2007). Application of Multi-attribute Decision Making Approach to Learning Management Systems Evaluation. *Journal of Computers*, *2*(10), 28–37. https://doi.org/10.4304/jcp.2.10.28-37

Armah Tagoe, K., & Aryee, O. (2014). *2010 Population & Housing Census: Ga West Municipality: District Analytical Report*. (S. K. Gaisie & J. Owusu Kagya, Eds.). Accra: Ghana Statistical Service.

ASEAN. (2014). Transportation Introduction – Role of Transportation in Logistics Product Movement. In *Logistics Planning & Analysis* (p. 9).

Attwairi, A. (2017). The Patterns and Trends of African Urbanization. Az-Zāwiyah, Libya.

Ayehu, G. T., Besufekad, S. A., Ayehu, G. T., & Besufekad, S. A. (2015). Land Suitability Analysis for Rice Production: A GIS Based Multi-Criteria Decision Approach. *American Journal of Geographic Information System*, *4*(3), 95–104. https://doi.org/10.5923/j.ajgis.20150403.02

Badri, M. A. (2007). Dimensions of Industrial Location Factors: Review and Exploration. *Business and*

Public Affairs, *1*(2), 4–26. https://doi.org/10.1017/CBO9781107415324.004
Bagdanavičiute, I., & Valiunas, J. (2013). GIS-based Land Suitability Analysis Integrating Multi-criteria Evaluation for the Allocation of Potential Pollution Sources. *Environmental Earth Sciences*, *68*(6), 1797–1812. https://doi.org/10.1007/s12665-012-1869-7
Bagheri, M., Sulaiman, W. N. A., & Vaghefi, N. (2012). Land Use Suitability Analysis Using Multi criteria Decision Analysis Method for Coastal Management and Planning: A Case Study of Malaysia. *Journal of Environmental Science and Technology*, *5*(5), 364–372. https://doi.org/10.3923/jest.2012.364.372
Banai-Kashani, R. (1989). A New Method for Site Suitability Analysis: The Analytic Hierarchy Process. *Environmental Management*, *13*(6), 685–693.
Batista E Silva, F., Koomen, E., Diogo, V., & Lavalle, C. (2014). Estimating Demand for Industrial and Commercial Land Use Given Economic Forecasts. *PLoS ONE*, *9*(3), e91991. https://doi.org/10.1371/journal.pone.0091991
Beedasy, J., & Whyatt, D. (1999). Diverting the Tourists : A Spatial Decision-Support for Tourism Planning on a Developing Island. *JAG*, *1*(3), 163–174. https://doi.org/10.1016/S0303-2434(99)85009-0
Beinat, E., & Nijkamp, P. (1998). *Multicriteria Analysis for Land-Use Management*. Springer Netherlands.
Benítez, J., Delgado-Galván, X., Gutiérrez, J. A., & Izquierdo, J. (2011). Balancing consistency and expert judgment in AHP. *Mathematical and Computer Modelling*, *54*(7–8), 1785–1790. https://doi.org/10.1016/j.mcm.2010.12.023
Berry, B. J. L., Simmons, J. W., & Tennant, R. J. (1963). Urban Population Densities: Structure and Change. *Geographical Review*, *53*(3), 389. https://doi.org/10.2307/212588
Bishop, I. D., Escobar, F. J., Karuppannan, S., Williamson, I. P., Yates, P. M., Suwarnarat, K., & Yaqub, H. W. (2000). Spatial Data Infrastructures for cities in Developing Countries. Lessons from the Bangkok Experience. *Cities*, *17*(2), 85–96. https://doi.org/10.1016/S0264-2751(00)00004-4
Bolger, & Wright, G. (1994). Assessing the Quality of expert Judgment Issues and Analysis. *Decision Support Systems*, *11*, 1–24.
Boroushaki, S., & Malczewski, J. (2008). Implementing an Extension of the Analytical Hierarchy Process Using Ordered Weighted Averaging Operators with fuzzy quantifiers in ArcGIS. *Computers and Geosciences*, *34*(4), 399–410. https://doi.org/10.1016/j.cageo.2007.04.003
Bosma, N., Van Stel, A., & Suddle, K. (2008). The Geography of New Firm Formation: Evidence from Independent Start-ups and New Subsidiaries in the Netherlands. *International Entrepreneurship and Management Journal*, *4*(2), 129–146. https://doi.org/10.1007/s11365-007-0058-8
Brunelli, M. (2015). *Introduction to the Analytic Hierarchy Process*. SpringerBriefs in Operations Research. https://doi.org/10.1007/978-3-319-12502-2
Brunelli, M., & Fedrizzi, M. (2014). Boundary Properties of the Inconsistency of Pairwise Comparisons in Group Decisions. *European Journal of Operational Research*, *240*(3), 765–773. https://doi.org/10.1016/j.ejor.2014.07.045
Brunelli, M., & Fedrizzi, M. (2015, January). Axiomatic Properties of Inconsistency Indices for Pairwise Comparisons. *Journal of the Operational Research Society*. https://doi.org/10.1057/jors.2013.135
Bruyelle, P., & Vieillard-Baron, H. (2001). Les banlieues. Des Singularités Françaises aux réalités Mondiales, 2001. *Hommes et Terres Du Nord*, *4*(1), 252–253.
Buczkowska, S., Coulombel, N., & Lapparent, M. De. (2016). Euclidean versus Network Distance in Business Location: A Probabilistic Mixture of Hurdle-Poisson Models. *Annals of Regional Science*, 21 p. https://doi.org/10.13140/RG.2.1.4875.6241
Bunruamkaew, K., & Murayama, Y. (2011). Site Suitability Evaluation for Ecotourism Using GIS & AHP: A Case Study of Surat Thani Province, Thailand. In *Procedia - Social and Behavioral Sciences* (Vol. 21, pp. 269–278). https://doi.org/10.1016/j.sbspro.2011.07.024
Carver, S. J. (1991). Integrating Multi-criteria Evaluation with Geographical Information Systems. *International Journal of Geographical Information Systems*, *5*(3), 321–339. https://doi.org/10.1080/02693799108927858
CERSGIS, U. of G. (2018). Unpublished Raw data. Legon - Accra.
Chai, Y. (2014). From Socialist Danwei to New Danwei: A Daily-life-based Framework for Fustainable Development in Urban China. *Asian Geographer*, *31*(2), 183–190. https://doi.org/10.1080/10225706.2014.942948
Chakhar, S., & Martel, J. (2006). Towards a Spatial Decision Support System: Multi-Criteria Evaluation

Functions Inside Geographical Information Systems. *HAL*, *2*, 97–123.
Chandio, I. A., Nasir, A., & Matori, B. (2011). Land Suitability Analysis Using Geographic Information System (GIS) for Hillside Development : A Case Study of Penang Island. *IPCBEE*, *19*(May 2014), 1–6.
Chen, J. (2014). GIS-based Multi-Criteria Analysis for Land use Suitability Assessment in City of Regina. *Environmental Systems Research*, *3*(1), 13. https://doi.org/10.1186/2193-2697-3-13
Clapson, M., & Hutchison, R. (2010). *Suburbanization in Global Society*. (M. Clapson & R. Hutchison, Eds.). Emerald.
Coffelt, T. A. (2018). Confidentiality and Anonymity of Participants. In M. Allen (Ed.), *The SAGE Encyclopedia of Communication Research Methods* (pp. 227–230). Thousand Oaks: SAGE Publications, Inc. https://doi.org/10.4135/9781483381411
Cofie, O., Rao, K., Paul, J., & Fernando, S. (2014). *Composting Experience in Developing Countries: Drivers and Constraints for Composting Development in Ghana, India, Bangladesh and Sri Lanka*. https://doi.org/10.13140/RG.2.2.28597.17124
Cohen, B. (2006). Urbanization in Developing Countries: Current Trends, Future Projections, and Key Challenges for Sustainability. *Technology in Society*, *28*(1–2), 63–80. https://doi.org/10.1016/j.techsoc.2005.10.005
Columb, M., & Atkinson, M. (2016). Statistical Analysis: Sample Size and Power Estimations. *BJA Education*, *16*(5), 159–161. https://doi.org/10.1093/bjaed/mkv034
Corona, P., Salvati, R., Barbarti, A., & Chirici, G. (2008). Land Suitability for Short Rotation Coppices Assessed through Fuzzy Membership Functions. In R. Lafortezza, G. Sanesi, C. T. R., & J. Chen (Eds.), *Patterns and Processes in Forest Landscapes Multiple* (pp. 191–211). Springer.
Crawford, G., & Williams, C. (1985). A Note on the Analysis of Subjective Judgment Matrices. *Journal of Mathematical Psychology*, *29*(4), 387–405. https://doi.org/10.1016/0022-2496(85)90002-1
Creswell, J. W. (2013). The Selection of a Research Approach. In B. Bauhaus, V. Knight, M. Markanich, & K. Koscielak (Eds.), *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed., pp. 3–23). Thousand Oaks, California, USA: SAGE Publications, Inc. https://doi.org/45593:01
Cutler, P., & Vandemark, L. (2002). *Down to Earth: Geographic Information for Sustainable Development in Africa*. *Development*. Washington, DC: National Academy Press.
Dang Khoi, D., & Murayama, Y. (2010). Delineation of Suitable Cropland Areas Using a GIS Based Multi-Criteria Evaluation Approach in the Tam Dao National Park Region, Vietnam. *Sustainability*, *2*, 2024–2043. https://doi.org/10.3390/su2072024
Deichmann, U., Lall, S. V, Redding, S. J., & Venables, A. J. (2008a). Industrial Location in Developing Countries. *World Bank Research Observer*, *23*(2), 219–246. https://doi.org/10.1093/wbro/lkn007
Deichmann, U., Lall, S. V, Redding, S. J., & Venables, A. J. (2008b). Industrial Location in Developing Countries. *The World Bank Research Observer*, *23*(May 2014), 220–246. https://doi.org/10.1093/wbro/lkn007
Deng, X., & Deng, Y. (2017, December). D-AHP method with Different Credibility of Information. *Soft Computing*, pp. 1–9. https://doi.org/10.1007/s00500-017-2993-9
Dennison, S. R. (1937). The Theory of Industrial Location. *The Manchester School*, *8*(1), 23–47. https://doi.org/10.1111/j.1467-9957.1937.tb01400.x
Department of Town and Country Planning - Ghana. (2011). *Zoning Guidelines and Planning Standards*. Accra: Ministry of Environment Science and Technology, Ghana.
Dikec, M. (2007). *Badlands of the Republic : Space, Politics and Urban Policy*. Blackwell Pub.
Diouf, R., Ndiaye, M. L., Traore, V. B., Sambou, H., Giovani, M., Lo, Y., … Beye, A. C. (2017). Multi Criteria Evaluation Approach Based on Remote Sensing and GIS for Identification of Suitable Areas to the Implantation of Retention Basins and Artificial Lakes in Senegal. *American Journal of Geographic Information System*, *6*(1), 1–13. https://doi.org/10.5923/j.ajgis.20170601.01
Djwa, P. D. K. (1960). *An analysis of industrial location factors with particular reference to Indonesia*. University of British Columbia. https://doi.org/10.14288/1.0102437
Dodgson, J., Spackman, M., Pearman, A., & Phillips, L. (2009). An Overview of Multi-criteria Analysis Techniques. In *Multi-criteria Analysis: A Manual* (pp. 6–161). London, UK: Department for Communities and Local Government.
Douglas, I., Hodgson, R., & Lawson, N. (2002). Industry, Environment and Health through 200 years in Manchester. *Ecological Economics*, *41*(2), 235–255. https://doi.org/10.1016/S0921-8009(02)00029-0

