A Cloud-based System for Supporting Knowledge Precincts (KPs) Site Selection in Egypt

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Abstract

This paper proposes a flexible and scalable cloud-based Decision Support System (Cloud-based DSS) to support the decision making process for Knowledge Precincts (KPs) site selection. The tool is presented to government decision makers who are involved in selecting locations for setting up new KPs in Egypt. The proposed prototype guides decision makers step by step through the decision making process based on factors influencing their KPs location decisions. Considering the available locations and based on the decision maker proprietary factors, the system computes KP location scores and recommends the most appropriate location for a KP. The prototype ranks the different location alternatives based on the importance of the factors determined by the system user. The KP location with the highest score is considered the best. The proposed tool is intended to be used by decision makers to choose the best location from several alternatives based on the relevant criteria in each case and for every decision maker. The system considers 5 main criteria and 34 sub-criteria that will be considered and /or weighed based on the case at hand.

Keywords: *Cloud-based Decision Support System (Cloud-based DSS), Knowledge Precincts (KPs).*

1. Introduction

ICT is used in E-business practices to improve the performance of the organizations. Keeping a successful implementation of E-business in mind, governments decided to use Information and communication Technology (ICT) in order to improve the performance of public sector services within E-government [1]. ICT offers new opportunities and choices; it enables governments to deliver services electronically through what is commonly known as E-government. E-government success requires (1) changing how government works, (2) how it deals with information, how officials view their jobs and interacts with the citizens, and (3) active partnerships between government, citizens and the private sector [2]. The E-government improves the productivity and helps in having the effective decision-making. However, in E-government practices reported in the literature, the objective is mostly about having the E-government offers services to citizens, government and business. In this paper, we work on application where the government is the consumer on an E-service offered in a cloud setting to support decision-making.

Government must keep up with the endless innovations in technology for delivering its services in an efficient way with a lower cost. Successful implementation of cloud computing technology can benefit the public sector in cost reduction. Governments cannot efficiently deliver their services with tightly controlled budgets. Therefore recent attention has shifted away from these traditional online E-government services to a new initiative which is called Cloud Government (C-government) [3] which is using the internet as the primary channel for communication and services delivery and that deploys its data and applications into remote Cloud Government. Several researchers agreed that the use of cloud computing is essential in E-government services especially in developing countries [4, 5]. Although cloud computing introduced many benefits to government sector, there are many risks associated with its implementation which use basically concerning security. However Cloud computing is the next stage of the ICT revolution in which data and applications will be housed centrally and accessible anywhere and anytime through various devices. The cloud computing approach is an essential component in many governments. Cloud computing can be one of the great benefits to government agencies of all types and sizes [6, 7].

A KP identified as a science technology parks, research parks, industrial parks or innovations parks refer to an area where knowledge-based activities are collected to achieve the following two primary objectives [8]: (i) to be a seedbed for knowledge, and to play the role of a facility that spread knowledge and innovation, (ii) to act as a motivation for regional economic development that promotes economic growth of the area. Major common spatial attributes of KPs are identified as follows (i) presence of mixed land use. Most of the new KP developments have manifested in the post-modern urban scene by adopting the mixed use environment as a tool to provide the live-work-learn-play in the same precinct, thus blurring the boundaries between various urban functions and activities, aiming at facilitation for the free flow of knowledge to every urban activity [9, 10], (ii) spatial clustering, KPs are planned in a way to allow agglomeration of activities with the common knowledge base (i.e., ICT, media, communications, biotech and others) in close proximity to each other. Thus forming knowledge based clusters or spatial zones. With the help of such clustering, firms benefit from the agglomeration of other knowledge-based industries and workers [11, 12] and (iii) transit-oriented development, one of the major characteristics of KPs is the centrality of its location, which is enhanced by providing it, the best connectivity in terms of supporting infrastructure that makes it accessible, served and well connected at the regional and global level. Hence most of these KPs are seen developing alongside major infrastructural elements like highways, high-speed metros or the railway lines [13].

Current Egyptian KP projects include Zewail City of Science and Technology, City of Scientific Research and Technological Applications (SARTA City), Smart Village, Sinai Technology Valley (STV), Northern Coast Technology Valley, Information Technology Institute (ITI), Borg Al Arab, New Assiut and Sadat City. However we do not know how these locations were chosen and where, the chosen locations allow us to realize the objective of the KPs. This research considers location decisions for setting up new KPs with factors relevant to the Egyptian economy. In a previous research on analysis was undergone and expert opinion was acquired to identify the following as important factors for KP site selection [14]. These factors are availability of human resources, enabled infrastructure, eco-system which refers to eco-friendly relationship between a KP and environment, supporting environment and services and geographical conditions. In this research a tool is contributed to be used by decision and policy makers, this decision tool is offered in a cloud environment. This will mainly contribute techniques in decision analysis for location problems and will offer cloud computing environment to the Egyptian Government to support their decisions.

