KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

INSTITUTE OF DISTANCE LEARNING

OPTIMAL LOCATION CHOICE FOR EVENTS

(CASE STUDY: TEACHER EDUCATION DIVISION OF GHANA)

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A THESIS SUBMITTED TO THE DEPARTMENT OF MATHEMATICS IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF MASTER OF SCIENCE IN INDUSTRIAL MATHEMATICS

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CERTIFICATION

I herein certify that this work was carried out solely by ODEI, ADOLF (PG4069010) in the Department of Mathematics, Institute of Distance Learning in partial fulfilment of the requirements for the award of Master of Science in Industrial Mathematics.

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DECLARATION

I hereby declare that this submission is my own work towards the M. Sc. and that to the best of my knowledge it contains no material previously published by another person nor material which has been accepted for the award of any degree of the University except due acknowledgement has been made in the text.

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DEDICATIION

To the Glory of God

I dedicated this Thesis to my dear wife; Beatrice Brago Odei, my children; Odei Nana Serwaa Nyarko, Odei Serwaa – Ampaafo Yaa and Odei-Akowah – Diamono Cornelius, my mother; Obaapanin Felicia Yaa Serwaa, and all my colleagues for their moral and mutual support.

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ABSTRACT

Employees of many institutions and organizations frequently travel to professional – development conferences and training events. Conference planners often decide on event locations arbitrarily with little regard for travel cost. In this thesis, a mathematical model for the determination of cost – effective event site for Teacher Education Division of Ghana (TEDG) is constructed. It involves using the Floyd's Algorithm for solving the all pairs shortest-path-network problem and conference site selection model. The study revealed that an amount of GH¢570,015.00 and GH¢917,280.00 would be spent in the cost – effective site and most expensive site respectively. It also established that meeting at Wa, the cost – effective location could save TEDG an amount of GH¢347,265.00 on every training event. Among the recommendations offered was that since the model minimizes event cost, thereby increasing the savings, TEDG and other institutions event planners could adapt the model in deciding where to host an event.

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LIST OF ABBREVIATIONS

AC: Accra

BO: Bolgatanga

CC: Cape Coast

CVBs: Convention and Visitors Bureaux

EOQ: Economics Order

GHc: Ghana Cedis

GPRTU: Ghana Private Road Transport Union

KD: Koforidua

KI: Kumasi

LP: Linear Programming

M & IE: Meals and Incidental Expenses

MCDM: Multi – Criteria Division Making

MP: Mathematical Programming

OR: Operations Research

PCMA: Professional Convection Management Association

SU: Sunyuni

TA: Takoradi

TE: Tamale

TEDG: Teacher Education Division of Ghana

TIA: Travel Industry Association

CHAPTER 1

INTRODUCTION

1.0 BACKGROUND TO THE STUDY

The meetings (conferences) and conventions industry has become a very important part of the global tourism and hospitality sector. For towns and cities, particularly, conferences or conventions have become one of their principal target markets. For this reason, Convention and Visitor Bureaux typically focus a great deal of their time and effort wooing large institutions and associations that are looking for an attractive host of convention site.

To select a convention site, a variety of influential decision variables should be simultaneously assimilated in the process of decision making and this has made the subject potentially complex (Clark and McCleary, 1995; Amiri et al, 2008) and has attracted the attention of researchers. The majority of studies focused on convention and meeting planner related studies (Bonn & Boyd, 1992; Bonn, Brand, & Ohlin, 1994; Oppermann, 1996; Go & Zhang, 1997). Oppermann and Chon (1997) proposed two models in the areas of associations' *location choice* and participation decision-making variables of the attendees. Their first model addresses the interactions and interrelationships among associations, *host locations,* and attendees. In the second model the influencing variables are then categorized into personal / business factors, association / conference factors, locations factors, and intervening opportunities. As a result, their paper suggested a structural model of association convention participation that integrates the three main factors which are *host location*, association meeting and potential attendees and discusses their relationships.

Moreover, the recurrent reason for employee travel is to attend professional conferences or development training. Employee training and development is one of the key considerations during decision making by administrators in the twenty-first century.

Training involves an expert, working with learners to transfer to them certain areas of knowledge or skills to improve themselves in their current jobs. Development is a broad, ongoing multi-faceted set of activities (training activities among them) to bring someone or an organization up to another threshold of performance, often to perform some job or new role in the future (Managementhelp, 2006).

Employee training and development initiatives transform organizations with providing extra skills to employees to not only increase safety and productivity but training leads to higher job satisfaction, which shows up in better corporate performance.

Valuable training also includes situational training that provides personnel the skill sets that allow them to make timely, knowledgeable decisions that benefit both the customer and the company (Managementhelp, 2006).

Communications, computer skills, customer service, diversity training which usually includes explanation about how people have different perspectives and views, and includes techniques to value diversity, ethics, human relations, quality initiatives, safety, sexual harassment are some typical topics of employee training and development (Managementhelp, 2**006).**

Most managers recognize that continuous learning in today's marketplace is essential. They know they are in the "Information Age." They want a competitive high performance organization but they just don't know where to begin. According to

Unixl (2007), there are five key reasons why managers don't go in for employee training and development**;** They don't have the time, they don't know how to do it, they don't know what material to use, they don't know how to follow it up, and they don't know how to get people to apply the new skills learned again. Zhang, Leung and Qu (2007) proposed that 'total cost factor' is one of the main factors that affect training, conference or convention organization. They discussed that as opportunity costs in using money and time are different, it is logical to further subdivide the total cost factors into 'total time cost' and 'total monetary cost' of the trip.

The total monetary cost, the travel costs (per diem, meals and incidental expenses, meeting – facility fees) associated with training constitutes a substantial portion of the institution annual budget. But Conference planners often decide on event locations arbitrarily with little regard for travel cost. In other words, a decision maker had discretion in deciding where to host the event. Since travel costs vary with the location, different training, conference, or meeting sites can produce radical differences in total temporary duty costs for a training event (Harold et al, 2001).

The best way to improve professional conferences and development training is to use Operations Research techniques such as network models in decision making. This will provide the decision makers the right methodology to evaluate relevant travel costs and to select least expensive conference site. An integrated approach to the problem of site selection for institutions and associations will not only minimize their travel expenses but also enable them to remain within the annual budget constraints.

1.1 PROBLEM STATEMENT

The Teacher Education Division of Ghana (TEDG), headquartered at Accra, has staff stationed in offices and institutions throughout the country especially in the regional capital with recurring employee – development training requirement. The training costs associated with this training constitute a substantial portion of the budget of the Teacher Education Division of Ghana.

Mission requirement often require the organizations' staff to travel to diverse destinations on special assignments. Such assignments as in – service training for teachers and administrators of schools, seminars on new educational reforms, education campaign, or availability of travel dates for key personnel may limit travel choices to a specific site. However, in the case of the TEDG, training and conference planners select the event location arbitrarily with little regard for total cost involved. In other words, decision makers had discretion in deciding where to host the event. Since travel costs vary with the location, different training, conference, or meeting sites can produce radical differences in total costs for training events. The problem, therefore, is to select the most cost – effective training location among many possible choices so that TEDG minimizes travel expenses and remain within annual travel – budget constraints.

1.2 OBJECTIVE OF THE STUDY

Generally, the objective of this thesis is to construct a mathematical model for the determination of cost-effective location choice for events for the Teacher Education Division of Ghana.

1.3 SPECIFIC OBJECTIVES

The study specifically seeks to:

i. Determine the cheapest travel cost across all regional capital pairs using the Floyd's Shortest – Route algorithm.

ii. Base on that determine the least expensive meeting, conference and training event site in Ghana.

iii. Offer recommendations to the institutions and other stakeholders on the application of the model in decision making.

1.4 METHODOLOGY

The data for this study will consist of secondary data collected from the study area in Ghana. The current transportation fares (travel cost) and incidental expenses will be collected from the national headquarters of GPRTU and the Teacher Education Division – Accra respectively. The maximum lodging cost per night and meals cost for hotels in the various regions will also be obtained from Ghana Tourism Authority National Headquarters at Accra. A Matlab code will be written for Floyd's shortest-route algorithm and use it to determine the cheapest travel cost among all town pairs. The per diem rates which comprise lodging, meals and incidental expenses (Harold et al, 2001) are then determined. The data, that is, cheapest travel cost, T_{ij} and per diem rates, P_j will be used as input data into the proposed location choice model formulated. This will then be analysed using Matlab codes.

1.5 SIGNIFICANCE OF THE STUDY

The finding of the most cost-effective training location will be the information for planning, improving training services provided and the ultimate utilization of limited resources.

The finding will be the fundamental information to help guide the annual budget planning, controlling and evaluation.

The finding will be used as the information to control the expenses when realizing the waste resources.

The model can help estimate the future expenses to be incurred and control the cost more effectively and efficiently.

1.6 SCOPE OF THE STUDY

The study will be limited to the ten regional capitals of Ghana with Teacher Education Division in Ghana. The restriction of the study to the regional capitals may not portray results that are representation of a specific district in the various regions. Owing to the limited time and financial constraints, this study has been restricted to just the regional capitals in Ghana.

1.7 ORGANIZATION OF THE THESIS

This thesis consists of five chapters: including this chapter. Chapter Two is on Literature Review which takes stock of what other people have written on the topic in terms of theories or concepts, scientific research studies and the overall goal of classifying how the present study intends to address the gap, silence or weakness in the existing literature. Chapter Three explains the methodology that is being used for the study. The findings and discussions will be presented in Chapter Four. Lastly, Chapter Five will discuss on the conclusion and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 The Meeting and Convention Industry

The meeting and convention industry is one of the fastest growing sectors in the hospitality and tourism industry in the world. According to the Travel Industry Association of America (TIA, 2009), the travel and hospitality industry accounted for $772.9 billion spent within the United States by international and domestic travelers. The meeting and convention industry is a main player in the tourism industry and accounts for $103 billion, which is 13.3% of the total amount spent in the tourism industry (Barley, 2008; TIA, 2009). The Meeting Market Report (2008) states that the number of meetings held nationally has increased; corporate meetings by 6%, association meeting by 8% and conventions by 8%. The largest meeting and convention market in the world – the US – is estimated by the Professional Convention Management Association (PCMA) to account for more than US$80 billion in annual spending (Crouch Louviere, 2004). The PCMA also estimates that two – thirds of that spending is attributable to association – sponsored events (PCMA, 2002). Crouch and Ritchie (1998), in comparison, concluded that 'about 70 to 75 percent of industry spending [in North America] is on association – organized events'. Other estimates include £6 billion annually for the United Kingdom (Cotterell, 1994), C4 to 5 billion in Canada (Kingston, 1995) and A2.4 to 3 billion in Australia (Australian Commonwealth Department of Tourism, 1995). Apart from the obvious economic benefits that arise from the hosting of meeting and conventions, destinations have recognized several other benefits including the expansion of international trade and cultural ties, the enhancement of civic pride, and political motivations (Crouch and Louviere, 2004).