Drobne, S., & Lisec, A. (2009). Multi-attribute Decision Analysis in GIS: Weighted Linear Combination and Ordered Weighted Averaging. *Informatica*, *33*, 459–474. https://doi.org/10.1017/CBO9781107415324.004
Dubois, D., & Prade, H. (1982). A Class of Fuzzy Measures Based on Triangular Norms: A General Framework for the Combination of Uncertain Information. *International Journal of General Systems*, *8*(1), 43–61. https://doi.org/10.1080/03081078208934833
Eastman. (2006a). *IDRISI Andes: Guide to GIS and Image Processing*. *Clark Labs*. Worcester, MA, USA: Clark Labs.
Eastman. (2006b). *IDRISI Andes Tutorial*.
Eastman, J. R. (1999). Multi-criteria Evaluation and GIS. *Geographical Information Systems*, 493–502. https://doi.org/10.1080/095008396180344
Eastman, J. R. (2005). Multi-criteria Evaluation and GIS. In P. Longley (Ed.), *Geographical Information Systems: Principles, Techniques, Applications and Management* (2nd ed., a, pp. 493–502). Chichester, New York: Wiley. https://doi.org/10.1080/095008396180344
Eberts, R. W., & McMillen, D. P. (1999). Agglomeration economies and urban public infrastructure. In C. Paul & M. E. S (Eds.), *Handbook of Regional and Urban Economics* (Vol. 3, pp. 1455–1495). Oxford, UK: Elsevier. https://doi.org/10.1016/S1574-0080(99)80007-8
Ekers, M., Hamel, P., & Keil, R. (2012). Governing Suburbia: Modalities and Mechanisms of Suburban Governance. *Regional Studies*, *46*(3), 405–422. https://doi.org/10.1080/00343404.2012.658036
Emrouznejad, A., & Marra, M. (2017). The State of the Art Development of AHP (1979–2017): A Literature Review with a Social Network Analysis. *International Journal of Production Research*, *55*(22), 6653–6675. https://doi.org/10.1080/00207543.2017.1334976
Enache, M., Ghani, E., & O'connell, S. (2016). *Structural Transformation in Africa - A Historical View* (No. 7743). *The World Bank Policy Research Woriking Paper*. New York, NY, USA.
Environmental Protection Agency. Environmental Assessment Regulations 1999 (1999). Ghana, Ghana. https://doi.org/http://extwprlegs1.fao.org/docs/pdf/gha78169.pdf
Erdoğan, A., & Zwick, P. D. (2016). Spatial Decision Making Under Determinism vs. Uncertainty: A Comparative Multi-level Approach to Preference Mapping. *Hacettepe Journal of Mathematics and Statistics*, *45*(4), 1245–1273. https://doi.org/10.15672/HJMS.20157712084
Farole, T. (2011). Special Economic Zones in Africa. In *The Practice of Industrial Policy* (pp. 234–254). Oxford University Press. https://doi.org/10.1596/978-0-8213-8638-5
Feng, J., Zhou, Y., & Wu, F. (2008). New Trends of Suburbanization in Beijing since 1990: from Government-led to Market-oriented. *Regional Studies*, *42*(1), 83–99. https://doi.org/10.1080/00343400701654160
Ferraldo, J. L. (2012). *Zoning for Exchange : Creative -Industrial Incubators in North Brooklyn and the Formalization of Innovation*. Columbia University.
Ferretti, V., & Pomarico, S. (2013). An Integrated Approach for Studying the Land Suitability for Ecological Corridors through Spatial Multicriteria Evaluations. *Environment, Development and Sustainability*, *15*(3), 859–885. https://doi.org/10.1007/s10668-012-9400-6
Fincham, J. E. (2008). Response Rates and Responsiveness for Surveys, Standards, and the Journal. *American Journal of Pharmaceutical Education*, *72*(2), 43. https://doi.org/10.5688/aj720243
Forsyth, A. (2012). Defining Suburbs. *Journal of Planning Literature*, *27*(3), 270–281. https://doi.org/10.1177/0885412212448101
Fourcaut. Annie. (2001). La Banlieue en Morceaux. *Les Annales de La Recherche Urbaine*, *89*(1), 182–183.
García Márquez, J. R., Krueger, T., Páez, C. A., Ruiz-Agudelo, C. A., Bejarano, P., Muto, T., & Arjona, F. (2017). Effectiveness of Conservation Areas for Protecting Biodiversity and Ecosystem Services: a Multi-criteria Approach. *International Journal of Biodiversity Science, Ecosystem Services and Management*, *13*(1), 1–13. https://doi.org/10.1080/21513732.2016.1200672
Ghana Statistical Service. (2019). Ghana Statistical Service.
Glaeser, E. L., & Kerr, W. R. (2009). Local Industrial Conditions and Entrepreneurship: How Much of the Spatial Distribution Can We Explain? *Journal of Economics and Management Strategy*, *18*(3), 623–663. https://doi.org/10.1111/j.1530-9134.2009.00225.x
Glaeser, E. L., & Maré, D. C. (2001). Cities and Skills. *Journal of Labor Economics*, *19*(2), 316–342. https://doi.org/10.1086/319563
Grant, J. L., Nelson, A. C., Forsyth, A., Thompson-Fawcett's, M., Blais, P., & Filion, P. (2013). The Future

of the Suburbs. Suburbs in Transition/The Resettlement of America's Suburbs/Suburbs in Global Context: the Challenges of Continued Growth and Retrofitting/Suburban urbanity: Re-envisioning Indigenous Settlement Practices/Toward a new Suburban A. *Planning Theory and Practice*, *14*(3), 391–415. https://doi.org/10.1080/14649357.2013.808833

Hamel, P., & Keil, R. (2015). *Suburban Governance : A Global View*. (R. Keil, Ed.) (III). Toronto, Canada: University of Toronto Press.

Hamel, P., & Keil, R. (2016). Governance in an Emerging Suburban World. *Cadernos Metrópole*, *18*(37), 647–670. https://doi.org/10.1590/2236-9996.2016-3702

Hanlon, B., Short, J. R., & Vicino, T. J. (2010). The Rise of the Suburban Metropolis. In *Cities and Suburbs: New Metropolitan Realities in the US* (pp. 37–55). Oxford, United Kingdom: Routledge.

Harris. (2010). Meaningful Types in a World of Suburbs. *Research in Urban Sociology*, *10*(December 2010), 15–47. https://doi.org/10.1108/S1047-0042(2010)0000010004

Harris. (2014). The Messy Reality of Agglomeration Economies in Urban Informality: Evidence from Nairobi's Handicraft Industry. *World Development*, *61*, 102–113. https://doi.org/10.1016/j.worlddev.2014.04.001

Harris, R. (2015). Suburbanization and Suburbanism. *International Encyclopedia of the Social & Behavioral Sciences: Second Edition*, (December 2015), 660–666. https://doi.org/10.1016/B978-0-08-097086-8.74044-X

Harris, R., & Larkham, P. J. (Peter J. . (1999). *Changing Suburbs : Foundation, Form, and Function*. E & FN Spon.

Harvey, D. (2009). Reshaping Economic Geography: The World Development Report 2009. *Development and Change*, *40*(6), 1269–1277. https://doi.org/10.1111/j.1467-7660.2009.01602.x

Hayden, D. (2009). *Building Suburbia: Green Fields and Urban Growth, 1820-2000*. Pantheon Books. https://doi.org/gkm279 [pii]\r10.1093/nar/gkm279 [doi]

Henderson. (2014). Urbanization and the Geography of Development. *Policy Research Working Paper, The World Bank*, *6877*(May), 29. https://doi.org/doi:10.1596/1813-9450-6877

Henderson, V. J., Shalizi, Z., & Venebles, J. A. (2000). *Geography and Development* (2456). *Policy Research Working Paper*. Washington, DC. https://doi.org/10.1016/j.biortech.2006.10.010

Hoover, E. M. (1937). *Location Theory and the shoe and Leather Industries* (Vol. 55). Cambridge, Massachusetts: Harvard University Press.

Huang. (2018). *Comprehensive Geographic Information Systems*. (T. J. Cova & M. H. Tsou, Eds.), *Comprehensive Geographic Information Systems* (1st ed., Vol. 3). Waltham, MA: Oliver Walter.

Huang, Y. (2007). Urban Development in Contemporary China. In *China's Geography: Globalization and the Dynamics of Political, Economic and Social Change* (1st ed., pp. 233–262). Plymouth, United Kingdom: Rowman and Littlefield Publishers, Inc.

Hwang, C., & Yoon, K. (1981). Methods for Multiple Attribute Decision Making. In *Multiple Attribute Decision Making* (Vol. 186, pp. 58–191). Springer, Berlin, Heidelberg. https://doi.org/10.1590/2236-9996.2016-3702

Isard, W. (1956). *Location and space-economy*. Cambridge, MA: The Technology Press of Massachusetts Institute of Technology AND John Wiley & Sons, Inc., New York.

Isard, W. (1960). The Scope and Nature of Regional Science. *Papers in Regional Science*, *6*(1), 9–34. https://doi.org/10.1111/j.1435-5597.1960.tb01698.x

Isard, W., & Kuenne, R. E. (1953). The Impact of Steel Upon the Greater New York-Philadelphia Industrial Region. *The Review of Economics and Statistics*, *35*(4), 289–301.

Jackson, K. T. (1985). *Crabgrass frontier : The Suburbanization of the United States*. Oxford University Press.