The remainder of the paper is organized as follows, Section 2 presents related work. Section 3 includes the overall service architecture of the prototype. In Section 4 the proposed features and implementation of a prototype are discussed. Finally, Section 5 outlines conclusions and future work.

2. Related Work

The following section covers different aspects related to the problem.

2.1 Evolution of Decision Support Systems (DSS) in Government Sector

DSS was the first application to use available computer hardware and software technologies to create an interactive and user-friendly environment for managers and end-users. DSS also transformed scattered data into meaningful business information for supporting operational and strategic decision making [15]. The establishment of a correct decision making system, can provide scientific basis for government departments decision making, and improves the propriety and rationality of policy making, to accomplish the purpose of increasing the efficiency of government management and promoting economic development [16].

Globalization, competition, business and socioeconomic pressures as well as market needs have all contributed to the deployment of mechanisms for effective decision making processes for government. Government decision making is targeting optimum allocation of scarce resources through the delivery of public services in the most efficient and effective way whether deploying the conventional methods or the newly emerging electronic channels such as E-government [17, 18]. Government decision making over the last couple of decades has been greatly affected by the emergence of ICT in the way decision-making processes have been transformed to capitalize on the opportunities enabled by such technologies with a focus on socioeconomic development [19].

DSS applications in the Arab Governments are broadly divided into two main purposes, the first one is a special purposes, and the other is general purposes integrated DSS [20], special purposes represents a very useful tool for addressing a specific problem or supporting a particular decision. The special purpose DSS applications examples include: (i) foreign exchange rate policy in Egypt [21]: to face the shortages in the foreign exchange with negative impacts on growth and balance of payments, (ii) development planning scenarios for Egypt [20]: designed to face the slowdown in the economic activity, a shortage in foreign exchange earnings, structural imbalances in the labor market, a relatively high rate of unemployment, and a growing government deficit, (iii) customs tariff policy formulation in Egypt [22]: to develop a homogeneous and consistent tariff structure, increase revenue to the treasury, and minimize the impact on low-income groups, (iv) external debt management system in Egypt [22]: to serve the large number of loans; this system was important to manage payment schedules, renegotiation of terms and interest rates, and monitoring transactions with a large number of creditor countries, banks, and international agencies and (v) fiscal reform program in Kuwait [20]: to evaluate the impact of suggested fiscal reform policies on the economy, and to capture economic multiplier effects of Kuwait’s fiscal program.

The General purpose DSS tools in Arab Governments are not particularly designed for specific applications, problems or issues. They provide general software capabilities that can fit several decisions using alternative analytical tools or models. The use of this category is very limited in the Arab countries. They are divided into data-centered, model-centered and knowledge-centered DSS [20]. The purpose of the first category is to manipulate an analytical database (or data warehouse) using the OLAP software technology. The second category relies on models and Model- Based Management System (MBMS) to support the decision-making process. Finally, the last category relies on knowledge processing, reasoning and expertise to support decision. There are two successful examples of general purpose DSS tools, the first one is the Information Decision Support Center (IDSC) of the government of Egypt [17] which is the first DSS center to be established in the Arab countries and the other one is Development Planning Decision Support project (DPSS) of the Ministry of Planning in Kuwait[19].

Egypt is considered as a typical developing country that faces the common problems of developing countries such as high unemployment, heavy foreign debt, high illiteracy rate, a balance of payments deficit, poor technological infrastructure and lack of financial resources. To overcome and deal with these problems, it has been striving to implement a nation-wide strategy to support the realization of its targeted socioeconomic development program. In the mid-1980s, the Egyptian government adopted a push strategy for the introduction, of large information and decision support systems (DSS) to improve government decision making with respect to socioeconomic development [22]. A socioeconomic approach to build the National Spatial Decision Support System and provide support for the national economy development in Egypt was proposed in [23]. This approach proposed a web based platform for collaboration between government authorities, industry experts and the public. A Spatial Decision Support System model for enhancing highways emergency services was presented in [24] to identify the shortest path and to find the accident location automatically without human intervention. DSS can provide efficient support to strategic decision making and development planning [25, 20]. Before decision support systems were implemented, the following characteristics were identified within Cabinet decision making: (i) it was rich data but poor information, (ii) information systems and management specialists were isolated from the decision makers and (iv) computer systems were not viewed as tools that could support decision making [25].