It is easy to understand, therefore, why destinations today covet this market segment. Yet, although trade and professional magazines on the meetings and conventions industry frequently publish 'checklists' of the various factors that professional meetings managers or conference organizers use to assess the suitability and attractiveness of alternative potential host sites, there has been surprisingly little systematic, empirical, r academic study (Clark and McClery, 1995; French, 1992; Oppermann, 1994, Zelinsky, 1994). Abbey and Link (1994) comment that:

"Despite the importance of this market segment to both individual properties and host cities, little research has been undertaken on its structure and workings. This lack of information is a handicap to operating managers and tourism officials for responsible marketing and promoting their products and services. While this lack of research is, on the other hand, a hindrance to the convention and meeting industry, it presents a promising opportunity for researchers. Convention and meeting research is, for the most parts, an untapped market for researchers. Considerable work is needed to increase understanding of this important segment of the tourism industry".

As indicated by Abbey and Link, there has been a little amount of research completed related to the meetings and convention industry. Many of the previous studies have focused on convention site selection, (Crouch and Louviere, 2004a; 2004b; Crouch and Ritchie, 1998; Lee and, 2005; Hu and Hiemstra, 1996), satisfaction with convention and site selection (Oh, Kim and Hong, 2009; Rutherford and Umbreit, 1993; Shaw, Lewis, and Khoreey, 1991), comparison and characteristics of event planners (Hye-Rin, Mckercher, and Kim, 2009; Weber, 2001; Jago and Deery, 2005; Toh, Peterson, and Foster, 2007), industry's adaptation of technology (Kim, 2009; Kim and Park, 2009; Wang, Hwang, and Fessenmaier, 2006; Davidsonm Alford, and Seaton, 2002), and the event planner's information search behavior (Getz, 2008; Amanda, 2009). Despite a number of studies related to the meetings and convention industry, there has been a paucity of research endeavours in regard to cost effective conference site selection model.

2.2 VENUE CLASSIFICATIONS

With increasing number of destinations introducing conference venues, the conference sector is one of the fastest growing tourism segments (Julie, 2005; Oppermann & Chon, 1997). The obvious appeal of the high-speed, relatively pride – resistant and year-round nature of the business has enticed many destination into targeting this sector as part of their wider economic strategy (Leask & Spiller, 2002). Barriers to entry within the conference sector are perceived to be low. Many organizations with the necessary facilities (room, table, chair and basic equipment) can provide an area for conference activity, and thus enter the conference market. Conference business to those outside the sector is considered very attractive, as it is perceived as being straightforward use of otherwise empty space. Competition has increased among towns and cities to win lucrative conference business (Leask &Spillier, 2002).

Although there is a lack of coherent ad accurate data within the conference sector (Ladkin & Spiller, 2000), estimates have been made as to the size of this sector. Roger (2003) estimated that there are approximately 5000 venues within the British Isles; however, less than a fifth of these would generate more than 40% to 50% of their annual turnover from conferences. This suggests that for majority of venues, conferences are not their primary source of revenue. Other estimates have also been made about the size of the conference sector. Robinson and Callan (2005) estimate the number of UK conference venues to be 3888, which together host an estimated 283,824 conferences annually and attract an estimated 9,176,976 delegates per annum.

Although estimates regarding the number of venues within the conference sector differ, authors agree that the sector is composed of many differing venue classifications; thus the sector should not be considered homogeneous (McCabe et al, 2000; Montgomery & Strick, 1995; Pearce, 1989; Roger, 2003; Weirich, 1992). With regard to venues, many purpose-build comference venues were developed through the 1980s as part of the central government's plan of economic regeneration, which aimed to create jobs and boost local economies (Spiller & Ladkin, 2000). In today's market place the majority of conference suppliers are not solely dedicated conference facilities, with most venues operating as part of the revenue mix within a larger business, for example hotels (Leask & Spiller, 2002). Hotels have supplied an increasing share of the demand for conference venues. By 1990 hotels led the market in terms of supplying conference facilities, accounting for 77% of all conference venues and 68% of all delegates' nights (Travel Industry Monitor, 1991).

The use of other venue types, such as sports stadia, museums and castles (Leask, 2003; Leask & Digance, 2001; Leask & Hood, 2000; Leask & Spiller, 2002) along with educational establishment facilities (Davidson & Cope, 2003; Paine, 1993), is increasing. Organizations such as museums and educational establishments have faced decreasing central budgets, resulting in a need to broaden their business mix and generate external revenue (Julie, 2005; Leask & Spiller, 2002).

Today four distinct classifications may be used for the venue sector:

- Purpose-built conference venues
- Hotels with conference facilities
- Educational establishments with conference facilities
- Visitor attractions with conference venues.

With the increase in the number and range of conference venues come both increased competition and the use of quality to differentiate between conference venues (Robinson & Callan, 2003). There is large-scale customer demand for quality products and service within the tourism industry (Lam & Zhang, 1999).

2.3. SERVICE QUALITY

'The attractiveness of convention tourism has spurred destinations to proactively pursue the conference market (Crouch & Weber, 2002, p. 57). This has resulted in an escalation in the building or expansion of conference centres and facilities, not only within particular country but worldwide. The intensity of this competition naturally gives rise to interest in the range of factors that underlie the choice of conference venues (Crouch & Louviere, 2004). Venue selection is encompassed within the theories of service quality, which were a significant preoccupation of the hospitality industry throughout the 1980s and 1990s (Johns, 1996; Julie, 2005).

Quality within a service environment can be examined in a number of differing ways (Hope & Muhlemann, 1998), as quality and service quality have received substantial theoretical attention for decades (Skalpe & Sandvik, 2002). One of the best known theoretical approaches can be seen in the work of Parasuraman, Zeithaml and Berry (1985), who formulated the 'gap model'. This model put forward the view that there may be four 'gaps' between expected service and the perceived quality of the service received that could lead to the reduction in service quality. These gaps are:

- Between expected service and management's perception of customer expectations.
- Between management perceptions of customer expectations and service quality specifications.
- Between service quality specifications and service delivery
- Between service delivery and external communications to customers. (cited in Hope & Muhlemann, 1998).

Based on these gaps Parasuraman et al (1991) also forwarded five generic dimensions, namely tangibles, reliability, responsiveness, assurance and empathy. These became the basis of a multi-item questionnaire entitled SERVQUAL, which has been widely used to measure perceptions of service quality (Coyle & Dale, 1993; Fick & Ritchie, 1991; Knutsson, 1995; Martin, 1995; Stevens et al, 1995). Not only have theories to define service quality been put forward, but the expected relationships between quality and variables such as costs, sales growth, productivity, return on investment, prices, customer satisfaction and loyalty have been the foundation for the development of theories in current research (Andersen & Fornell, 2000).

Such research has identified that approximately 70% of identifiable factors explaining why customers move from one service provider to another relate to dissatisfaction with the service experience (Whiteley, 1991). Moreover, estimates show that the cost of poor quality to the service sector is approximately 30% of gross sales (Tally, 1991).

Service quality can therefore be defined as a measure of how well the service meets customer's expectations (Gronroos, 1984; Lewis & Booms, 1983). It is also seen as confirming the requirements of customers, to meet their expectations and to satisfy them (Deming, 1986). The term 'expectations' is used within these definitions of service quality. Expectations are seen as the reference points against which the performance of customer-satisfying behaviours by the service provider, including that of a conference venue provider, are judged by the service consumer (Parasuraman et al, 1991), for any business, including conference venues, that strives for longevity and an expansion of their market share. The fundamental principle in achieving service quality is to manage those customer-satisfying behaviours that are both specific and measurable (McCleary & Weaver, 1982; Peters & Waterman, 1982).

With reference to the conference sector, one aspect intrinsically linked to service quality is that of customer satisfaction (Zeithaml & Bitner, 1996). The quality of the product, including the conference product, is reflected in the level of customer satisfaction, and thus such customer satisfaction can be used as an indicator of quality (Troye et al, 1995). Customer satisfaction is achieved through the provision of quality product, and a quality product is perceived to be in existence when the supplier meets the custmers' expectations. This view point supports the findings of other authors, namely Shetty and Ross (1985), King (1987) and Culp et al (1993), who state that to understand the performance of service quality, firms must first examine whether the service provided will meet customers' requirements and expectations. Therefore firms should focus on the following issues:

- Knowing the customers' requirements, especially those quality attributes considered important by customers (Headly & Choi, 1992).

- Fulfilling customers' requirements on quality attributes as much as possible, especially those that are considered important by customers.
- Investigating where the service performed is satisfactory to customers and where it is not.
- Taking appropriate action to correct or improve service in cases where quality is poor (cited Yang, 2003).

It is apparent that awareness of customers' expectations, and the measurement of service quality, is fundamental issues to any organization (Headley & Choi, 1992). The above four issues are key to the recognition of customers' expectations within the conference sector. Such expectations within the venue selection process stem from selecting the most appropriate venue for the delegate's needs. Thus, an understanding of the venue's quality attributes demanded by the conference organizer, within their venue site selection criteria, is essential if conference service providers are to achieve and maintain service quality.

2.4. CONVENTION/CONFERENCE SITE SELECTION CRITERIA

To select a cost – effective convention site, a variety of influential decision variable should be simultaneously assimilated in the process of decision making and this has made the subject potentially complex (Amiri, et al, 2008; Clark and McCleary, 1995). According to the extensive review of the site selection studies in the literature, a five – step conceptual model of the site selection process was proposed by Crouch and Ritchie (1998) and they discovered several categories of site selection factors, coupled with various antecedent conditions and competing sites influences. Convention preplanning, site selection analysis and recommendations, site selection decision, convention held and post convention evaluation are the five steps that have to be taken in convention site selection process. The five principal steps according to Crouch and Ritchie (1998), Amiri, et al (2008), and Crouch and Louviere (2004) are:

Step 1 (Preplanning) occurs before alternative host sites are identified and analysed. It includes issues such as setting convention objectives, formulating a preliminary budget, establishing possible dates for the convention, etc. alternative sites are then evaluated in step 2. This might involve actual site inspections, receiving bids from competing host sites, liaison with local association chapters and Convention and Visitor Bureaux (CVBs), collecting information about each site on key selection criteria such as size of meeting facilities, air access, range of accommodation, the attractiveness of the site environment, etc. step 2 ends with a recommendation from the association's meetings manager or planner, or a committee assigned the task of investigating alternative sites. The final decision (step 3) from among the alternatives is usually made separately from the site analysis and recommendations stage (step 2) since this becomes a decision usually for the board or executive of the association or institution rather than the meeting planner or site committee. The executive may opt for a site that was not the first preference or recommendation arising from step 2. At this stage, political issues can often intervene to shape the final decision.