Jafari, S., & Zaredar, N. (2010). Land Suitability Analysis Using Multi Attribute Decision Making Approach. *International Journal of Environmental Science and Development*, (May), 441–445. https://doi.org/10.7763/IJESD.2010.V1.85

Jan, N., & Tom, C. (2015). Rethinking Suburbia: A Case Study of Metropolitan Miami. *Environment and Planning A*, *47*(1), 69–88. https://doi.org/10.1068/a46281

Jankowski, P. (1995). Integrating Geographical Information Systems and Multiple Criteria Decision-Making Methods. *International Journal of Geographical Information Systems*, *9*(3), 251–273. https://doi.org/10.1080/02693799508902036

Jiang, & Eastman, J. R. (2000). Application of Fuzzy Measures in Multi-criteria Evaluation in GIS. *International Journal of Geographical Information Science*, *14*(2), 173–184.

https://doi.org/10.1080/136588100240903
Jiang, J. (2007). *Analysis of the Suitable and Low-Cost Sites for Industrial Land Using Multi Criteria Evaluation : A Case of Panzhihua , China. Science*. Royal Institute of Technology (KTH).
Jirásková, E. (2002). A Comparison of Location Factors Evaluation in the Secondary and Tertiary Sectors. *Business Administration and Management*, *XVIII*(1), 217. https://doi.org/10.15240/tul/001/2015-1-004
John, A. C. (2015). Reliability and Validity : A Sine Qua Non for Fair Assessment of Undergraduate Technical and Vocational Education Projects in Nigerian Universities. *Journal of Education and Practice*, *6*(34), 68–75.
Johnson, L. C. (2006). Style wars: Revolution in the Suburbs? *Australian Geographer*, *37*(2), 259–277. https://doi.org/10.1080/00049180600701935
Kalantari, A. H. (2013). *Facility Location Selection for Global Manufacturing*. The University of Wisconsin-Milwaukee.
Kallas, Z. (2011). Butchers ' Preferences for Rabbit Meat; AHP Pairwise Comparisons versus a Likert Scale Valuation. In *Proceedings of the International Symposium on the Analytic Hierarchy Process for Multicriteria Decision Making* (pp. 1–6). Sorrento.
Kazibudzki, P. T., & Grzybowski, A. Z. (2013). On Some Advancements within Certain Multicriteria Decision Making Support Methodology. *American Journal of Business and Management*, *2*(2), 143–154. https://doi.org/10.1016/S0304-3975(00)00330-3
Kebede, S. (2013). *Groundwater in Ethiopia*. Heidelberg, Berlin: Springer- Verlag.
Keenan, P. B. (2003). Spatial Decision Support Systems. In M. Mora, F. G, & G. JND (Eds.), *Decision Making Support Systems: Achievements and challenges for the New Decade* (pp. 28–39). Idea Group Inc. https://doi.org/10.1016/B978-0-08-097086-8.72060-5
Keenan, P. B. (2006). Spatial Decision Support Systems: A Coming of Age. *Control and Cybernetics*, *35*(1), 9–27.
Keil, R. (2018). After Suburbia: Research and Action in the Suburban Century. *Urban Geography*, 21. https://doi.org/10.1080/02723638.2018.1548828
Kelly, R. A., Jakeman, A. J., Barreteau, O., Borsuk, M. E., ElSawah, S., Hamilton, S. H., … Voinov, A. A. (2013). Selecting Among Five Common Modelling Approaches for Integrated Environmental Assessment and Management. *Environmental Modelling and Software*, *47*, 159–181. https://doi.org/10.1016/j.envsoft.2013.05.005
Kihoro, J., Bosco, N. J., & Murage, H. (2013). Suitability Analysis for Rice Growing sites using a Multicriteria Evaluation and GIS Approach in great Mwea Region, Kenya. *SpringerPlus*, *2*(1), 1–9. https://doi.org/10.1186/2193-1801-2-265
Kim, H., Jeong, H., Jeon, J., & Bae, S. (2016). The Impact of Impervious Surface on Water Quality and its Threshold in Korea. *Water (Switzerland)*, *8*(4), 1–9. https://doi.org/10.3390/w8040111
Kimelberg, S. M., & Williams, E. (2001). Evaluating the Importance of Business Location Factors:The Influence of Facility Type. *Growth and Change: A Journal of Urban and Regional Policy*, *44*(1), 92–117.
Krejčí, J., & Stoklasa, J. (2018). Aggregation in the Analytic Hierarchy Process: Why Weighted Geometric Mean Should be Used instead of Weighted Arithmetic Mean. *Expert Systems with Applications*, *114*, 97–106. https://doi.org/10.1016/j.eswa.2018.06.060
Krzyzanowski, W. (1927). Review of the Literature of the Location of Industries. *Journal of Political Economy*, *35*(2), 278–291. https://doi.org/10.1086/253840
Kumar, S., Luthra, S., Haleem, A., Mangla, S. K., & Garg, D. (2015). Identification and Evaluation of Critical Factors to Technology Transfer using AHP Approach. *International Strategic Management Review*, *3*(1–2), 24–42. https://doi.org/10.1016/j.ism.2015.09.001
Laurini, R. (2001). Systems Analysis of the Urban Planning Process. In *Information systems for Urban Planning (A hypermedia co-operative approach)* (pp. 1–40). London, UK: Taylor & Francis Group.
Lee, S. D. (2011). *Facility Location. SSRN*. Dhaka, Bangladesh. https://doi.org/10.2139/ssrn.1916608
Leigh, N. G., & Lee, S. (2005). Philadelphia ' s Space In Between : Inner - Ring Suburb Evolution. *Opolis*, *1*(1), 13–32.
Lin, S. (2014). A Comparative Study of Suburbanization in United States and China. *Journal of Geography and Geology*, *6*(4), 132–139. https://doi.org/10.5539/jgg.v6n4p132
Lukoko, P., & Mundia, C. (2016). GIS Based Site Suitability Analysis for Location of a Sugar Factory in Trans Mara District. *International Journal of Sciences: Basic and Applied Research (IJSBAR)*, *4531*(3), 324–339.

Lwasa, S. (2014). *Managing African Urbanization in the Context of Environmental Change* (Vol. 2). Kampala, Uganda.

Mabin, A., Butcher, S., & Bloch, R. (2011). *The Struggle to Belong: Dealing with Diversity in 21st Century Urban Settings; Scope and Dimensions of Suburbanisation in African Cities*. *International RC21 conference 2011*. Amsterdam.

Mabin, A., Butcher, S., & Bloch, R. (2013). Peripheries, Suburbanisms and Change in Sub-Saharan African Cities. *Social Dynamics*, *39*(2), 167–190. https://doi.org/10.1080/02533952.2013.796124

Malczewski, J. (2000). On the Use of Weighted Linear Combination Method in GIS: Common and Best Practice Approaches. *Transactions in GIS*, *4*(1), 5–22. https://doi.org/10.1207/s15327051hci0404_1

Malczewski, J. (2004). GIS-based Land-use Suitability Analysis: A Critical Overview. *Progress in Planning*, *62*(1), 3–65. https://doi.org/10.1016/j.progress.2003.09.002

Malczewski, J. (2006a). GIS-based Multicriteria Decision Analysis: A Survey of the Literature. *International Journal of Geographical Information Science*, *20*(7), 703–726. https://doi.org/10.1080/13658810600661508

Malczewski, J. (2006b). Ordered Weighted Averaging with Fuzzy Quantifiers: GIS-based Multicriteria Evaluation for Land-use Suitability Analysis. *International Journal of Applied Earth Observation and Geoinformation*, *8*(4), 270–277. https://doi.org/10.1016/j.jag.2006.01.003

Malczewski, J., & Rinner, C. (2015). Introduction to GIS-MCDA. In *Multicriteria Decision Analysis in Geographic Information Science* (pp. 23–54). Berlin Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-74757-4

Marshall, A. (1920). *Principles of Economics*. *London: Macmillan and Co. 8th ed. 1920*.

Martin, R. L. (2004). *A Study on the Factors of Regional Competitiveness*. *A draft final report for The European Commission Directorate-General Regional Policy, Cambridge: University of Cambridge*. Cambridge, MA. https://doi.org/10.1002/2014JD022376.Received

Martina, B. (2010). Exploring Alternative Futures of the World Water System. Building a Second Generation of World Water Scenarios - Driving force: Governance. *Prepared for the United Nations World Water Assessment Programme UN WWAP*, 39.

Mateo, J. R. S. C. (2012). *Multi-Criteria Analysis in the Renewable Energy Industry*. *Green Energy and Technology* (Vol. 83). London: Springer London. https://doi.org/10.1007/978-1-4471-2346-0

Matthews, K. B., Sibbald, A. R., & Craw, S. (1999). Implementation of a Spatial Decision Support System for Rural Land use Planning: Integrating Geographic Information System and Environmental Models with Search and Optimisation Algorithms. *Computers and Electronics in Agriculture*, *23*, 9–26.

Mcgranahan, G., Mitlin, D., Satterthwaite, D., Tacoli, C., & Turok, I. (2009). *Africa's Urban Transition and the Role of Regional Collaboration*. London, UK.

McKay, A., & Perge, E. (2015). Spatial Inequality and its Implications for Growth–Poverty-Reduction Relations. In A. McKay & E. Thorbecke (Eds.), *Economic Growth and Poverty Reduction in Sub-Saharan Africa* (pp. 197–226). Croydon, UK: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198728450.003.0007

McManus, R., & Ethington, P. J. (2007). Suburbs in Transition: New Approaches to Suburban History. *Urban History*, *34*(2), 317–337. https://doi.org/10.1017/S096392680700466X

Mediaty Arief, U., Yazidun Nafi, A., Subiyanto, & Hermanto. (2018). An Accurate Assessment Tool Based on Intelligent Technique for Suitability of Soybean Cropland: Case Study in Kebumen Regency, Indonesia. *Heliyon*, *4*, 28. https://doi.org/10.1016/j.heliyon.2018

Memarbashi, E., Azadi, H., Barati, A., Mohajeri, F., Passel, S., & Witlox, F. (2017). Land-Use Suitability in Northeast Iran: Application of AHP-GIS Hybrid Model. *ISPRS International Journal of Geo-Information*, *6*(12), 396. https://doi.org/10.3390/ijgi6120396

Mieszkowski, P., & Mills, E. S. (1993). The Causes of Metropolitan Suburbanization. *Journal of Economic Perspectives*, *7*, 135–147.

Mills, E. S., & Price, R. (1984). Metropolitan Suburbanization and Central City Problems. *Journal of Urban Economics*, *15*(1), 1–17. https://doi.org/10.1016/0094-1190(84)90019-6

Mohajan, H. K. (2017). Two Criteria for Good Measurements in Research: Validity and Reliability. *Annals of "Spiru Haret". Economic Series*, *17*(4), 59. https://doi.org/10.26458/1746

Mokarram, M., & Hojati, M. (2017). Using Ordered Weight Averaging (OWA) Aggregation for Multi-criteria Soil Fertility Evaluation by GIS (case study: southeast Iran). *Computers and Electronics in Agriculture*, *132*(March), 1–13. https://doi.org/10.1016/j.compag.2016.11.005

MoLGRD. (2014). Districts of Ghana.

Montibeller, G., & Von Winterfeldt, D. (2015). Biases and Debiasing in Multi-Criteria Decision Analysis. In *Proceedings of the Annual Hawaii International Conference on System Sciences* (Vol. 2015–March, pp. 1218–1226). Hawaii, USA. https://doi.org/10.1109/HICSS.2015.148

Moses, A., Iwara, E., Gbadebo, N., Olubukola, O., & Omin, I. (2018). Geographic Foci of Industries: A Suitability Analysis. *Journal of Geography, Environment and Earth Science International*, *14*(1), 1–14. https://doi.org/10.9734/JGEESI/2018/39994

Mousseau, V., & Chakhar, S. (2015). Multicriteria Decision Making, Spatial. *International Journal of Applied Engineering Research*, *10*(30), 22757–22762. https://doi.org/10.1007/978-0-387-35973-1

MPCU. (2018). *Ga West Municipal Assembly: Medium Term Development Plan (2018 - 2021).* Amasaman- Accra.