2.2 Adopting Cloud-Based Decision Support Systems in the Government Sector

Cloud computing is defined by the National Institute of Standards and Technology (NIST) as a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [26]. NIST has identified five essential characteristics of cloud computing as follows: on-demand service, broad network access, resource pooling, rapid elasticity, and measured service [25]. Cloud Computing Service Models [26]: (i) Software as a Service (SaaS), (ii) Platform as a Service (PaaS), (iii) Infrastructure as a Service (IaaS) and XaaS that is defined as anything or everything (XaaS) as a service such as communication (CaaS), network (NaaS), storage (SaaS), Decision Support System (DSaaS) [27], etc. NIST cloud deployment models include [26]: (i) public cloud, (ii) Private cloud, (iii) community cloud and (iv) hybrid cloud, the cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability.

Cloud computing can benefit governments in three areas [28]: (i) increasing national competitiveness, (ii) enhancing citizen services, governments can use cloud computing to deliver their services more efficiently for instance healthcare by providing access to electronic health records and other medical information and (iii) driving down costs.

However there are various forms of risks associated with cloud computing implementation to government agencies as users of cloud services. Despite the risks that are associated with using cloud computing, most government do not seem to hesitate to fully incorporate it and they do not limit their use to only one service model or application, but some of governments agencies promote the overall application of cloud computing in public sector by establishing specialized market place for their agencies [28]. Many governments have already used cloud computing. These include several projects such as (US Government-USA.gov, US Government- Apps.gov, Department of defense (DoD), Defense information system agency (DISA) – USA, National Aeronautics and space Administration (NASA) – USA, city of Edmonton- Canada), case studies from examples exist in Asia (Japan) and case studies from Europe (United Kingdom, Germany, Greece). Although there are some risks associated with cloud computing implementation in government sector, the examination of the previous case studies showed that cloud computing has already been adopted by some government agencies around the world [28]. According to the Cloud Security Alliance (CSA) and European Network and Information Security Agency (ENISA) [29], the key threats in a cloud environment are: data leakage, data loss, account hijacking, insecure APIs, denial of service, malicious insiders, abuse of cloud services, insufficient due diligence, shared technology vulnerabilities, and loss of governance and compliance, but various control measurements are today considered while building cloud infrastructure to mitigate the threats.

2.3 KPs site selection in Egypt

KP location selection is the determination of a geographic site to locate a new KP. Selecting a KP location is an important and a critical decision due to the high cost of relocation. The KP location selection process encompasses the identification, analysis, evaluation and selection among alternatives. The general procedure for making location decisions consists of the following steps: first, decide on the criteria that will be used to evaluate location alternatives, next, identify criteria that are important, then develop location alternatives, and finally, evaluate the alternatives and make a selection.

In previous research, Knowledge Precincts location criteria were identified by review of literature and visits to the current Egyptian KPs and expert’s view [14]. Based on a great number of location criteria and KPs experts criteria were reduce to the most important. Analytical Hierarchy Process (AHP) method, as one of the best methods of Multi Criteria Decision Making (MCDM) techniques is proposed to rank the KP location criteria based on the KPs decision maker’s preferences against set of location alternatives. Finally, the result with the most proper location will be presented to the decision maker. KPs Location Criteria of KPs were identified as result of 5 Main criteria and 34 sub-criteria. The 5 main criteria were included: availability of human resources, enabled infrastructure, eco-system which refers to eco-friendly relationship between a KP and environment, supporting environment and services and geographical conditions.

3. The Architecture of the proposed cloud-based DSS

The proposed decision support tool in the previous section to solve the KP site selection problem is used within a cloud-based DSS architecture in order to be offered to the government decision maker. In this section the overall service architecture is presented, highlighting each of its parts and showing the main characteristics. The logic and functionalities of the proposed Cloud-based DSS software tool are described thoroughly in this section.

3.1 The Interface Module (The user layer)

Allows the government decision maker (end user) to access a Cloud-based DSS through internet connection in order to participate in the process of choosing the proper KP location via any device (mobile phone, computer and tablet etc.). The user's layer is the visible part of the application that represents the tool that the policy makers in government interact with. This layer can be executed on the policy maker in government/users devices.

The main purpose of this layer is allowing the user to register to the decision support system, select and store their KP location criteria preferences with access to an interactive interface to get the result with the most suitable location. The application includes 5 main pages:

I. **Log in:** This page is where the users log to the application to load all the information. This application uses decision maker's preferences in government for choosing a new KP location, so the authentication is crucial to keep data safe.

II. **Edit previous session/new session:** the user can either review one of her/his existing location site selection or launch a new selection.