After the convention or conference is held (step 4), either implicitly or explicitly, the convention and site is evaluated (step 5) to see what lessons need to be learnt before the next convention is planned.

The site selection decisions are influenced by several factors and can be broadly separated into site – specific and association factors (Weber and Chon, 2002). The majority of previous studies have endeavoured to recognize many of this topic's selection contributive factors (for example, Oppermann, 1996; Go and Zang, 1997;

Crouch and Ritchie, 1998; Chacko and Fenich, 2000; Kim and Kim, 2003; Crouch and Louviere, 2004; Amiri et al, 2008).

Go and Zang (1997) classified the convention site selection criteria into two primary categories: first, the convention destination site's environment addressing a city's capacity to host an international convention and second the meeting facilities. The proposed conceptual model of convention site selection by Crouch and Ritchie (1998) investigates eight primary factors together with several aspects, culminating in the recognition of 36 attributes that affect the choice of a convention site.

Table 2.1: Convention Site Selection Factors

Category	Dimension
Accessibility	Cost-the monetary expense of transportation and access
	Time-the duration/distance of travel involved and the opportunity cost of that time
	Frequency-the frequency of connections to the site
	Convenience-the scheduling convenience of the
Connections	
	Barriers-the extent of any travel formalities that inhibit travel such as visas, customs, etc.
Local support	Local chapter-the extent of assistance and backing offered by the local chapter of the association
	CVB/convention centre-the extent of planning, logistical, and promotional support offered
	Subsidies-the extent to which the destination offers to defray costs through rebates and subsidies

Extra-conference Opportunities	Entertainment-restaurants, bars, theatres, nightclubs, etc Shopping-malls, major department stores, low prices, etc. Sightseeing-architecture, museums, monuments, attractions, parks, historical sites, local tours, etc. Recreation-sports and activities either as spectator or participant Professional opportunities - visiting local clients, negotiations, business deals, selling, making contacts, etc.
Accommodation Facilities	Capacity-the number of rooms available and whether more than a single hotel is required Cost-the cost of suitable accommodation at the site Service-the perception of the standards of service Security-the extent to which the hotels provide a safe and secure environment Availability - are the facilities available?
Meeting Facilities	Capacity-ability of site to provide suitable sized facilities Layout-suitability of the facility layout and floor plan Cost-the cost of the meeting space required Ambience-the ability of the facility to create an appropriate atmosphere and environment Service-the perception of the standards of service Security-the extent to which the facility provides a safe and secure meeting space Availability - are the facilities available when required?
Information	Experience-has the site performed satisfactorily in the past? Reputation-what is the reputation of the destination among other meeting planners Marketing-the effectiveness of the destination's marketing activities
Site	Climate-the desirability of the destination's climate Setting-the attractiveness of the destination's surroundings

Environment	Infrastructure-the suitability and standard of local infrastructure Hospitality - the extent to which the host organizations and community excel in welcoming visitors. Risks-the possibility of strikes, natural disasters, boycotts, and other possible adverse events Profitability-the extent to which the site would produce a profit (loss) for the convention
Other Criteria	Association promotion-would the site add credibility to the association and build membership? Novelty - the extent to which the destination represents a novel location for the Association's next convention.

(From Crouch & Louviere, 2004; Crouch & Ritchie, 1998)

Figure 2.2 also shows that each factor was subdivided along several dimensions, for example, accessibility was divided by cost, time, frequency, convenience and barriers. In total, 36 conference destinations attributes were identified, which the authors hypothesized as governed conference organizers through a three-stage process: (1) convention preplanning; (2) site selection analysis; and (3) site selection decisions. Crouch and Ritchie (1998) identified factors including:

- Meeting facilities, including standards of service
- Accessibility, including barriers, convenience, frequency, time and cost
- Accommodation, including capacity, cost and availability.

With reference to the summary review of Crouch and Louviere (2004) the ranked convention site attributes in terms of their order of importance (from most to least important) to site selection, (Figure 2.3) are as follows:

- Cost of the convention/conference venue,
- Food quality,
- Suitability of the plenary room,
- Mix of on-site versus off-site accommodation,

- Proximity of the site to convention participants,
- Suitability of the exhibition space,
- Suitability of the break-rooms,
- Accommodation room rates,
- Attractiveness of the physical setting,
- Extent of available entertainment , shopping, sightseeing, recreation, and organized tours,
- Availability of unrestricted economy airfares to the site,
- Attractiveness of the social/cultural setting, and
- Availability of audio-visual systems and facilities.

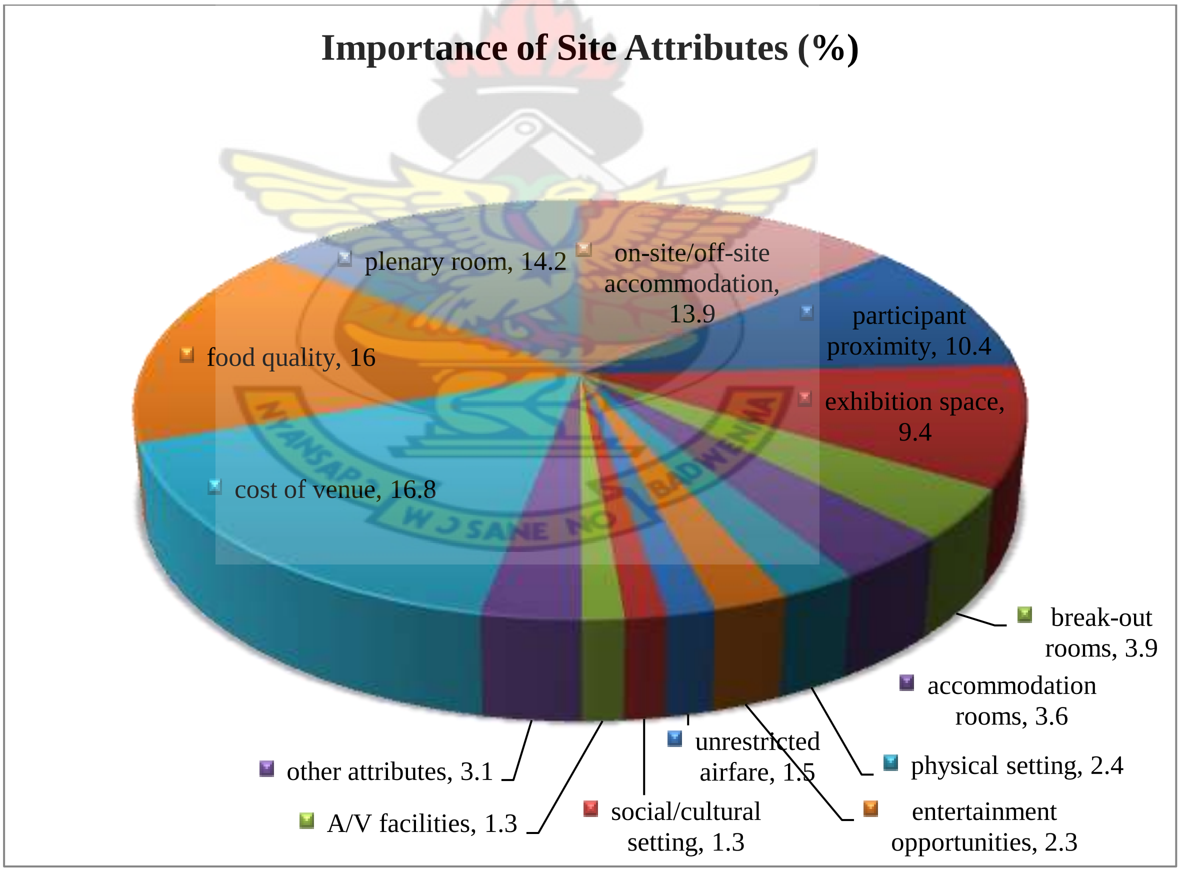


Figure 2.1: Importance of Site Attributes

(From Crouch & Louviere, 2004)

Moreover with reference to the summary review of Kim and Kim (2003) the main criteria for convention site selection can be characterized as follows: meeting room facilities, service quality, restaurants, transportation and attractiveness of the destination are the major attributes. Several contributive and worthwhile studies have been made regarding site attributes which among them are the study of Chacko and Fenich (2000) and Crouch and Louviere (2004) are of vital importance (Amiri et al , 2008). A regression analysis was performed by Chacko and Fenich (2000) to explore the significance of US convention destination attributes. Crouch and Louviere (2004) applied the logistic choice model using designed experimental data to explore the determinants of convention selection. Amiri, et al, (2008) presented a hybrid Multi – Criteria Decision Making (MCDM) model to solve convention site selection.