Mu, L. (2008). A Shape-based Buffering Method. *Environment and Planning B: Planning and Design*, *35*(3), 399–412. https://doi.org/10.1068/b33046

Muhsin, N., Ahamed, T., & Noguchi, R. (2017). GIS-based Multi-criteria Analysis Modeling used to Locate Suitable Sites for Industries in Suburban areas in Bangladesh to Ensure the Sustainability of Agricultural Lands. *Asia-Pacific Journal of Regional Science*, *2*, 35–64. https://doi.org/10.1007/s41685-017-0046-0

Mustafa, a a, Singh, M., Sahoo, R. N., Ahmed, N., Khanna, M., & Sarangi, A. (2011). Land Suitability Analysis for Different Crops : A Multi Criteria Decision Making Approach using Remote Sensing and GIS. *Researcher*, *3*(12), 61–84.

Nai, E. (2018a). Personal communication. Amasaman - Accra.

Nai, E. (2018b). Unpublished Raw Data. Amasaman - Accra.

Najmaei, A. (2016). Using Mixed-Methods Designs to Capture the Essence of Complexity in the Entrepreneurship Research: An Introductory Essay and a Research Agenda. In E. S. . Berger & A. Kuckertz (Eds.), *Complexity in Entrepreneurship, Innovation and Technology Research* (pp. 13–36). https://doi.org/10.1007/978-3-319-27108-8

Nganso, T. B., Kyerematen, R., & Obeng-Ofori, D. (2012). Review of Biodiversity in Sacred Groves in Ghana and Implications on Conservation. *Current Trends in Ecology, Volume 3*, *3*(May 2014), 1–10.

Nicolaides, B., & Wiese, A. (2017). Suburbanization in the United States after 1945. *Oxford Research Encyclopedia of American History*, *1*, 1–53. https://doi.org/10.1093/acrefore/9780199329175.013.64

O, O. J., & Shyllon, D. O. (2014). Suitability Analysis in Determining Optimal Landfill Location Using Multi-Criteria Evaluation (MCE), GIS & Remote Sensing. *International Journal of Computational Engineering Research*, *04*, 2250–3005.

Oduro, & Adamtey, R. (2017). The Vulnerability of Peri-urban Farm Households with the Emergence of Land Markets in Accra. *Journal of Science and Technology*, *37*(1), 85–100. https://doi.org/10.4314/just.v37i1.8

Oduro, C. Y., Adamtey, R., & Ocloo, K. (2015). Urban Growth and Livelihood Transformations on the Fringes of African Cities: A Case Study of Changing Livelihoods in Peri-Urban Accra. *Environment and Natural Resources Research*, *5*(2), 81–98. https://doi.org/10.5539/enrr.v5n2p81

Ohri, A., & Singh, P. K. (2010). Spatial Multi Criteria Analysis for Siting Industies. *International Journal of Industrial Engineering Research and Development (IJIERD)*, *1*, 94–114.

Osei, E. (2017). The Impact of Manufacturing Industries on Ghana's Economy. *International Journal of Research Studies in Management*, *6*(2), 73–94. https://doi.org/10.5861/ijrsm.2017.2003

Owoo, N. S., & Lambon-quayefio, M. P. (2017). The Agro-processing Industry and its Potential for Structural Transformation of the Ghanaian Economy. *World Institute for Development Economics Research (WIDER)*, (9), 27.

Palacios, J. (2005). Economic Agglomeration and Industrial Clustering in Developing Countries: The Case of the Mexican Silicon Valley. In *Joint Research Program Series* (pp. 161–271).

Parry, J. A., Ganaie, S. A., & Sultan Bhat, M. (2018). GIS based Land Suitability Analysis Using AHP Model for Urban Services Planning in Srinagar and Jammu urban Centers of J&K, India. *Journal of Urban Management*, *7*(2), 46–56. https://doi.org/10.1016/j.jum.2018.05.002

Pavić, Z., & Novoselac, V. (2013). Notes on TOPSIS Method. *International Journal of Research in Engineering and Science (IJRES)*, *1*(2), 5–12.

Pholo Bala, A., Tenikué, M., & Nafari, B. L. (2017). *Market Potential, Agglomeration Effects and the Location of French Firms in Africa*. *Ssrn*. Johannesburg, SA. https://doi.org/10.2139/ssrn.3097080

Porter, M. (1998). Clusters and the New Economics of Competition. *Harvard Business Review*, (November),

77–90.
Predöhl, A. (1928). The Theory of Location in Its Relation to General Economics. *Journal of Political Economy*, *36*(3), 371–390. https://doi.org/10.2307/1822752
Puşcaciu, R.-M. (2014). An Incursion in the Economic Theory of Location. *European Integration Realities and Perspectives*, *9*(0), 223–230.
Rahman, R., & Saha, S. K. (2008). Remote Sensing, Spatial multi criteria Evaluation (SMCE) and Analytical Hierarchy Process (AHP) in Optimal Cropping Pattern Planning for a Flood Prone Area. *Journal of Spatial Science*, *53*(2), 161–177. https://doi.org/10.1080/14498596.2008.9635156
Rappaport, J. (2005). The Shared Fortunes of Cities and Suburbs. In *Economic Review - Federal Reserve Bank of Kansas City* (pp. 33–60).
Rauber, A., Miksa, T., Mayer, R., & Proell, S. (2015). Repeatability and Re-usability in scientific Processes: Process context, data identification and verification. In *CEUR Workshop Proceedings* (Vol. 1536, pp. 246–256). Vienna, Austria.
Regional Activity Centre for Cleaner Production (RAC/CP). (2005). *Pollution Prevention in the Paper Sector*.
Richardson, H., & Bae, C. (2000). Compact Cities in Developing Countries: Assessment and Implications. In M. Jenks & B. Rod (Eds.), *Compact cities: Sustainable urban forms for developing countries* (pp. 25–36). London, UK: Spon Press.
Rikalovic, A., Cosic, I., Labati, R. D., & Piuri, V. (2015). A Comprehensive Method for Industrial Site Selection: The Macro-Location Analysis. *IEEE Systems Journal*, (December), 1–10. https://doi.org/10.1109/JSYST.2015.2444471
Rikalovic, A., Cosic, I., & Lazarevic, D. (2014). GIS based Multi-criteria Analysis for Industrial Site Selection. *Procedia Engineering*, *69*(December), 1054–1063. https://doi.org/10.1016/j.proeng.2014.03.090
Rosenthal, S., & Strange, W. (2010). Small Establishments/Big Effects: Agglomeration, Industrial Organization and Entrepreneurship. In E. Glaeser (Ed.), *Agglomeration Economics* (pp. 277–302). Chicago, IL, USA: University of Chicago Press. https://doi.org/papers2://publication/uuid/5BC03E1A-9DC2-4781-9719-B705B63C5290
Rowe, G., & Wright, G. (2001). Differences in Expert and Lay Judgments of Risk: Myth or Reality? *Risk Analysis*, *21*(2), 341–356. https://doi.org/10.1111/0272-4332.212116
Saaty, T. L. (1980). *The Analytic Hierarchy Process : Planning, Priority Setting, Resource Allocation* (Ist). New York: McGraw-Hill International Book Co.
Saaty, T. L. (2004). The Analytic Hierarchy Process. In *Strategic Decision Making: Applying the Analytic Hierarchy Process* (pp. 11–21). Springer-Verlag. https://doi.org/10.3414/ME10-01-0028
Saaty, T. L. (2008). Decision making with the Analytic Hierarchy Process. *Int. J. Services Sciences*, *1*(1), 83–98.
Saaty, T. L., & Vargas, L. G. (2013). *Decision Making with the Analytic Network Process* (Vol. 195). Boston, MA: Springer US. https://doi.org/10.1007/978-1-4614-7279-7
Sabaei, D., Erkoyuncu, J., & Roy, R. (2015). A Review of Multi-criteria Decision Making Methods for Enhanced Maintenance Delivery. In *Procedia CIRP* (Vol. 37, pp. 30–35). https://doi.org/10.1016/j.procir.2015.08.086
Safari, H., & Soufi, M. (2014). Select a Hypermarket Location Based on Fuzzy Multicriteria decision making (F-MCDM) TECHNIQUES (HYBRID OF F-DELPHI, F-AHP, F-LLSM and F-PROMETHEE). *Arabian Journal of Business and Management Review*, *4*(1), 76–95.
Sander, H. A., Ghosh, D., van Riper, D., & Manson, S. M. (2010). How Do You Measure Distance in Spatial Models? An Example Using Open-space Valuation. *Environment and Planning B: Planning and Design*, *37*(5), 874–894. https://doi.org/10.1068/b35126
Sarath, M., Saran, S., & Ramana, K. V. (2018). Site Suitability Analysis for Industries Using Gis and Multi Criteria Decision Making. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *IV*(November), 447–454. https://doi.org/10.5194/isprs-annals-IV-5-447-2018
Sarkar, A., Ghosh, A., & Banik, P. (2014). Multi-criteria Land Evaluation for Suitability Analysis of Wheat: A Case Study of a Watershed in Eastern Plateau Region, India. *Geo-Spatial Information Science*, *17*(2), 119–128. https://doi.org/10.1080/10095020.2013.774106
Schoonenboom, J., & Johnson, R. B. (2017). How to Construct a Mixed Methods Research Design. *Kolner Zeitschrift Fur Soziologie Und Sozialpsychologie*, *69*, 107–131. https://doi.org/10.1007/s11577-017-0454-1

Schueler, T. R. (1994). The Importance of Imperviousness. *Watershed Protection Techniques*, *1*(3), 1–12. https://doi.org/Doi: 10.1016/0021-9517(74)90218-8

Seto, K. C., Fragkias, M., Güneralp, B., & Reilly, M. K. (2011). A Meta-Analysis of Global Urban Land Expansion. *PLoS ONE*, *6*(8), 23777. https://doi.org/10.1371/journal.pone.0023777

Shahid, R., Bertazzon, S., Knudtson, M. L., & Ghali, W. A. (2009). Comparison of Distance Measures in Spatial Analytical Modeling for Health Service Planning. *BMC Health Services Research*, *9*, 14. https://doi.org/10.1186/1472-6963-9-200

Shalamzari, M. J., Gbolami, A., Sigaroudi, K. S., & Shabani, A. A. (2018). Site Selection for Rainwater Harvesting for Wildlife using Multi-Criteria Evaluation (MCE) Technique and GIS in the Kavir National Park, Iran. *Journal of Rangeland Science*, *8*(1), 77–92.

Shaw, A. (1999). Emerging Patterns of Urban Growth in India. *Economic and Political Weekly*, *34*(16/17), 969–978.

Shen, J. (2011). *Suburban Development in Shanghai: A case of Songjiang*. Cardiff University.