III. **Ranking list:** This page shows a dynamic and interactive list that represents the ranking of each of the selected criteria and sub criteria after making AHP pair-wise comparison. This is one of the most valuable results for the decision maker's point of view.

IV. **Settings:** This section contains different views to represent all the inputs that the decision maker has introduced to the system. Moreover it allows decision maker to interact with them

V. **Help:** This page contains a form to send an email to the administrator of the app.

To sum up, this layer is where the data from the user is collected, stored to the further analyzed in the system.

3.2 Computing module(Business logic)

The Backend server is the core of the application. It contains all the application logic and is the communication bridge between the user, the database and the different computing nodes. The Backend server has to provide all the information needed by the user, so it can display it in a user friendly way, and also receive all the information provided by the user and save it or transform it as needed.

The business logic receives all the data from the user layer, transforms and manipulates this data and ensures that this data is stored in the data layer. To sum up, this is the layer where the work is done, it is the main part of the system. Not all the criteria are included, but only those that meet the following condition: criteria and sub-criteria of a KP location is selected (weighted) by user in the input data form in the previous module (Interface module), then AHP pair wise comparison between these set of factors carry out a multi criteria analysis which makes it possible to rank the alternative locations of KP and the final result with the proper location will be presented via user interface.

3.3 Data layer module

A data layer helps you collect more accurate analytics data, store information about the users and more. The proposed Cloud-based DSS uses a data layer to store all the data related to the users, the KP location selection criteria and sub criteria and also the results of applying the Cloud-based decision support tool. The main function of the data layer is storing data from different sources.

3.4 Location reports module

This module handles the location results computed after completing user input phase. The results are displayed in a text (report). The report includes information on the top four location results, and how their scores are calculated.

4. Proposed features and implementation of a prototype

This section is divided into two parts, the first one is set of the features of the proposed prototype and the other one is screenshots of user interface.

4.1 Proposed features of the prototype

The following major features will play a primary role in the success of the proposed Cloud-based DSS:

1. Multi-tenant solution: this is becoming a key technology for the success of cloud applications [30, 31], which is defined as an architecture in which a single instance of a software application serves multiple customers, each customer is called a tenant. Tenants may be given the ability to customize some parts of the application such as color of the user interface (UI), but they cannot customize the application's code. Multi-tenancy enables sharing of resources and costs across a large pool of users thus allowing for centralization of infrastructure in locations with lower costs.
2. The application is accessed over different devices and platforms, only authorized users should be able to access the cloud–based DSS service.
3. The application does not require special integration and installation work.
4. User data and business processes are stored in a data center.
5. The application is scalable with no limits on the number of users or workloads.
6. The majority of the compute cycle can happen in a data center.
7. The application can run on the user's computing system or the provider's web servers.
8. As a cloud–based DSS service, a very high uptime is considered. In a real life implementation in multiple locations, applications should be available with a 100% uptime.
9. The prototype is easy to use and can be provided through a stable environment.

4.2 Implementation of the prototype

The proposed prototype integrates AHP decision making within a site selection tool designed to support government decision makers seeking to set up a new KP within Egypt. The cloud-based DSS prototype implementation guides decision makers step by step through the decision making process. They select criteria and sub-criteria influencing location decisions to rank different location alternatives.

Figure 1. Registering form

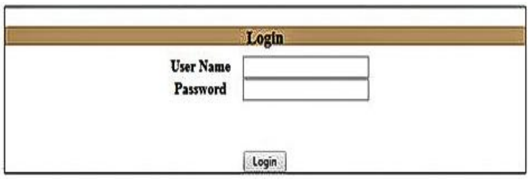

Figure 2. Login form

Figure 1 displays registering view, if the decision maker is new to the application, the starting point is the **Register**. The register form allows policy makers to create a profile in the application. The starting point to use the application is the **Login** in figure 2 once the decision maker is logged in, he/she is allowed to enter into his/her private space.