2.5 SITE SELECTION MODEL

Although there are a significant number of quantitative research efforts regarding site selection in domestically oriented applications (Francis et al 1983; Thizy et al 1985; Verter and Dincer, 1995), the number of papers that investigate the site selection models are comparably few. These studies include mixed-integer programming models, mean variance approaches that consider a degree of uncertainty and also multiple criteria techniques such as goal programming. The mixed-integer programming models include the work of Haug, Cohen and Lee (Haug, 1985 & 1992; Cohen and Lee, 1989). In the Haug paper a multi-period mixed-integer model is developed with a single objective function based on profits (Haug, 1985). The profit maximization takes into consideration numerous country specific factors. The Haug paper studies the problems that high technology firms encounter when they investigate the expansion or transfer of production to a foreign country (Haug, 1992). Optimization is carried out through the cumulative average costs. Cohen and Lee (1989) presented a mixed-integer nonlinear model which investigates decisions that involves establishing a global manufacturing and distribution network. The mean variance approach was used in the studies by Hanink (1989), Hodder and jucker

(1985a), and Hodder and Dincer (1986). Hanink (1985) proposed a 0-1 quadratic model without constraints, which employs the mean variance approach in an effort to choose the optimal "portfolio" of sites by maximizing the expected return of investment. In their model, Hodder and Jucker (1985a) introduced variability of prices and exchange rates. Their mixed, 0-1 quadratic, uncapacitated model was solved by decomposition methods (Jucker and Carlson, 1976; Hodder and Jucker, 1985b). Hodder and Dincer (1986) provided a more elaborate formulation that included simultaneous location and financing decisions. Finally, Schniederjans and Hoffman (1992) and Min and Melachrinoudis (1996) used the goal programming technique to handle conflicting goals in the international site selection process. Schniedderjans and Hoffman (1992) presented a decision process based on a deterministic 0-1 goal programming model that handles the problem of the acquisition of a foreign firm. Min and Melachrinoudis (1996) formulated a goal programming model which resulted in a mixed-integer nonlinear program. The innovative attributes of this model are (a) the study of the site selection problem under the assumption of alternative entry modes, and (b) the introduction of uncertainty through stochastic goals. A study by Hajidimitriou and Georgiou (1997) provides a goal programming model which investigates the site selection problem for firms contemplating expansion in the Balkan region. The particular model includes region-specific factors which prevail in this area. A recent study by Crouch and Jordan (2003) provides a model of Australian convention sites which examines the buyer behavior of professional convention organizers with respect to the selection of a host city. Amiri et al (2008) presented a hybrid Multi-Criteria Decision Making model to solve convention site selection. In their paper, they used interval comparison matrix which is inspired by analytical hierarchy process to compare the criteria against each other. Finally, a study by Harold et al (2001) provides cost-effective training site selection model using spanning tree algorithm.

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

This part of the project reviews the method, mathematical tools and algorithm that will help us to solve the proposed site selection model.

3.1 MATHEMATICAL MODELLING

A Mathematical model involves creating an abstract system of equations which describes and helps reasoning about a real life system. It is a mathematical representation of a process, device or concept by means of a number of variables which are defined to represent the inputs, outputs, and internal states of the device or process, and a set of equations and inequalities describing the interaction of these variables (http://www.answers.com/topic/mathematical-model; 05/11/11, 8:40 PM). It is a mathematical theory or system together with its axioms. The mathematical model serves the purpose of finding an optimal solution to a planning or decision problem, answer a variety of what-if questions and establish understandings of the relationships among the input data to extrapolate past data to derive meaning.

Mathematical models include techniques such as Linear Programming (LP), Computer Simulation, Decision Theory, Regression Analysis, Economic Order Quantity (EOQ), and Break-Even Analysis (http://www.math.ualbarta.cal~devies/er2001/slides.pdf; 05/11/11, 8:00 AM).

3.2.0 MATHEMATICAL PROGRAMMING

Mathematical Programming (MP) is the use of mathematical models; particularly optimizing models, to assist in taking decisions. It is one of a number of Operations Research (OR) techniques.

OPTIMIZATION

Optimization is the process by which the best solution is selected from among several possible solutions. Most engineering problems, including those associated with the analysis, design, construction, operation, and maintenance, involve decision making. Usually, there will be a criterion that is to be minimized or maximized while satisfying several social, economical, physical, and technological constraints. There will be a number of parameters that can be varied in the decision making process. As the number of parameters increases, it becomes necessary to use systematic procedures for solving the decision making problems.

Definition of an optimization problem

The formulation of an optimization problem involves the development of a mathematical model for the physical or engineering problem. In practice, several assumptions have to be made to develop a reasonably simple mathematical model that can predict the behavior of the system fairly accurately. The results of optimization will be different with different mathematical model of the same physical system. Hence, it is necessary to have a good mathematical model of the system, so that the results of optimization can be used to improve the performance of the system.

A general optimization problem can be stated in mathematical form as

$$Find\ X = \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \\ . \\ . \\ . \\ x_n \end{Bmatrix}$$

That maximizes $f(x)$

Subject to

$$gj(x) \leq 0; j = 1,2, \ldots, m;$$

And

$$hk(x) = 1,2, \ldots, p;$$

where xi (i = 1, 2, …, n) are the decision variables x is the vector of decision variables,

$f(x)$ is the merit, or criterion, or objective function, $gj(x)$ is the jth inequality constraint function that is required to be less than or equal to zero, $h_k(x)$ is the kth equality constraint function that is required to be equal to zero, n is the number of decision variables, m is the number of inequality constraints, and p is the number of equality constraints.

Terminology

Decision variables

The formulation of an optimization problem begins with the identification of a set of variables that can be varied to change the performance of the system. These are called the decision or design variables, and their values are freely controlled by the decision maker. A set of numerical values, one for each decision variables, constitutes a solution (acceptable or unacceptable) to the optimization problem.

Objective function

When different solutions are obtained by changing the decision variables, a criterion is needed to judge whether one solution is better than another. This criterion, when expressed in terms of the decision variables, is called the objective, merit, or cost function. The interest of the decision maker is to select suitable values for the decision variables so as to minimize or maximize the objective function.

Inequality constraints

In any decision making problem, there will be limitations or conditions imposed on the decision variables that may include economical, physical, or functional limitations. In many cases, the validity of the mathematical model used for the physical system imposes restrictions on the decision variables. These limitations, or conditions, when expressed in terms of the decision variables, are known as constraint functions. When the constraint function is restricted to have only negative or zero values, the resulting constraint is known as the inequality constraint. On the other hand, if the constraint function is required to be equal to zero, the resulting constraint is called the equality constraint

Feasible solution

Any set of decision variables that satisfy the constraints of the problem (both inequality and equality constraints) is known as a feasible solution. A feasible solution is an acceptable solution to the decision maker in terms of the constraints, but may or may not minimize the objective function.

Optimum solution

A feasible solution that minimizes the objective function is known as the optimum solution.

<u>TYPES OF OPTIMIZATION PROBLEMS</u>

Optimization problems are also known as mathematical programming problems.

In some practical situations, the constraints may be absent, and the problem reduces to

$$Find\ X = \begin{Bmatrix} x1 \\ x2 \\ x3 \\ . \\ . \\ . \\ xn \end{Bmatrix}$$

That minimizes $f(x)$

The problem is known as a constrained optimization problem. Depending on the nature of functions, Optimization problems can be classified as linear and nonlinear programming problems. A linear programming problem is one in which all the functions involved, namely, $f(x), g_j(x) and\ h_k(x)$ are linear in terms of the design variables. A nonlinear programming problem is one in which at least one of the functions is nonlinear in terms of the decision variables.

Specifically, the least-cost training or conference location uses the objective function as follows:

$$\text{Minimize } \sum_j^N X_j \times \left(\sum_i^N M_i \times \left(T_{ij} + D \times P_j \right) \right)$$

$$\text{Subject to } \sum_j^N X_j \geq 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots * $$

Where

$i, j =$ towns,

$D =$ duration of event (days),

$M_i =$ number of participants from town i,

$P_j =$ per diem rate at town j,

$T_{ij} =$ the cost of travel to town j from town i,

$X_j = 1$ if conference in town j, 0 otherwise.

3.2.1 NETWORK MODELS

One of the most prominent OR techniques is network programming (in which the problem can be modeled as a network). Network models are applicable to an enormous variety of decision problems that can be modeled as networks optimization problems and solved efficiently and effectively. Some of these decision problems are really physical problems such as transportation or flow of commodities. However, many network problems are more of an abstract representation of processes or activities such as the critical path activity network in project management.

The family of network optimization problems includes the following prototype models: shortest path, assignment, critical path, max flow, transportation, and min cost flow problems. These problems are easily stated by using a network of arcs, and nodes (http://home.ubalt.edu/ntsbarsh/opre640a/partIII.htm; 07/12/11, 6:20 PM).

3.2.2 SHORTEST – ROUTE PROBLEM

The shortest route (path) problem is the problem of determining the best way to traverse a network to get from an origin to a given destination as cheaply as possible. Suppose that in a given network there are *m* nodes and n arcs (i.e. edges) and a cost C_{ij} associated with each arc (i to j) in the network. Formally, the Shortest Path (SP) problem is to find the shortest (least cost) path from the start node 1 to the finish node *m* and the cost C_{ij} of the path is the sum of the costs on the arcs in the path (http://home.ubalt.edu/ntsbarsh/opre640a/partIII.htm; 07/12/11, 6:20 PM).

In graph theory, the shortest route problem is the problem of finding a route (path) between two vertices (or nodes) such that the sum of the weights of its constituent edges is minimized (http://www.answers.com/topic/shortest-path-problem; 07/12/11, 8:40 PM). It determines the shortest route between a source and destination in a transportation network. An example is finding the quickest way to get from one location to another on a road map; in this case, the vertices represent locations and the edges represent segments of road and are weighted by the time needed to travel that segment (Hamdy, 2007).

Formally, given a weighted graph (that is, a set V of vertices, a set E of edges, and a real – valued weight function$f: E \rightarrow R$), and one element v of V, find a path p from v to a V' of V so that

$$\sum_{p \in P} f(P)$$

is minimal among all paths connecting v to V' (http://www.answers.com/topic/shortest-path-problem).

3.2.3 ALGORITHMS OF SHORTEST WAY BETWEEN TWO TOWNS

Literature presents several algorithms which find shortest way between two points from concrete graph node to all the other ones. They are: Dijkstra, Bellman-Ford, A* Search, Johnson and Floyd-Warshall algorithms. According to Cherkassky et al (1996), Dijkstra's algorithm solves the single-pair, single-source,and single-destination shortest path problems, Bellman-Ford algorithm solves the single-source problem if edge weights may be negative , A* Search algorithm solves for single pair shortest path using heuristics to try to speed up the search whilst the last two solves all pairs shortest paths. Floyd's algorithm is the simplest and fastest. Thus, Floyd-Warshall algorithm will be considered for the purpose of this study.

3.2.4 FLOYD'S SHORTEST PATH ALGORITHM

Floyd's algorithm is a more generalized algorithm compared to Dijkstra's because it determines the shortest route between any two nodes in the network. The algorithm represents an n – node network as a square matrix with n rows and n columns. Entry (i, j) of a matrix gives the distance d_{ij} from node i to node j, which is finite if i is linked directly to j, and infinite otherwise. The Floyd's algorithm is based on a simple intuitive logic. It states that if the travel to a node from its preceding node can be made shorter by traveling via another node, which is linked to the preceding node, it is always advisable to travel via the extra node so that the travel distance is minimum. This can be stated mathematically as follows:

Given three nodes i, j, and k as shown in the Figure 3.1, with the connecting distances shown on three arcs, it is shorter to reach j from i passing through k if

$d_{ik} + d_{kj} < d_{ij}$.