Sheppard, E. (2001). Geographic Information Systems: Critical Approaches. In *International Encyclopedia of the Social Behavioral Sciences* (pp. 6182–6185). Pergamon. https://doi.org/http://dx.doi.org/10.1016/B0-08-043076-7/02524-9

Shibru, D., Suryabhagavan, K. ., Mekuria, A., & S, H. (2014). Application of AHP for Environmental Suitability Analysis of Resettlement Site selection : The case of Chawaka District , Western Ethiopia. *International Journal of Geoinformatics*, *10*(September 2016), 63–72.

Sieber, R. (2006). Public Participation Geographic Information Systems: A Literature Review and Framework. *Annals of the Association of American Geographers*, *96*(3), 491–507.

Singh, P. (2015). Role of Geographical Information Systems in Tourism Decision Making Process: A Review. *Information Technology and Tourism*, *15*(2), 131–179. https://doi.org/10.1007/s40558-015-0025-0

Song, B., & Kang, S. (2016). A Method of Assigning Weights Using a Ranking and Nonhierarchy Comparison. *Advances in Decision Sciences*, *2016*, 1–9. https://doi.org/10.1155/2016/8963214

Sridhar, K. (2004). *Cities with Suburbs: Evidence from India*. New Delhi , India.

Store, R., & Kangas, J. (2001). Integrating Spatial Multi-criteria Evaluation and Expert Knowledge for GIS-based Habitat Suitability Modelling. *Landscape and Urban Planning*, *55*(2), 79–93. https://doi.org/10.1016/S0169-2046(01)00120-7

Strjer Madsen, E., Smith, V., & Dilling-Hansen, M. (2003). *Industrial Clusters, Firm Location and Productivity Some Empirical Evidence for Danish Firms.* (No. 26). Aarhus , Denmark.

Sugumaran, R., & Brain, B. (2007). GIS-Based Site Suitability Decision Support System for Planning Confined Animal Feeding Operations in Iowa. In B. N. Hilton (Ed.), *Emerging Spatial Information Systems and Applications* (pp. 219–238). Hershey, Pennsyvania, USA: Idea Group Inc. https://doi.org/10.1017/CBO9781107415324.004

Sugumaran, V., & Sugumaran, R. (2007). Web-based Spatial Decision Support Systems (WebSDSS): Evolution, Architecture, Examples and Challenges. *Communications of the Association for Information Systems*, *19*, 844–875. https://doi.org/10.17705/1CAIS.01940

Sultani, R. M., Soliman, A. M., & Al-hagla, K. S. (2009). The Use of Geographic Information System (GIS) Based Spatial Decision Support System (SDSS) in Developing the Urban Planning Process. *Architecture & Planning Journal*, *20*(February 2016), 97–115.

Sunley, P. (2015). *Structural Transformation, Adaptability and City Economic Evolutions* (No. ES/N006135/1). *Working Paper 1*. Swindon, UK.

Swank, J. M., & Mullen, P. R. (2017). Evaluating Evidence for Conceptually Related Constructs using Bivariate Correlations. *Measurement and Evaluation in Counseling and Development*, *50*(4), 270–274. https://doi.org/10.1080/07481756.2017.1339562

Teaford, J. C., & Harris, R. (1997). Post-suburbia: Government & Politics in the Edge cities. *Urban History Review*, *26*(1), 54.

Teddlie, C., & Yu, F. (2007). Mixed Methods Sampling: A Typology With Examples. *Journal of Mixed Methods Research*, *1*(1), 77–100. https://doi.org/10.1177/2345678906292430

Temurcin, K., Kervankiran, I., & Dziwornu, M. G. (2017). Spatial Structure and Distribution of Manufacturing Industries in the Greater Accra Region of Ghana. *Prace Komisji Geografii Przemysłu Polskiego Towarzystwa*, *31*(October), 12. https://doi.org/10.24917/20801653.314.5

Tennøy, A., Hansson, L., Lissandrello, E., & Næss, P. (2016). How Planners' Use and Non-use of Expert

Knowledge Affect the Goal Achievement Potential of Plans: Experiences from Strategic Land-use and Transport Planning Processes in three Scandinavian cities. *Progress in Planning*, *109*, 1–32. https://doi.org/10.1016/j.progress.2015.05.002

Thatcher, R. W. (2010). Validity and Reliability of Quantitative Electroencephalography. *Journal of Neurotherapy*, *14*(2), 122–152. https://doi.org/10.1080/10874201003773500

The World Bank. (2010). *Industrial Clusters and Micro and Small Enterprises in Africa*. (Y. Yoshino, Ed.), *Directions in Development - General.* Washington, D. C. USA. https://doi.org/10.1056/EM201007160000004

Thomson, A. J., & Schmoldt, D. L. (2001). Computers and Electronics in agriculture Ethics in computer software design and development. *Computers and Electronics in Agriculture*, *30*, 85–102.

Tienwong, K., Dasananda, S., & Navanugraha, C. (2009). Integration of Land Evaluation and the Analytical Hierarchy Process Method for Energy crops in Kanchanaburi, Thailand. *ScienceAsia*, *35*(2), 170–177. https://doi.org/10.2306/scienceasia1513-1874.2009.35.170

Todes, A. (2014). New African Suburbanisation? Exploring the Growth of the Northern Corridor of eThekwini/KwaDakuza. *African Studies*, *73*(2), 245–270. https://doi.org/10.1080/00020184.2014.925188

Tomashevskii, L. (2015). Eigenvector Ranking Method as a Measuring Tool: Formulas for Errors. *European Journal of Operational Research*, *240*(3), 774–780. https://doi.org/10.1016/j.ejor.2014.07.050

Turcotte, M. (2008). *The City/Suburb Contrast: How Can we Measure it? Canadian Social Trends*.

Ullah, K. M., & Mansourian, A. (2016). Evaluation of Land Suitability for Urban Land-Use Planning: Case Study Dhaka City. *Transactions in GIS*, *20*(1), 20–37. https://doi.org/10.1111/tgis.12137

UN-HABITAT. (2011). *The Economic Role of Cities*. (X. Q. Zhang & T. Osanjo, Eds.), *The Global Urban Economic Dialogue Series*. Nairobi, Kenya: UN-HABITAT.

UNECA. (2013). *Industrialization for an Emerging Africa*. Abidjan, Côte d'Ivoire.

UNECA. (2017). *Economic Report on Africa 2017: Urbanization and Industrialization for Africa's Transformation*. Addis Ababa, Ethiopia.

Vaggione, P. (2013). *Urban Planning for City Leaders*. (V. Quinlan, Ed.). Nairobi, Kenya: UNON, Publishing Services Section. https://doi.org/10.1007/SpringerReference_168760

Vernon, H. J. (2009). Cities and development. *Cities and Development*, *50*(1), 1–267. https://doi.org/10.4324/9780203086452

Viladecans-Marsal, E. (2004). Agglomeration Economies and Industrial Location: City-level Evidence. *Journal of Economic Geography*, *4*(5), 565–582. https://doi.org/10.1093/jnlecg/lbh040

Wang, X. (2013). *The Role of Economic Development Zones in National Development Strategies: The Case of China*. *ProQuest Dissertations and Theses*. Pardee Rand Graduate school.

Waters, D. (2002). Facilities location. In *Operations management - Producing Goods and Services* (p. 647). Sambalpur, Odisha, India.

Weber, A. (1929). *Alfred Weber's Theory of location of Industries*. (C. . Friedrich, Ed.). Chicago, Illinois , USA.: The University of Chicago Press.

Williamson, J. (2011). *Industrial Catching Up in the Poor Periphery 1870-1975* (No. 16809). Cambridge, MA. https://doi.org/10.3386/w16809

Xie, Y., & Wu, X. (2008). Danwei Profitability and Earnings Inequality in Urban China. *China Quarterly*, *34*(195), 558–581. https://doi.org/10.1017/S0305741008000775

Yankson, P. W. K., & Bertrand, M. (2012). Challenges of Urbanization in Ghana. In *The Mobile City of Accra : Urban Families, Housing and Residential Practices* (pp. 25–46). Dakar, Senegal: CODESRIA.

Yazdani, M., Monavari, S. M., Omrani, G. A., Shariat, M., & Hosseini, S. M. (2015). Landfill Site Suitability Assessment by means of Geographic Information System Analysis. *Solid Earth*, *6*(3), 945–956. https://doi.org/10.5194/se-6-945-2015

Zadeh Sarraf, A., Mohaghar, A., & Bazargani, H. (2013). Developing TOPSIS Method Using Statistical Normalization for Selecting Knowledge Management Strategies. *Journal of Industrial Engineering and Management*, *6*(4), 860–875. https://doi.org/10.3926/jiem.573

Zebik, G. (2011). Typology of Suburban Communities in Poland. *Bulletin of Geography*, *16*(16), 173–188. https://doi.org/10.2478/v10089-011-0021-x

Zeng, D. Z. (2016). *Global Experiences of Special Economic Zones with Focus on China and Africa: Policy Insights*. *Journal of International Commerce, Economics and Policy* (Vol. 07). Addis Ababa, Ethiopia. https://doi.org/10.1142/S1793993316500186

Zhou, L., & Wu, J. (2012). *GIS-Based Multi-Criteria Analysis for Hospital Site Selection in Haidian District of Beijing*. Gävle University College.

Zhou, & Ma, L. J. C. (2000). Economic Restructuring and Suburbanization in China. *Urban Geography*, *21*(3), 205–236. https://doi.org/10.2747/0272-3638.21.3.205

Zhu, B., & Xu, Z. (2014). Decision Support Analytic Hierarchy Process-hesitant Group Decision making. *European Journal of Operational Research*, *239*, 794–801. https://doi.org/10.1016/j.ejor.2014.06.019

APPENDICES

Appendix 1: Informed consent and interview guide for experts.

This informed consent form is for CEOs and managers of large-scale manufacturing companies who the researcher is humbly inviting to participate in the research titled "*An Integrated Modelling Approach to Assess Industrial Location Suitability in the Ga West Municipality, Ghana*". As part of the research, a short interview will be used to understand the reasons why entrepreneurs situated their businesses in particular locations in the municipality.
The researcher is Ms Elsie Nai, a Master's student at the University of Twente, Faculty of Geo-information Science and Earth Observation (ITC), the Netherlands.

This consent form is in two parts, *Part 1 and Part 2*
Part 1 is the study information which is to share some background information about the research with the participant and the proposed questions to be answered in the interview.
Part 2 is a Certificate of consent to be signed before the interview starts. A copy of the Certificate of Consent will be given to the participant for records keeping.

Part 1
There has been an increase in the number of manufacturing businesses in the Ga west municipality in recent times. Many industries have located in different parts of the municipality for different reasons. It is important to understand why entrepreneurs prefer certain particular locations in the municipality more than others. The objective of the researcher is therefore to conduct a personal interview with participants to find out which factors their firms considered during the site selection process. This research is part of the requirements for an MSc degree at the University of Twente, Netherlands.