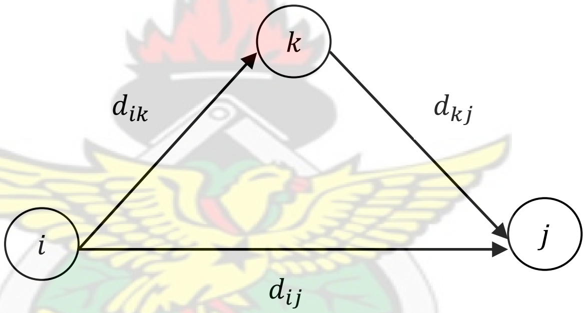


Fig. 3.1: A Directed Graph Showing Nodes i, k, and j

In such a case, it is optimal to replace the direct route (i, j) by the sum of routes (i, k) and (k, j). A systematic method to exhaust all routes joining every node set i, k, j is to first form a matrix D_o. This matrix is formed by the distances (costs) between all the possible pairs of nodes in the network. According to Hamdy (2007), a triple operation exchange is then applied to the chosen nodes using the following steps:

Step 0: Defined the starting distance $n \times n$ matrix D_0 and node sequence matrix S_0 as given in Figure 3.2. The diagonal elements are marked with (0) to indicate that they are blocked. Set step number k equal to 1 i. e. $k = 1$.

Fig. 3.2: Starting distance matrix $\boldsymbol{D_0}$ and node sequence matrix $\boldsymbol{S_0}$

$$D_0$$

$$\begin{array}{c|cccccc|}
 & 1 & 2 & \cdots & j & \cdots & n \\
\hline
1 & 0 & d_{12} & \cdots & d_{1j} & \cdots & d_{1n} \\
2 & d_{21} & 0 & \cdots & d_{2j} & \cdots & d_{2n} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
i & d_{i1} & d_{i2} & \cdots & d_{ij} & \cdots & d_{in} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
n & d_{n1} & d_{n2} & \cdots & d_{nj} & \cdots & 0 \\
\hline
\end{array}$$

$$S_0$$

$$\begin{array}{c|cccccc|}
 & 1 & 2 & \cdots & j & \cdots & n \\
\hline
1 & 0 & 2 & \cdots & j & \cdots & n \\
2 & 1 & 0 & \cdots & j & \cdots & n \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
i & 1 & 2 & \cdots & j & \cdots & n \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
n & 1 & 2 & \cdots & j & \cdots & 0 \\
\hline
\end{array}$$

General step k: Define row k and column k as pivot row and pivot column. As explained earlier, row k and column k intersect at a diagonal element. Apply the triple operation to each element d_{ij} in D_{k-1} (i.e. on all elements in D_{k-1}, which are not on the diagonal and not on the selected row and column), for all i and j. If the condition

$d_{ik} + d_{kj} < d_{ij}$, $(i \neq k, j \neq k, and\ i \neq j)$

is satisfied, make the following changes:

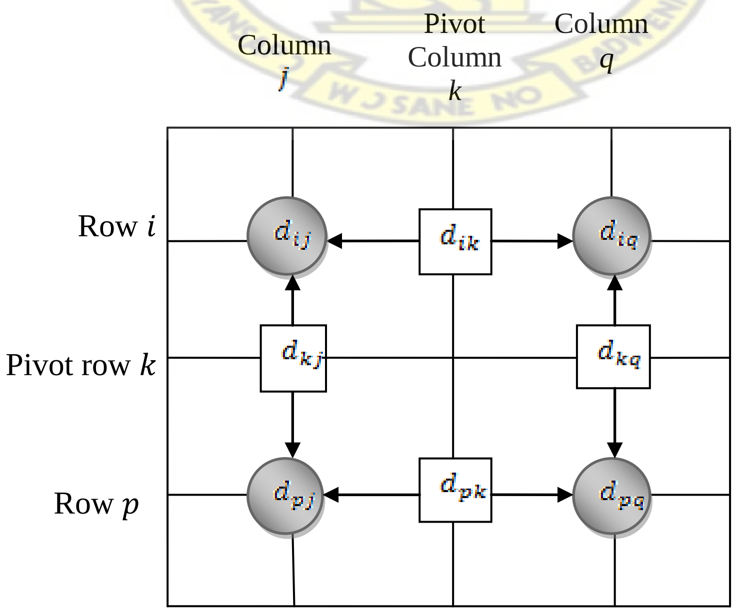
(a) Create new matrix D_k by replacing d_{ij} in D_{k-1} with $d_{ik} + d_{kj}$.

(b) Create new matrix S_k by replacing s_{ij} in S_{k-1} with k. Set $k = k + 1$. If $k = n + 1$, stop; else repeat step k.

Step k of the algorithm can be explained by representing D_{k-1} as shown in figure 3.3. The intersection of row k and the column k defines the current pivot row and column. Row i represents any of the rows 1, 2, …, $k-1$, and row p represents any of the rows $k+1, k+2, \ldots, n$. Similarly, column j represents any of the columns $1, 2, \ldots, k-1$, and column q represents any of the columns $k+1, k+2, \ldots, n$. The triple operation can be applied as follows:

If the sum of the elements on the pivot row and the pivot column (shown by squares) is smaller than the associated intersection element (shown by a circle), then it is optimal to replace the intersection distances (or the values in the circles) by the sum of the pivot distances (values in the squares).

Fig. 3.3: Schematic Diagram showing the Pivot Manipulation in a Floyd's Matrix



After n steps the shortest route between any two nodes i and j can be determined as the entry d_{ij} in the matrices D_n and S_n using the following rules:

1. From D_n, d_{ij} gives the shortest distance between nodes i and j.
2. From S_n, determine the intermediate node $k = s_{ij}$ that yields the route $i \rightarrow k \rightarrow j$. If $s_{ik} = k$ and $s_{kj} = j$, stop; all the intermediate nodes of the route have been found. Otherwise, repeat the procedure between nodes i and k, and between nodes k and j.

   The *if conditions* of the algorithm are as follows (they are given in a programmer friendly way to help in its coding and understanding):

If $(i \neq k, j \neq k, and\ i \neq j)$

  If $d_{ik} \neq \infty$ and $d_{kj} \neq \infty$

    If $d_{ij} = \infty$

      or $d_{ij} \neq \infty$ and $d_{ik} + d_{kj} < d_{ij}$

then make the following change:

Create D_k *by replacing* d_{ij} in D_{k-1} *with* $d_{ik} + d_{kj}$

These conditions can be shown in the form of a flow chart as follows:

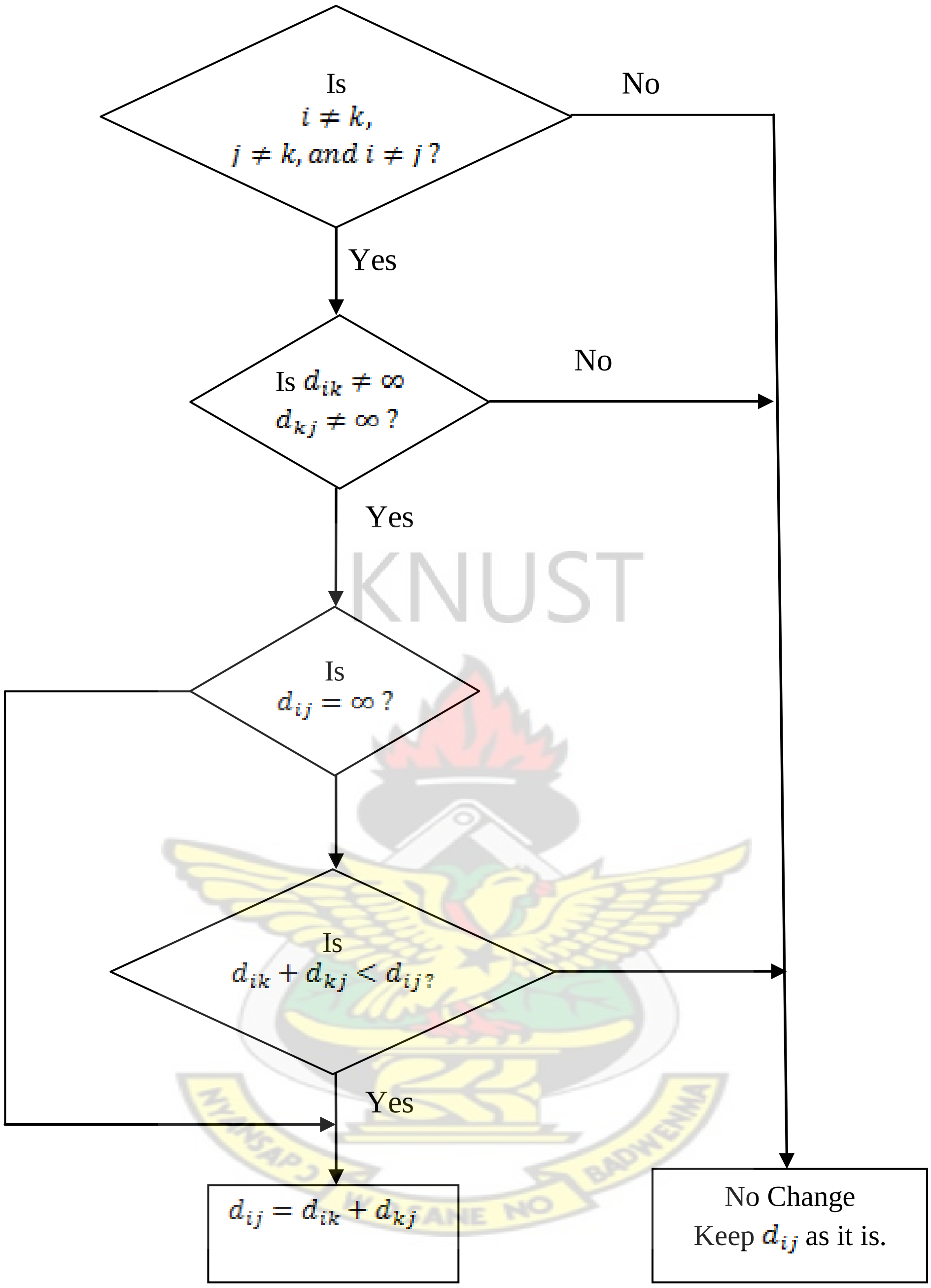


Figure 3.4: Flow Chart Showing the Floyd's Algorithm

Pseudocode:

<u>Procedure Floyd-Warshall (G)</u>

```
for i  = 1 to n do   initializing the source matrix
        for  j  = 1 to n do
                d[i, j, 0] = w(i, j)
                s[i, j] = 0                    ** s[i, j] keeps the break point vertex
for k  = 1 to n do         number of iterations
        for i  = 1 to n do
                for j  = 1 to n do
                        if i ≠ j & k ≠ j & i≠ k;
                                if d[i, k, k − 1]+d[k, j, k − 1] < d[i, j, k − 1] then
                                        d[i, j, k] = d[i, k, k − 1]+d[k, j, k − 1];
                                        s[i, j] = k;
                                else
                                        d[i, j, k] = d[i, j, k − 1]
                                end
                        end
                end
        end
end
```

This algorithm gives the shortest route between any two nodes (towns). This leads to a final updated version of Adjacency matrix with respective shortest route distances (cost) as the matrix elements. The computation complexity is given by n^3 (Dequan, 2009).

The Floyd's algorithm correct distance labels in a systematic way until they represent the shortest path distance. It is more robust and involves lesser computational overhead in large networks. Moreover, practical experience also indicates that Floyd's algorithm is faster than Dijkstra's algorithm in MATLAB simulation (Shang and Ruml, 2004).

Example 1

(Shortest Route Problem using Floyd's Algorithm)

For the network in Figure 3.4, find the shortest routes between every two nodes. The distances (in miles) are given on the arcs. Arc (3, 5) is directional, so that no traffic is allowed from node 5 to node 3. All the other arcs allow two-way traffic.

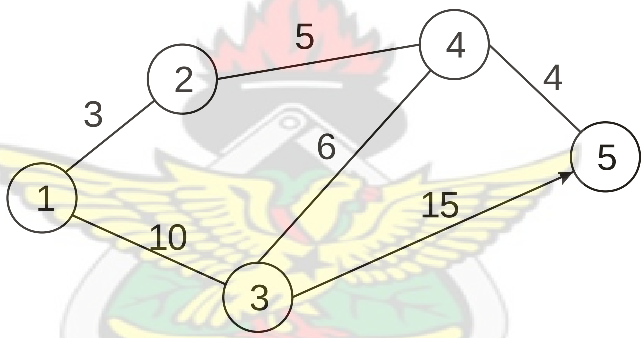


Figure 3.5: Network for example 1

Solution

We let the numbers in column 1 and row 1 of each network be the origin and destination nodes respectively.9+

Iteration 0. The matrices D_0 and S_0 give the initial representation of the network. D_0 is symmetrical, except that $d_{53} = \infty$ because no traffic is allowed from node 5 to node 3.

D_0

Node	1	2	3	4	5
1	0	3	10	∞	∞
2	3	0	∞	5	∞
3	10	∞	o	6	15
4	∞	5	6	0	4
5	∞	∞	∞	4	0

S_0

Node	1	2	3	4	5
1	0	2	3	4	5
2	1	0	3	4	5
3	1	2	0	4	5
4	1	2	3	0	5
5	1	2	3	4	0

Iteration 1. Set $k = 1$. The pivot row and column are shown by the lightly shaded second row and second column in the D_0 matrix. The darker cells, d_{23} and d_{32}, are the only ones that can be improved by the triple operation. Thus, D_1 and S_1 are obtained from D_0 and S_0 in the following manner:

1. Replace d_{23} and d_{32} with $d_{21} + d_{13} = 3 + 10 = 13$ and set $s_{23} = 1$.
2. Replace d_{32} with $d_{31} + d_{12} = 10 + 3 = 13$ and set $s_{32} = 1$.

D_1

	1	**2**	**3**	**4**	**5**
1	0	3	10	∞	∞
2	3	0	**13**	5	∞
3	10	**13**	0	6	15
4	∞	5	6	o	4
5	∞	∞	∞	4	O

$\boldsymbol{S_1}$

	1	**2**	**3**	**4**	**5**
1	0	2	3	4	5
2	1	0	**1**	4	5
3	1	**1**	0	4	5
4	1	2	3	0	5
5	1	2	3	4	0

Iteration 2. Set $k = 2$, as shown by the lightly shaded row and column in D_1. The triple operation is applied to the darker cells in D_1 and S_1. The resulting changes are shown in both D_2 and S_2

D_2

	1	2	3	4	5
1	0	3	10	**8**	∞
2	3	0	13	5	∞
3	10	13	0	6	15
4	**8**	5	6	0	4
5	∞	∞	∞	4	0

S_2

	1	2	3	4	5
1	0	2	3	**2**	5
2	1	0	1	4	5
3	1	1	0		
4	**2**	2	3	0	
5	1	2	3		0

Iteration 3. Set $k = 3$, as shown by the shaded row and column in D_2. The new matrices are given by D_3 and S_3.

D_3

	1	2	3	4	5
1	0	3	10	8	25
2	3	0	13	5	28
3	10	13	0	6	15
4	8	5	6	0	4
5	∞	∞	∞	4	0

S_3

	1	2	3	4	5
1	0	2	3	2	3
2	1	0	1	4	3
3	1	1	0	4	5
4	2	2	3	0	5
5	1	2	3	4	0

Iteration 4. Set $k = 4$, as shown by the shaded row and column in D_3. The new matrices are given by D_4 and S_4.

D_4

	1	2	3	4	5
1	0	3	10	8	**12**
2	3	0	**11**	5	**9**
3	10	**11**	0	6	**10**
4	8	5	6	0	4
5	**12**	**9**	**10**	4	0

S_4

	1	2	3	4	5
1	0	2	3	2	**4**
2	1	0	**4**	4	**4**
3	1	**4**	0	4	**4**
4	2	2	3	0	5
5	**4**	**4**	**4**	4	0

Iteration 5. Set $k = 5$, as shown by the shaded row and column in D_4. No further improvements are possible in this iteration.

The final matrices D_4 and S_4 contain all the information needed to determine the shortest route between any two nodes in the network. For example, from D_4, the shortest distance (least cost) from node 1 to node 5 is $d_{15} = 12$ miles. To determine the associated route, remember that a segment (i, j) represents a direct link only if $s_{ij} = j$. Otherwise, i and j are linked through at least one other intermediate node. Because $s_{15} = 4 \neq 5$, the route is initially given as $1 \rightarrow 4 \rightarrow 5$. Now, because $s_{14} = 2 \neq 4$, the segment $(1, 4)$ is not a direct link, and $1 \rightarrow 4$ is replaced with $1 \rightarrow 2 \rightarrow 4$, and the route $1 \rightarrow 4 \rightarrow 5$ now becomes $1 \rightarrow 2 \rightarrow 4 \rightarrow 5$. Next, because $s_{12} = 2$, $s_{24} = 4$, and $s_{45} = 5$, no further "dissecting" is needed, and $1 \rightarrow 2 \rightarrow 4 \rightarrow 5$ defines the shortest route.

3.3.1 Solving the Least – cost event site Problem

The solution methodology used to optimize the results for this problem involves simple arithmetic. Given travelers from different towns that must come together for a meeting, the total travel cost is the sum of the products of the number of travelers from each town and the round-trip-transportation cost from that town to a candidate town. The additional cost of lodging, meals and incidental expenses (M & IE) is the product of the number of people traveling to the training event site and the duration of the meeting in days. We can best illustrate the methodology by example.

3.3.2 Solving the Least-cost Event Site Selection Model

An institution, with field offices in various towns, wants to hold conference involving a number of participants from each field office. The institution wishes to hold the conference in one of the towns. The institution compensates the travelers for temporary duty expenses incurred in performance of duties, which include the costs of transportation, meals, lodging, and incidentals. The least-cost training or conference location minimizes total costs and is derived as follows:

$$\text{Minimize } \sum_{j}^{N} X_j \times \left(\sum_{i}^{N} M_i \times \left(T_{ij} + D \times P_j \right) \right)$$

$$\text{Subject to } \sum_{j}^{N} X_j \geq 1 \text{ ………………………………………………………*}$$

Where

i, j = towns,

D = duration of event (days),

M_i = number of participants from town i,

P_j = per diem rate at town j,

T_{ij} = the cost of travel to town j from town i,

$X_j = 1$ if conference in town j, 0 otherwise.

The constraint ensures that at least one candidate city is found. In many cases only one city i will provide the least cost among all N cities so $X_i = 1$ and $X_k = 0$ for $k \neq i$. The constraint will be satisfied because $\sum_{j}^{N} X_j = 1$ for these cases. However, we need to provide for the possibility that there may be a case where two cities provide the least cost, and for this case the constraint will be satisfied because $\sum_{j}^{N} X_j > 1$.

Example 2

Consider the situation in which 11 people originating from four towns must attend a four – day meeting at one of these origin towns. The expense data varies by town (Table 3.2). To compute the total cost for holding the meeting in Sunyani, we calculate transportation costs from all points of origin:

Table 3.1: Expenses Data

Origin Town	Number of Travelers	Meals and Incidental expenses Per Day (GH¢)	Lodging Per Day (GH¢)
Techiman	2	38	97
Sunyani	3	42	120
Atebubu	2	30	55
Dormaa	4	42	75

Table 3.2: Travel Costs

Route	Round Trip Travel Cost/Person (GH¢)
Sunyani – Dormaa	30
Atebubu – Dormaa	25
Techiman – Dormaa	35
Atebubu – Sunyani	18
Techiman – Atebubu	15

Transportation costs from all points of origin are:

(#passengers)×(Sunyani – Dormaa Travel Cost) = (3 people)×(GH¢30/person)

= GH¢90.00

(# Atebubu passengers)×(Atebubu – Dormaa travel cost)

= (2 people)×(GH¢25/person) = GH¢50.00

(# Techiman passengers)×(Techiman – Dormaa travel cost)

= (2 people)×(GH¢35/person) = GH¢70.00

Thus the total transportation costs are (GH¢90 + GH¢50 + GH¢70) = GH¢210.00.

We compute Meals and Incidental Expenses (M & IE) as per The Joint Travel Regulations, allowing 75% for the first and last days traveled with 100% given for full travel days (Harold et al, 2001). We can calculate the Dormaa M & IE as follows:

(Total number of passengers traveling to Dormaa)×(Dormaa M & IE)×(# of days – 0.5 (assuming the meeting is more than one day)) = (7 people)×(GH¢42/day per person)×(4.5 days) = GH¢1,323.00.

Again we calculate lodging costs for people that travel to Dormaa, assuming they arrive the day before the meeting and depart the day the meeting ends.

(Total number of people who travel to Dormaa)×(Dormaa maximum lodging rate)×(# of days for the training event) = (7 people)×(GH¢75/day per person)×(4 days)

= GH¢2,100.00.