The questions below are to be asked during the interview;

1. Why did you choose to locate your manufacturing company in the Ga west municipality?
2. Why did you choose this particular location?
3. How does the physical infrastructure and public facilities in this municipality benefit your company?
4. In your opinion, which localities in the municipality are attracting more manufacturing companies?
5. What do you think is the reason why these companies are moving to these areas?
6. How do you perceive the prices of land for industries in this locality as compared to other areas in the municipality?
7. Do you think there is still some land available in this locality if I want to build a factory?
8. Are you happy with your current location?
9. Would you prefer to maintain your business here or move to somewhere else in the municipality?
10. Where would you prefer to expand your business if you had the opportunity (and land was available)?

Duration and Confidentiality

1. Participation in this interview is voluntary. The interview should only take 30 minutes to complete.
2. For the purpose of maintaining the original words of the participant for analysis, the interview will be recorded. The recorded interview will be transcribed by the researcher and accessed only by the researcher and her academic colleagues at ITC, University of Twente.
3. The participant is allowed to have access to the interview transcript by contacting the researcher through the email address: e.a.nai@student.utwente.nl
4. Answers to the interview questions will be archived in the ITC, University of Twente Database.

5. Any academic use of the information provided in the interview will not include the personal identity (name) or personal information (address, phone number, position in the company) of the participant or any other information that will identify the participant.

Thank you for your willingness to participate in the interview.

Appendix 2: Certificate of consent for experts

Part 2

Please tick the appropriate boxes	Yes	No
I have read and understood the study information dated DD/MM/YYYY, or it has been read to me. I have been able to ask questions about this study and my questions have been answered to my satisfaction.	☐	☐
I consent to voluntarily be a participant in this study. I also understand that taking part in the study involves giving answers to interview questions.	☐	☐
Use of the information in the study I understand that the information I provide is for academic purposes.	☐	☐
I understand that my personal information and identity will not be used in any academic document.	☐	☐
Future use and reuse of the information by others I give permission for the answers that I provide in the interview to be archived in the *University of Twente (ITC) Database.* The data can be used for future academic research and learning.	☐	☐

Signatures

………………………………	……….…………………..….	……………………………..
Name of Participant	Signature	Date
……………………………	……………………………	……..……………………..
Name of Researcher	Signature	Date

Appendix 3: Informed consent for large-scale manufacturing business officials

This informed consent form is for officials of large scale manufacturing companies who the researcher is humbly inviting to participate in the research titled "*An Integrated Modelling Approach to Assess Industrial Location Suitability in the Ga west municipality, Ghana*". As part of the research, a simple questionnaire will be used to rate the factors that entrepreneurs considered before locating their businesses in the municipality. The Researcher is *Ms Elsie Nai,* a Master's student at the University of Twente, Faculty of Geo-information Science and Earth Observation (ITC), the Netherlands.

This consent form is in two parts*, Part 1 and Part 2*
Part 1 is the study information which is to share some background on the research with the participant.
Part 2 is a Certificate of consent to be signed before the survey starts. *A copy of the Certificate of Consent will be given to the participant for records keeping.*

Part 1
There has been an increase in the number of manufacturing businesses in the Ga west municipality in recent times. Many companies have established in different parts of the municipality for different reasons. Some reasons are however, more important than others.
The researcher therefore wants to conduct a survey to rate the most critical factors that made business owners and entrepreneurs to locate their manufacturing businesses in some particular areas in the Ga west municipality. The survey is to help the researcher to meet the requirements of a Master's degree at ITC, University of Twente, the Netherlands.

Fifteen (15) factors have been identified to be very important in selecting a location for an industry in the Ga west municipality.

1. The participant is kindly requested to assign a score of importance on each row by comparing the **factor A** (on the left) to the **factor B** (on the right).

2. Please cross (**X**) the factor that was more important in deciding the location of your current company. That is, for each row, if the factor on the left was more important than the factor on the right, assign a score of 3 or 5 or 7 or 9 depending on the level of importance.

3. If the factor on the right was more important than the factor on the left assign a score of 3 or 5 or 7 or 9 using a cross sign (**X**).

4. If two factors are seen to be of equal importance, then cross (**X**) "1"for that row.

This is an example;

Factors A	Extremely			Very Strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very Strongly		Extremely	Factors B
Distance to CBDs	9	8		7 ×	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Proximity to raw material source**
Proximity to raw material source	9	8		7	6	5	4	3	2	1 ×	2	3	4	5	6	7	8	9	**Availability of developable land**

Duration and Confidentiality
The questionnaire should only take 20 minutes to complete. The personal identity of the participant is confidential and not required in the survey except for the certificate of consent.

Appendix 4: Certificate of consent for business officials

Part 2

Please tick the appropriate boxes	Yes	No
I have read and understood the study information dated DD/MM/YYYY, or it has been read to me. I have been able to ask questions about this study and my questions have been answered to my satisfaction.	☐	☐
I consent to voluntarily be a participant in this study. I also understand that taking part in the study involves giving answers to a questionnaire.	☐	☐
Use of the information in the study I understand that the information I provide is for academic purposes.	☐	☐
I understand that my personal data (name) will not be used in the survey	☐	☐
Future use and reuse of the information by others I give permission for the answers that I provide to the questionnaire to be archived in the *University of Twente (ITC) Database.* The data can be used for future academic research and learning.	☐	☐

Signatures

……………………………… …. ………………..… … ….……………………

Name of Participant Signature Date

……………………………… . ………….………… ……………………..

Name of Researcher Signature Date

Appendix 5: AHP questionnaire for rating industrial location factors in the Ga west municipality.

PARTICIPANTS - BUSINESS OFFICIALS
WHICH FACTORS DID YOUR COMPANY CONSIDER MORE IMPORTANT IN ITS SITE SELECTION? FACTOR ON THE LEFT? OR FACTOR ON THE RIGHT OF THE ROW? CROSS A NUMBER TO THE LEFT OR RIGHT. OR NUMBER 1 FOR EQUAL IMPORTANCE.

ECONOMIC FACTORS Comparing Factors A to Factors B Please Cross (x) one number per row using the scale: 1= Equally important, 3= Moderately important, 5=Strongly important, 7= Very Strongly important, 9= Extremely important, (2,4,6,8)= intermediate importance																		
Factors A	Extremely		Very Strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very Strongly		Extremely	**Factors B**
Availability of developable land	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Availability / Proximity to raw material source
Availability of developable land	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Distance to CBDs
Availability / Proximity to raw material source	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Distance to CBDs

SOCIO-ECONOMIC FACTORS Comparing Factors A to Factors B Please Cross (x) one number per row using the scale: 1= Equally important, 3= Moderately important, 5=Strongly important, 7= Very Strongly important, 9= Extremely important, (2,4,6,8)= intermediate importance																		
Factors A	**Extremely**		**Very Strongly**		**Strongly**		**Moderately**		**Equally**		**Moderately**		**Strongly**		**Very Strongly**		**Extremely**	**Factors B**
Availability of unskilled labour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Distance to Accra waste-sorting plant**
Availability of unskilled labour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Litigation-free area**
Availability of unskilled labour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Closeness to higher educational institutions**
Availability of unskilled labour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Proximity to health facilities**
Availability of unskilled labour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Availability of reliable electricity supply**
Availability of unskilled labour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Availability of municipal water supply**
Availability of unskilled labour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Groundwater potential**
Distance to Accra waste-sorting plant	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Litigation-free area**

SOCIO-ECONOMIC FACTORS Comparing Factors A to Factors B Please Cross (x) one number per row using the scale: 1= Equally important, 3= Moderately important, 5=Strongly important, 7= Very Strongly important, 9= Extremely important, (2,4,6,8)= intermediate importance																		
Factors A	Extremely		Very Strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very Strongly		Extremely	**Factors B**
Distance to Accra waste - sorting plant	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Closeness to higher educational institutions
Distance to Accra waste - sorting plant	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Proximity to health facilities
Distance to Accra waste - sorting plant	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Availability of reliable electricity supply
Distance to Accra waste - sorting plant	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Availability of municipal water supply
Distance to Accra waste - sorting plant	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Ground water potential
Litigation-free area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Closeness to higher educational institutions
Litigation -free area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Proximity to health facilities
Litigation -free area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Availability of reliable electricity supply

SOCIO-ECONOMIC FACTORS **Comparing Factors A to Factors B** Please Cross (x) one number per row using the scale: 1= Equally important, 3= Moderately important, 5=Strongly important, 7= Very Strongly important, 9= Extremely important, (2,4,6,8)= intermediate importance																		
Factors A	**Extremely**		**Very Strongly**		**Strongly**		**Moderately**		**Equally**		**Moderately**		**Strongly**		**Very Strongly**		**Extremely**	**Factors B**
Litigation-free area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Availability of municipal water Supply**
Litigation-free area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Ground water potential**
Closeness to higher educational institutions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Proximity to health facilities**
Closeness to higher educational institutions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Availability of Reliable electricity supply**
Closeness to higher educational institutions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Availability of municipal water supply**
Closeness to higher educational institutions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Ground water potential**
Proximity to Health Facilities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Availability of reliable electricity supply**
Proximity to Health Facilities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Availability of municipal water supply**

SOCIO-ECONOMIC FACTORS Comparing Factors A to Factors B Please Cross (x) one number per row using the scale: 1= Equally important, 3= Moderately important, 5=Strongly important, 7= Very Strongly important, 9= Extremely important, (2,4,6,8)= intermediate importance																		
Factors A	Extremely		Very Strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very Strongly		Extremely	**Factors B**
Proximity to Health facilities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Groundwater Potential**
Availability of Reliable Electricity Supply	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Availability of Municipal Water Supply**
Availability of Reliable Electricity Supply	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Groundwater Potential**
Availability of Municipal Water Supply	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Groundwater Potential**

TELECOMMUNICATION & TRANSPORTATION FACTORS Comparing Factors A to Factors B Pleas Cross (x) one number per row using the scale: 1= Equally important, 3= Moderately important, 5=Strongly important, 7= Very Strongly important, 9= Extremely important, (2,4,6,8)= intermediate importance																		
Factors A	Extremely		Very Strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very Strongly		Extremely	**Factors B**
Closeness to Accra-Kumasi Highway	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Availability of mobile network
Closeness to Accra-Kumasi Highway	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Closeness to Tema Port
Closeness to Accra-Kumasi Highway	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Distance to Municipal Assembly
Availability of mobile network	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Closeness to Tema Port
Availability of mobile network	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Distance to Municipal Assembly
Closeness to Tema Port	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Distance to Municipal Assembly

GENERAL FACTORS **Comparing General Factors A to General Factors B** Please Cross (x) one number per row using the scale: 1= Equally important, 3= Moderately important, 5=Strongly important, 7= Very Strongly important, 9= Extremely important, (2,4,6,8)= intermediate importance																		
Factors A	**Extremely**		**Very Strongly**		**Strongly**		**Moderately**		**Equally**		**Moderately**		**Strongly**		**Very Strongly**		**Extremely**	**Factors B**
Economic Factors	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Socio-economic**
Economic Factors	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Telecomm. and transportation**
Socio-economic	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Telecomm. and transportation**

THANK YOU

for completing this questionnaire

Your time is greatly appreciated

Appendix 6: Interview invitation letter to Ga West Municipal Chief Executive (MCE)

Elsie A Nai
Hengelosestraat 99-158
7514 AE Enschede
The Netherlands
28th September, 2018

The Municipal Chief Executive
Ga West Municipal Assembly
P. O. Box 1
Amasaman- Accra
Ghana

Dear Hon.,

REQUEST FOR INTERVIEW

I am a student of the University of Twente, Faculty of Geo-Information Science and Earth Observation (ITC), Netherlands. I am undertaking a research to identify the factors that influence the location of manufacturing industries in the Ga west municipality.