The total cost to host the training event in Dormaa is thus

(GH¢210 + GH¢1323 + 2100) = GH¢3633.00

We compute the costs for Atebubu, Sunyani, and Techiman using the same methodology (table 3.4).

Table 3.3: Aggregating the costs of travel, meals and incidental expenses, and lodging for all possible locations yields Atebubu as the lowest – cost meeting site.

Town	Travel (GH¢)	M and IE (GH¢)	Lodging (GH¢)	Total (GH¢)
Dormaa	210	1323	2100	3633
Sunyani	222	1512	3840	5574
Atebubu	184	1215	540	**1939**
Techiman	269	1539	3492	5300

How The Cost of Travel, T_{ij}, is Determined

The travel cost T_{ij} is based on government and GPRTU transportation fares. The cost between towns i and j (called a town pair) is based on one-way travel. Since no car station services every other station, a one-way trip is often composed of multiple legs. For example, a trip from Accra to Takoradi usually means a transfer in either Cape Coast or Kumasi through Cape Coast and then non-stop to Takoradi. The cheapest route is determined by solving a shortest route (path) problem where we have four nodes (Accra, Kumasi, Cape Coast and Takoradi) and the following five arcs or town pairs: Accra - Cape Coast, Accra - Kumasi, Kumasi - Cape Coast, Cape Coast - Takoradi, Accra - Takoradi. The cost for each arc, c_{ij}, is the GPRTU approved transportation fares. Hence the travel cost from Accra to Cape Coast and back, $T_{Accra,Cape\ Coast}$, would be the (total cost of the least cost path from Accra to Cape Coast)×2. Any shortest-path algorithm can be used for this problem. But Floyd's algorithm is more robust and involves lesser computational overhead in large networks (Ravi, 2004).

Example 3

(Numerical example of the Least-cost Event Site model)

A financial institution, with field offices in five towns, wants to hold a 1-day conference involving one participant from each field office. The institution wishes to hold the conference in one of the five towns. Determine the least-cost conference location. Data are provided as follows:

Duration, D = 1 day

Table 3.4: Towns and their per diem rates per participant

Town Index	Town	P_j per participant	M_i
1	Brekum	199	1
2	Sunyani	151	1
3	Techiman	168	1
4	Nkoranza	267	1
5	Kintampo	188	1

Table 3.5: Round-trip costs (T_{ij}) per participant.

	Brekum	Sunyani	Techiman	Nkoranza	Kintampo
Brekum	0	188	258	380	268
Sunyani	188	0	336	206	306
Techiman	258	336	0	266	288
Nkoranza	380	206	266	0	300
Kintampo	268	306	288	300	0

Solution

The towns in column 1 of table 3.5 are the origin towns of the participants and the towns in columns 2 through 6 are the potential conference sites. Therefore, if Sunyani is the conference site, the travel cost from Brekum to Sunyani and back, T_{12}, is 188. Therefore if $X_1 = 1$ (Brekum is conference site) and X_2 through $X_5 = 0$ we have

Table 3.6: Cost for meeting in Brekum

i	M_i	T_{i1}	P_1 per participant	$M_i \times (T_{i1} + D \times P_1)$
1	1	0	0	**0**
2	1	188	199	**387**
3	1	258	199	**457**
4	1	380	199	**579**
5	1	268	199	**467**

The total cost for Brekum is $0 + 387 + 457 + 579 + 467 = GH¢1{,}890$.

The conference participant from Brekum is not paid per diem since the conference site is located at his duty station. Only the conference participants visiting Brekum on temporary duty status are paid per diem.

Also if $X_2 = 1$ (Sunyani is conference site) and X_1, X_3 through $X_5 = 0$ we have

Table 3.7: Cost for meeting in Sunyani

i	M_i	T_{i2}	P_2 per participant	$M_i \times (T_{i2} + D \times P_2)$
1	1	188	151	**339**
2	1	0	0	**0**
3	1	336	151	**487**
4	1	206	151	**357**
5	1	306	151	**457**

The total cost for Sunyani is $339 + 0 + 487 + 357 + 457 = GH¢1{,}640$.

Repeating this process for the other three towns, we get these total costs:

Table 3.8: Total costs for meeting in various towns

j	Conference Site	Total Cost (Gh¢)
1	Brekum	1,890
2	Sunyani	**1,640**
3	Techiman	1,820
4	Nkoranza	2,220
5	Kintampo	1,914

Least-cost meeting site

By inspection, it could be observed from Table 3.9 that, the least-cost conference site is Koforidua.

It quickly becomes obvious that while manually calculating all of the costs is a straight-forward, albeit time-consuming task, a MATLAB Programme is therefore developed to speed up the calculations.

CHAPTER 4

DATA ANALYSIS AND MODELLING

4.0 GENERAL OVERVIEW

This chapter analyses the secondary data used as input to the proposed site selection model of the study and discusses results obtained from the analysis. The data analysis was implemented using the two developed MATLAB programmes (leasttravelcost.m and leastcost_conferencesite.m). Specifically the Floyd's algorithm was used to determine the least travel costs as input parameters and the other programme was used to solve the site selection model.

4.1 DATA COLLECTION

The data used for the project were collected from the respective national headquarters of Ghana Private Road Transport Union (GPRTU), Ghana Tourism Authority and Teacher Education Division of Ghana (TEDG) at Accra, the National capital. The Floyd's Algorithm was coded using MATLAB and used to minimize the travel costs (the data from GPRTU) across the ten (10) regional capital towns in Ghana. Data obtained from the Ghana Tourism Authority consist of December, 2010 hotel tariffs at the regional capitals while the data from TEDG was about incidental expenses of participant the training events they organize and the number of participants from each region.

Table 4.1: **Summary of Data and their Sources**

Data	Source
Travel Cost	Ghana Private Road Transport Union
Hotel Tariffs	Ghana Tourism Authority
Incidental Expenses	Teacher Education Division of Ghana

4.2 DATA ANALYSIS

4.2.1 MODEL INPUT DATA

The per diem (lodging and meals costs) for each town were calculated and the travel costs were also analyzed using the Floyd's Algorithm code. The actual code is included in Appendix A. The summary of both data are given below as the input data. The maximum number of participants envisaged to attend the pending conference was pegged at three (3) and is written against each town.

Duration of event (days), D = 3.

Table 4.2: Summary of per diem rates per participant

Town Index	Town	Per diem per participant/day, P_j	# of participants, M_i
1	Accra, AC	1050	3
2	Ho, HO	862.5	3
3	Takoradi, TA	915	3
4	Cape Coast, CC	690	3
5	Koforidua, KD	787.5	3
6	Kumasi, KI	885	3
7	Sunyani, SU	855	3
8	Tamale, TA	637.5	3
9	Bolgatanga, BO	637.5	3
10	Wa	607.5	3

Table 4.2 depicts the per diem rate at each capital town and this per diem includes lodging cost, meals and incidental expenses per participant per day.

The output of the Floyd's Algorithm is presented in Table 4.3. These results represent the travel costs of round-trip per person in Ghana Cedis (GH¢). The entries below the main diagonal symmetrically equal those above it.

Table 4.3: Floyd Matrix of the ROUND – TRIP TRAVEL COST (T_i) IN (GH₵)

	AC	HO	TA	CC	KD	KI	SU	TE	BO	WA
AC	0	42	240	129	144	174	297	357	471	372
HO	42	0	282	171	186	216	339	399	513	414
TA	240	282	0	111	384	258	381	441	555	456
CC	129	171	111	0	273	147	270	330	444	345
KD	144	186	384	273	0	135	258	318	432	333
KI	174	216	258	147	135	0	123	183	297	198
SU	297	339	381	270	258	123	0	138	252	156
TE	357	399	441	330	318	183	138	0	114	174
BO	471	513	555	444	432	297	252	114	0	150
WA	372	414	456	345	333	198	156	174	150	0
TOTAL	**2226**	**2562**	**3108**	**2220**	**2463**	**1722**	**2214**	**2316**	**3228**	**2598**

Table 4.4: CODE (TOWN) SEQUENCE (S_i)

	AC	HO	TA	CC	KD	KI	SU	TE	BO	WA
AC	0	2	4	4	5	6	6	6	8	6
HO	1	0	4	1	1	1	6	6	8	6
TA	4	4	0	4	4	4	6	6	8	6
CC	1	1	3	0	1	6	6	6	8	6
KD	1	1	4	1	0	6	6	6	8	6
KI	1	1	4	4	5	0	7	8	8	10
SU	6	6	6	6	6	6	0	8	8	10
TE	6	6	6	6	6	6	7	0	9	10
BO	8	8	8	8	8	8	8	8	0	10
WA	6	6	6	6	6	6	7	8	9	0

The towns in column one (1) of Table 4.3 are the origin towns of the participants and the towns in columns two (2) through Eleven (11) are the potential conference or event sites. For instance, if Sunyani, SU, is the conference site, the travel cost from Accra, AC to Sunyani and back, $T_{1,7}$ is GH¢297.00 for the three participants from Accra. Similarly, the travel costs from Ho, Takoradi, Cape Coast, Koforidua, Kumasi, Tamale, Bolgatanga and Wa to Sunyani and back are GH¢339.00, GH¢381.00, GH270.00, GH¢258.00, GH¢123.00, GH¢138.00, GH¢252.00 and GH¢156.00 respectively. The values in row Twelve (12) represent the collective travel costs to the respective potential host towns. For example, if the meeting is held at Koforidua the total travel cost by all the participants is GH¢2,463.00.

Table 4.4 represents the associated routes connecting the town-pairs. The travel cost from Kumasi with index 6 to Takoradi, indexed 3 and back, $T_{6,3}$ is GH¢258.00, (Table 4.3). The associated route, $S_{6,3}$ from Table 4.4 is 4. Since the segment $S_{6,3} = 4 \neq 3$, it means Kumasi and Takoradi are linked through at least one intermediate town, possibly Cape Coast, indexed 4. Considering Kumasi to Ho, $S_{6,2}$, we could deduce from Table 4.4 that $S_{6,2} = 1 \neq 2$.This implies that from Kumasi to Ho is not a direct link and Kumasi → Ho is replaced with Kumasi → Accra → Ho and the route Kumasi → Takoradi now becomes Kumasi → Cape Coast → Takoradi. That is, $S_{6,3} = S_{6,1} \rightarrow S_{1,3.}$ The associated travel costs of the route are GH¢147.00 + GH¢111.00 = GH¢258.00 (Table 4.3). Moreover, the route Sunyani → Takoradi, $S_{7,3} = 6 \neq 3$ means that the towns are linked through at least one other intermediate town. These towns are Kumasi and Cape Coast indexed 6 and 4 respectively. Thus the route becomes Sunyani → Kumasi → Cape Coast → Takoradi (Table 4.4).

4.2.2 MODELLING

To solve for the cheapest training event site, an algebraic representation model of the problem was developed to derive the minimum total costs for each town as follows:

$$\text{Minimize } \sum_{j}^{N} X_j \times \left(\sum_{i}^{N} M_i \times \left(T_{ij} + D \times P_j \right) \right)$$

$$\text{Subject to } \sum_{j}^{N} X_j \geq 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots * $$

Where

i, j = towns,

D = duration of event (days),

M_i = number of participants from town i,

P_j = Per diem rate at town j,

T_{ij} = the cost of travel to town j from town i,

X_j = 1 if conference in town j, 0 otherwise.

The constraint ensures that at least one candidate town is found. In many cases only one town i will provide the least cost among all N towns so $X_i = 1$ and $X_k = 0$ for k

$\neq i$. The constraint will be satisfied because $\sum_{j}^{N} X_{j} = 1$ for these cases. However, we need to provide for the possibility that there may be a case where two or more towns will provide the least cost, and for this case the constraint will be satisfied because $\sum_{j}^{N} X_{j} > 1$.

The model was coded using MATLAB and makes its calculations based on input from the user. The code is included in Appendix A. The output was displayed for analysis in the form of text files.

The data in Tables 4.1 and 4.2 represent P_j and T_{ij} respectively are the input data and for the purpose of this study, M_i value is 3 participants from each office and D is 3 days.

4.3 Results from the Model Solution

Table 4.5 below shows the summary results of the site selection model for the training event. The study revealed that Accra, AC is the most expensive site at GH¢917,280.00 and it is GH¢347265.00 more than the least cost alternative, Wa, at GH¢570,015.00. This represents a 37.85% (GH¢347265.00) savings on this training event alone. If the model is constrained to choose one of the towns from the central regions of Ghana, then Koforidua, KD is chosen at GH¢712665.00. Koforidua is 22.31% (GH¢204615.00) less expensive than Accra (Table 4.6). If TEDG could save 37.85% on every training event, it might realize potential GH¢347265.00 savings based on the estimated Accra training cost. Even if a conservative estimate of 5% annual savings is used, it is possible that TEDG could realize an annual GH¢45864.00 saving on travel related to training.

Table 4.5: Total Costs for Meeting in Capitals of Central Regions of Ghana only

j	Conference Site	Total Costs
5	Koforidua, KD	GH¢712,665.00
6	Kumasi, KI	GH¢769,680.00
7	Sunyani, SU	GH¢759,870.00

Table 4.6: Total Costs for Meeting in Various Regional Capital Towns

j	Conference Site	Total Costs
1	Accra, AC	GH¢917,280.00
2	Ho, HO	GH¢775,485.00
3	Takoradi, TA	GH¢834,390.00
4	Cape Coast, CC	GH¢625,500.00
5	Koforidua, KD	GH¢712,665.00
6	Kumasi, KI	GH¢769,680.00
7	Sunyani, SU	GH¢759,870.00
8	Tamale, TE	GH¢590,895.00
9	Bolgatanga, BO	GH¢613,215.00
10	Wa, WA	GH¢570,015.00

Least-cost meeting site

The true strength of this methodology is that it may, as this study shows, provide a counterintuitive answer to the problem. In this case, the intuitive answer is to send everyone to Kumasi since it is the town with the least aggregate travel cost of GH¢1,772.00 (Table 4.3). However, the reduced M and IE and lodging costs (per diem) for Wa or any other site outweigh the transportation benefits provided by staying in Kumasi (Table 4.2).

TABLE 4.7: SUMMARY OF ROUTES TO COST-EFFECTIVE SITE

From	To	Round-trip cost (GH¢)	Route
1 AC	10 WA	372	1 – 6 – 10
2 HO	10 WA	486	2 – 1 – 6 – 10
3 TA	10 WA	456	3 – 4 – 6 – 10
4 CC	10 WA	345	4 – 6 – 10
5 KD	10 WA	333	5 – 6 – 10
6 KI	10 WA	198	6 – 10
7 SU	10 WA	156	7 – 10
8 TE	10 WA	174	8 – 10
9 BO	10 WA	150	9 – 10

Table 4.7 above is an excerpt of table 4.4 showing all the shortest routes from all the origin towns to the estimated cost-effective host site with their round-trip costs. The numbers preceding the codes of towns in columns one (1) and two (2) are the respective index of the towns. These are used in column four (4) to represent the intermediate nodes (towns) in each route to the host site. Thus we can deduce that the route from Accra to Wa is 1 – 6 – 10 which denotes Accra → Kumasi → Wa

4.4 SENSITIVITY ANALYSIS

While this model is a useful tool to aid decision making in site selection for conferences, there remain several types of uncertainty associated with this method of analysis. One of such uncertainty is the effect of change of values due to inflation or otherwise.

Table 4.8: Total Cost for meeting in Various Regional Capital Towns at 5%, 20% and 80% increase of the Transportation and Per diem

j	Conference site	Total cost (5% increase)	Total Cost (20% increase)	Total Cost (80% increase)
1	AC	920670	1050840	1454760
2	HO	817970	880686	1199529
3	TA	826560	937854	1299483
4	CC	628245	700794	929556
5	KD	712040	800982	1079973
6	KI	771990	873756	1172880
7	SU	762558	862200	1171746
8	TE	594990	658782	866619
9	BO	619370	686646	908415
10	WA	574170	635454	831627

Least-cost meeting site

The study has revealed that Wa is the least cost town with the cost of GH₵570015.00. With a 5% increase in the transportation cost of the respective towns, Wa remains the least cost town at GH₵574170.00; an increase of GH₵4155.00 (0.72%). Accra remains the most expensive site at GH₵920670.00; an increase of GH₵3390.00 representing 0.37%.

At 20% increase of transportation cost and the per diem, Accra is still the most expensive site at GH₵1050840.00 with an increase 12.71% (GH₵133560) and Wa, the least cost site with GH₵635454.00; an increase of GH₵65439.00 representing 10.30%. A test of 80% increase of the Transportation cost and the Per diem still reveals that Accra is the highest cost town with GH₵1454760.00; (37.0%) of the original cost. Wa remains the least cost town with GH₵831627.00, 31.46% increase of the original cost.

None of the respective town recorded a change in their positions.

The analysis shows that the model is certain and can stand the test of time even with an appreciable percentage change of values.

4.5 FINDINGS

The study was an attempt to develop methodology which could be used in the different institutions to select and optimize the most cost – effective training location among many possible choices. The results generated from the data gathered aim at providing insights into the institution under study and do not necessarily translate to being representative of the entire population. The participants' places of origin were chosen from the ten regional capital towns in Ghana. The data was collected and analyzed using MATLAB code for Floyd's algorithm. Another MATLAB code was used to solve the model.

From Tables 4.5 and 4.6, the most expensive conference or training site is Accra with total cost of GH¢8,570,880.00. About 0.26% (GH¢2,196.00) constituted transportation cost (Table 4.3) and 99.74% of the total expenses is estimated to be the per diem cost. The most cost-effective conference site selected is Wa with GH¢2,670.00 and GH¢5,000,850.00 as transportation and total cost respectively (Tables 4.3 and 4.6). Thus the model suggested that the subsequent meetings could be held at Wa. However, the model is flexible enough to allow event planners to choose a preferred destination.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.0 INTRODUCTION

This chapter presents the summary and conclusions drawn from the study and makes some recommendations to help the TEDG and other institutions to live within their budget allocated for training and conferences.

5.1 SUMMARY

The researcher sought to develop site selection methodology using Floyd's Shortest-route Algorithm to minimize the travel costs of staff in various institutions. The purpose specifically was to determine the least expensive meeting, training and conference event site and this involved mathematical model to minimize the cost of holding meeting or conference at a particular town. The Teacher Education Division of Ghana was used as case study. In all, the ten regional capitals were used in the study. Data was collected from the National Headquarters of Teacher Education Division of Ghana, Ghana Tourism Authority and Ghana Private Road and Transport Union (GPRTU) in Accra. Floyd's shortest-route algorithm was used as the mathematical tool to solve the transportation cost problem and MATLAB code was used. The following were findings of the study:

On the issue of least expensive conference site, the analysis revealed that Wa, the Regional Capital of Upper West is the least expensive site with aggregate cost of GH¢5,70015.00. The total travel cost needed to transport all the Thirty (30) visiting participants to the cost-effective site was found to be GH¢2670.00. The model revealed that Accra, the National Capital and Regional Capital of Greater Accra Region is GH¢347,265.00 more than the least cost alternative, Wa. This represents a 37.85% savings on this training event alone. About 0.46% constitutes transportation cost and 99.54% of the total expenses are estimated to be the per diem cost. If the model is constrained to choose one of the capitals of the central regions of Ghana, Koforidua is chosen at GH¢712,665.00. Koforidua is 22.31% less expensive than Accra. If TEDG could save 37.85% on every training event, it might realize potential GH¢347265.00 savings based upon the estimated Accra training cost. Even if a conservative estimate of 5% annual savings is used, it is possible that TEDG could realize an annual GH¢45864.00 saving on travel related to training.

5.2 CONCLUSION

Based on the results from the study it was concluded that the most expensive conference site is Accra and the least expensive alternative site, that is, most cost-effective site is Wa, capital city of Upper West Region. The model developed reveals that if TEDG adapts to the model they can make a saving of GH¢347,265.00 on every meeting or conference event. Hence we can conclude that the shortest-route algorithm we used to develop the model can have a dramatic increase in the saving margin of the institutions in terms of training events, should they adapt to it.

5.3 RECOMMENDATIONS

From the conclusion, we realized that using network models in decision making to select event site helps to minimize the event cost, thereby increase their savings. It is therefore recommended that TEDG and other institutions event planners should adapt this model in their selection of cost-effective site.

It is also recommended that institutions be educated to consult mathematicians to use Floyd's shortest-route algorithm to find an appropriate mathematical model to help them in decision making and planning events more efficiently.

Moreover, immediate funding from agencies for continued refinement of the event site selection model programme is recommended.

Lastly, it is recommended that the study should be replicated for the Upper West Region using the district capitals for the most potential cost - effective conference sites and create window-based user interface for the programme to help naive users of MATLAB.

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