Ga west is undergoing a lot of economic transformations with an increasing demand for land for the establishment of industries. I am particularly interested in understanding how the industrial site selection decisions of entrepreneurs can be used to determine the most optimal sites for the location of industries in the future.

In view of this, I would very much appreciate if you can spare me some 30 minutes out of your busy schedule for an interview on your views about how the Assembly plans to take advantage of the increasing land demand and the strategies to attract more investors to the municipality. Your responses will provide more insight on the role of the Assembly in promoting industrial development in the municipality as it will be referenced in my MSc. research project.

I will travel to Ghana to collect data for the research from the 10th to 30th October, 2018 as such, I would be very grateful if we could arrange an appointment for this interview within this time period.

I will contact your office in the coming days to discuss the appropriate date in this respect. Please find enclosed, a support letter from the University of Twente for your retention.
I count on your kind co-operation.

Sincerely,

Elsie A. Nai

Appendix 7: Informed consent form for MCE

This informed consent form is for the Municipal Chief Executive of the Ga West Municipal Assembly who the researcher is humbly inviting to participate in the research titled "*An Integrated Modelling Approach to Assess Industrial Location Suitability in the Ga West Municipality, Ghana".* As part of the research, a short interview will be conducted to understand the role of the Assembly in promoting industrial development in Ga west.

The researcher is *Ms Elsie Nai,* a master's student at the University of Twente, Faculty of Geo-information Science and Earth Observation (ITC), the Netherlands.

This consent form is in two parts*, Part 1 and Part 2*

Part 1 is the study information which gives some background information about the research and the interview questions.

Part 2 is a Certificate of consent to be signed before the interview starts. *A copy of the Certificate of Consent will be given to the MCE for records keeping.*

Part 1

There has been an increase in the number of manufacturing businesses in the Ga west municipality in recent times. This presents some great opportunities for the municipality as a whole. In view of this, it is important to understand the strategies of the Assembly towards making this opportunity beneficial to the municipality. The objective of the researcher is therefore to conduct a personal interview to find out the views of the MCE on how the Assembly plans to take advantage of the increasing industrial land demand and the strategies to attract more investors to the municipality. This research is part of the requirements for an *MSc degree at the University of Twente, the Netherlands.*

The questions below are to be answered during the interview;

1. What makes Ga west more attractive to business entrepreneurs than other suburban municipalities in Accra?
2. How important is the increase in the number of manufacturing industries to the economic development of the municipality?
3. What is the vision of the Assembly in terms of employment creation through industrial development?
4. Does the Assembly have any future plans to create industrial parks in the municipality? (if yes; question 5-10, if no question 7 and 10)
5. In which areas is the Assembly planning to locate these industrial parks (if it had any plans)?
6. Which location factors are important to the Assembly in selecting sites for industrial parks?
7. In your opinion, how do you think industrial parks will benefit manufacturing companies in the municipality?
8. Which strategies is the Assembly putting in place to encourage industries to locate in the proposed industrial park(s)?
9. Please can you mention some of these strategies?
10. Which publicity (advertising) strategy does the Assembly have in place to attract more investors into the municipality?

Duration and Confidentiality

1. Participation in this interview is voluntary. The interview should only take 30 minutes to complete.
2. For the purpose of maintaining the original words of the participant for analysis, the interview will be recorded. *The recorded interview will be transcribed by the researcher and accessed only by the researcher and her academic colleagues at ITC, University of Twente.*
3. A copy of the transcript will be sent to the participant to review and correct any errors before it is used in the research.

4. The participant is allowed to have access to the interview transcript by contacting the researcher through the email address: *e.a.nai@student.utwente.nl*
5. The answers to the interview questions will be archived in the *ITC, University of Twente Database.*
6. The identity and personal information about the participant will be kept confidential throughout the analysis process.
7. Any academic use of the information provided in the interview will be anonymized.

Thank you for your willingness to participate in the interview.

Appendix 8: Certificate of consent - MCE

Part 2

Please tick the appropriate boxes	Yes	No
I have read and understood the study information dated DD/MM/YYYY, or it has been read to me. I have been able to ask questions about this study and my questions have been answered to my satisfaction.	☐	☐
I consent to voluntarily be a participant in this study. I also understand that taking part in the study involves giving answers to interview questions.	☐	☐
Use of the information in the study I understand that the information I provide is for academic purposes.	☐	☐
I understand that my personal information and identity will not be used in any academic document.	☐	☐
Future use and reuse of the information by others I give permission for the answers that I provide in the interview to be archived in the *University of Twente (ITC) Database*. The data can be used for future academic research and learning.	☐	☐

Signatures

…………………………………	……….…………………..….	……………………………..
Name of participant	Signature	Date
……………………………	……………………………	……..……………………….
Name of researcher	Signature	Date

Appendix 9: Interview invitation letter to the Municipal Physical Planning Officer

Elsie A Nai
Hengelosestraat 99-158
7514 AE Enschede
The Netherlands
28th September, 2018

The Municipal Physical Planning Officer
Ga West Municipal Assembly
P. O. Box 1
Amasaman- Accra
Ghana

Dear Sir,

REQUEST FOR INTERVIEW

I am a student of the University of Twente, Faculty of Geo-Information Science and Earth Observation (ITC), the Netherlands. I am undertaking a research to identify the factors that influence the location of manufacturing industries in the Ga west municipality.

Ga west municipality is undergoing a lot of economic transformations with an increasing demand for land for industrial purposes. I am particularly interested in understanding how the industrial site selection decisions of entrepreneurs can be used to determine the most optimal sites for the location of industries in the future.

In view of this, I would very much appreciate if you can spare me some 30 minutes out of your busy schedule for an interview on your views on how zoning can be used to promote industrial development in the municipality. Your responses will provide more insight on the current strategies at the physical planning department for managing the increasing demand for industrial land..

I will travel to Ghana to collect data for the research from the 10th to 30th October, 2018, therefore, I would be very grateful if you could arrange an appointment for this interview within this time period.

I will contact your office in the coming days to discuss the appropriate date in this respect.
Counting on your co-operation.

Sincerely,

Elsie A. Nai

Appendix 10: Informed consent form for Municipal Physical Planning Officer

This informed consent form is for the Municipal Physical Planning Officer of Ga West Municipal Assembly who the researcher is humbly inviting to participate in the research titled "*An Integrated Modelling Approach to Assess Industrial Location Suitability in the Ga West Municipality, Ghana"*. As part of the research, a short interview will be conducted to understand how the Physical Planning Department is using zoning to manage industrial expansion in Ga west.

The researcher is *Elsie Nai,* a Master's student at the University of Twente, Faculty of Geo-information Science and Earth Observation (ITC), the Netherlands.

This consent form is in two parts*, Part 1 and Part 2*
Part 1 is the study information which gives some background information about the research.
Part 2 is a Certificate of Consent to be signed before the interview starts. *A copy of the Certificate of Consent will be given to the Planner for records keeping.*

Part 1
Demand for land for industries is on the increase in the Ga west municipality. Certain localities in the municipality are generally more preferred by entrepreneurs due to the comparative advantages these areas have over other areas. Zoning is an effective technique that can be used to ensure that manufacturing industries are located in appropriate places so that their impacts on the environment is minimized.

The objective of the researcher in this respect is to conduct a personal interview to find out the views of the Municipal Planning Officer on how the Physical Planning Department is using industrial zoning to manage industrial expansion in the municipality. This research is part of the requirements for an *MSc degree at the University of Twente, the Netherlands.*

The questions below are to be asked during the interview;

1. It is evident that certain areas of the Ga west municipality are experiencing a high demand for industrial land. Can you tell me why entrepreneurs prefer these areas to other places in the municipality?
2. Which areas have been zoned for industries according to the existing spatial plans?
3. What factors make these zoned areas suitable for the location of industries?
4. Do you see a higher demand for industrial land in the future than presently? (If yes, question 5, if no, question 6)
5. Why do you say so?
6. Are the current industrial zones adequate for the increasing demand for industrial land?
7. In the preparation of future planning schemes, which areas do you think are likely to be most suitable for creating industrial zones?
8. Please can you tell me why you find these areas to be potentially suitable?
9. How can the physical planning department use industrial zoning to increase the productivity of large scale manufacturing companies in the municipality?
10. How is your office managing the current rapid land use change occurring around industrial concentrations in the municipality?

Duration and Confidentiality

1. Participation in this interview is voluntary. The interview should only take 30 minutes to complete.
2. For the purpose of maintaining the original words of the participant for analysis, the interview will be recorded. *The recorded interview will be transcribed by the researcher and accessed only by the researcher and her academic colleagues at ITC, University of Twente.*
3. A copy of the transcript will be sent to the participant to review and correct any errors before it is used in the research.
4. The participant is allowed to have access to the interview transcript by contacting the researcher through the email address: *e.a.nai@student.utwente.nl*

5. The answers to the interview questions will be archived in the *ITC, University of Twente Database.*
6. The identity of the participant will be coded and kept confidential throughout the analysis process.
7. Any academic use of the information provided in the interview will not include the identity (name) or personal information (address, phone number, office position) of the participant or any other information that will identify the participant.

Thank you for your willingness to participate in the interview.

Appendix 11: Certificate of consent for Municipal Physical Planning Officer

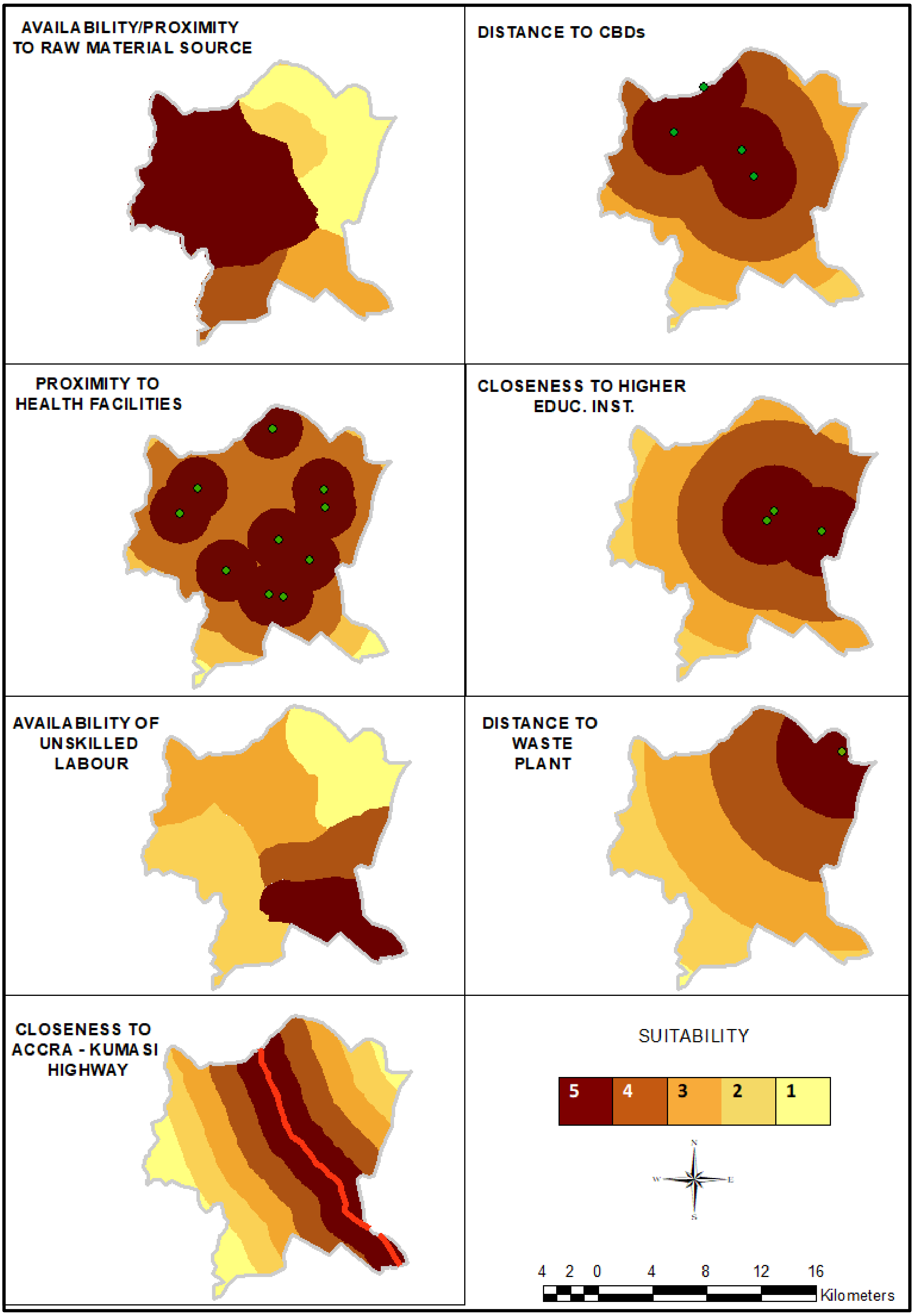
Part 2

Please tick the appropriate boxes	Yes	No
I have read and understood the study information dated DD/MM/YYYY, or it has been read to me. I have been able to ask questions about this study and my questions have been answered to my satisfaction.	☐	☐
I consent to voluntarily be a participant in this study. I also understand that taking part in the study involves giving answers to interview questions.	☐	☐
Use of the information in the study I understand that the information I provide is for academic purposes.	☐	☐
I understand that my personal information and identity will not be used in any academic document.	☐	☐
Future use and reuse of the information by others I give permission for the answers that I provide in the interview to be archived in the *University of Twente (ITC) Database.* The data can be used for future academic research and learning.	☐	☐

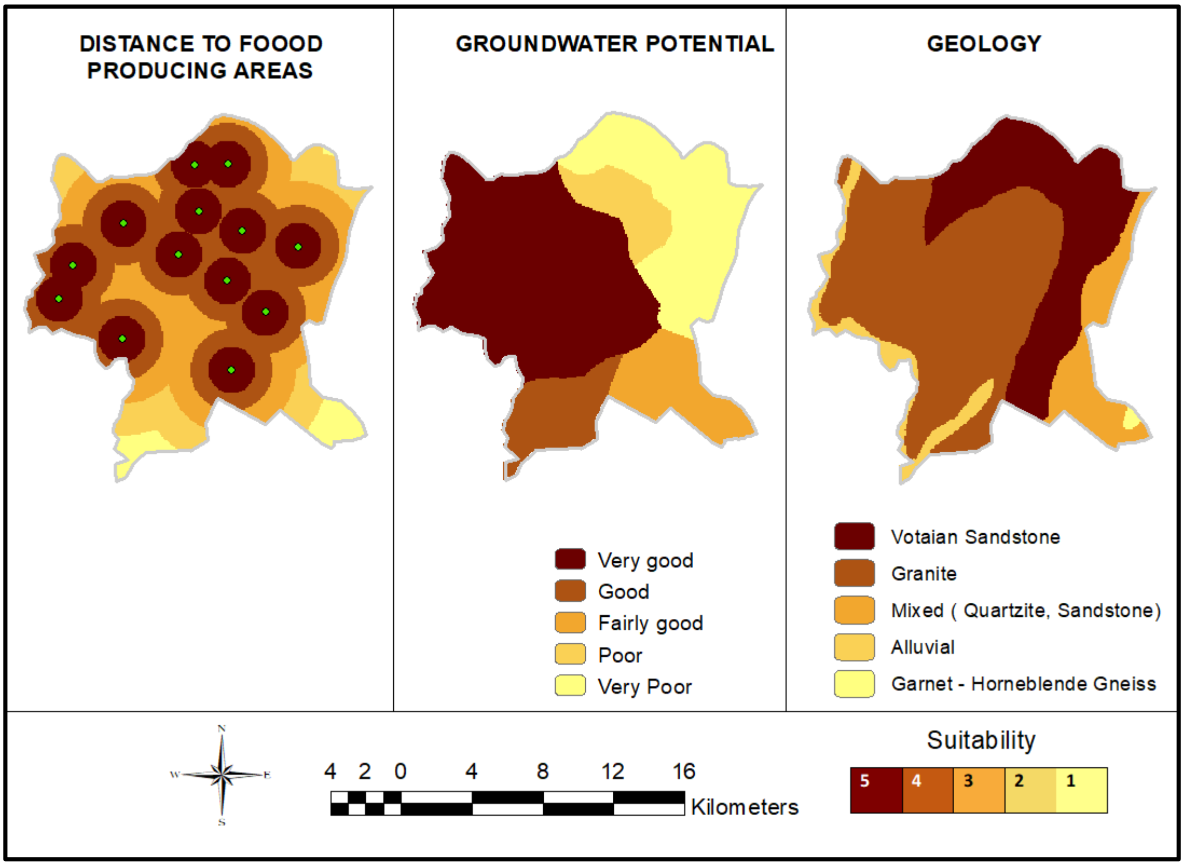
Signatures

………………………………	………...………………..….	.……………………………..
Name of participant	Signature	Date
………………………………	……………………………	.……..……………………..
Name of Researcher	Signature	Date

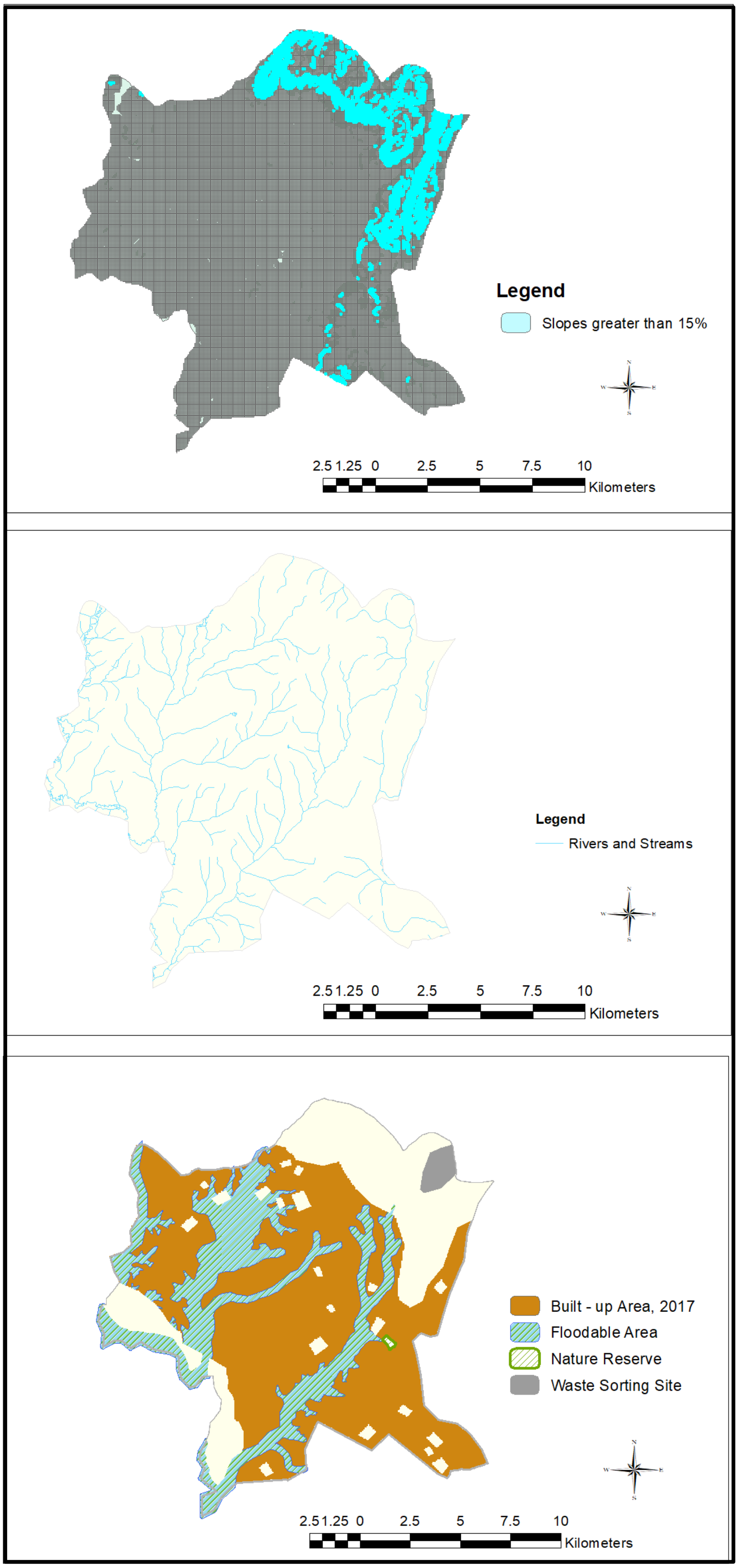
Appendix 12: Independent variables



Appendix 13: Composition of raw material source layer



Appendix 14: Constraints and land use assumptions



Appendix 15: Reliability of scores

A.

Reliability Statistics: Economic factors responses

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.989	.990	32

B.

Reliability Statistics: Socio-economic factors responses

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.983	.983	32

C.

Reliability Statistics: Telecommunication and transportation factors responses

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.981	.982	32