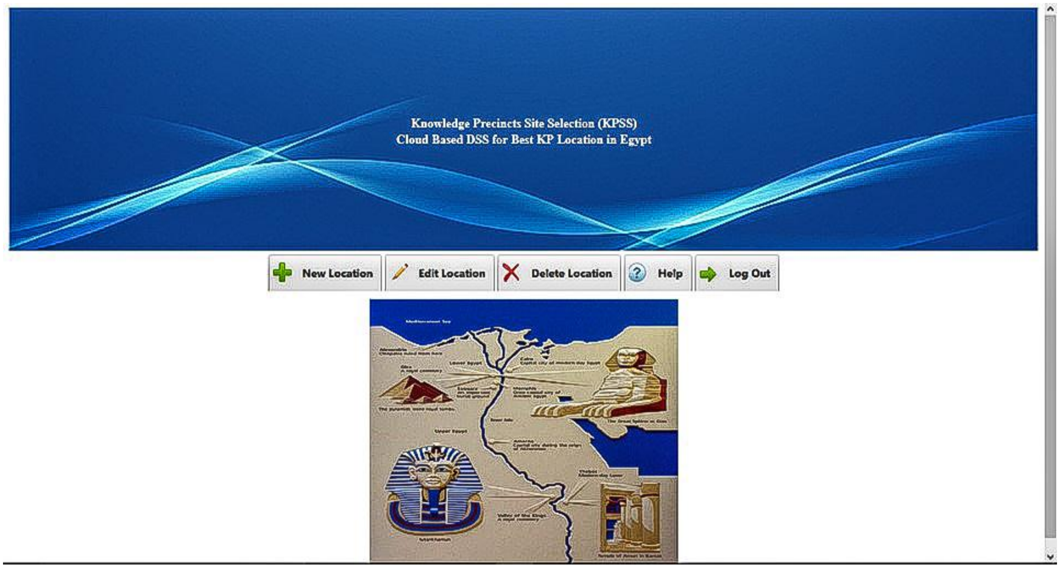

Figure 3. Main page of the prototype

According to the frequency, in figure 3. the first page is the main page of the prototype that allow the decision maker to select from the menu as the following: make a new site selection session to choose new KP location from **New Location** tab, edit or delete previous one using **Edit, Delete Locations** tabs, ask for help and logout from the system.

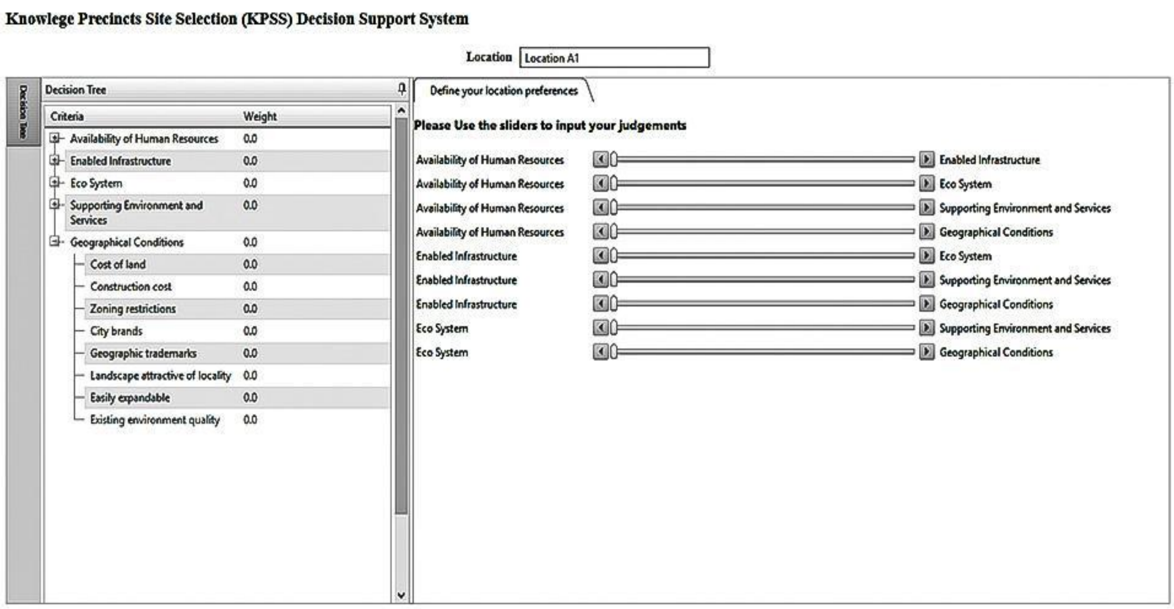

Figure 4. Interface for choosing criteria and sub-criteria of KP location

There are many criteria that affect decision making in this problem. In this study, the location problem is solved with AHP method. In figure 4. KP location criteria and sub-criteria are listed in the left side **(Decision Tree View)** to allow the decision maker to select from them upon his/her preferences by clicking on each one in the decision tree list, and then the selected criteria and sub-criteria will appear on the right side of the form. Saaty's 1-to-9 scale [32] is used by the decision maker in the right side of the form in figure 4 while comparing between criteria and sub-criteria. The interface captures user's location preferences and requirements through AHP pair wise comparisons. In the backend, the system computes scores for the KPs location alternatives to be then ranked according to the user's requirements.

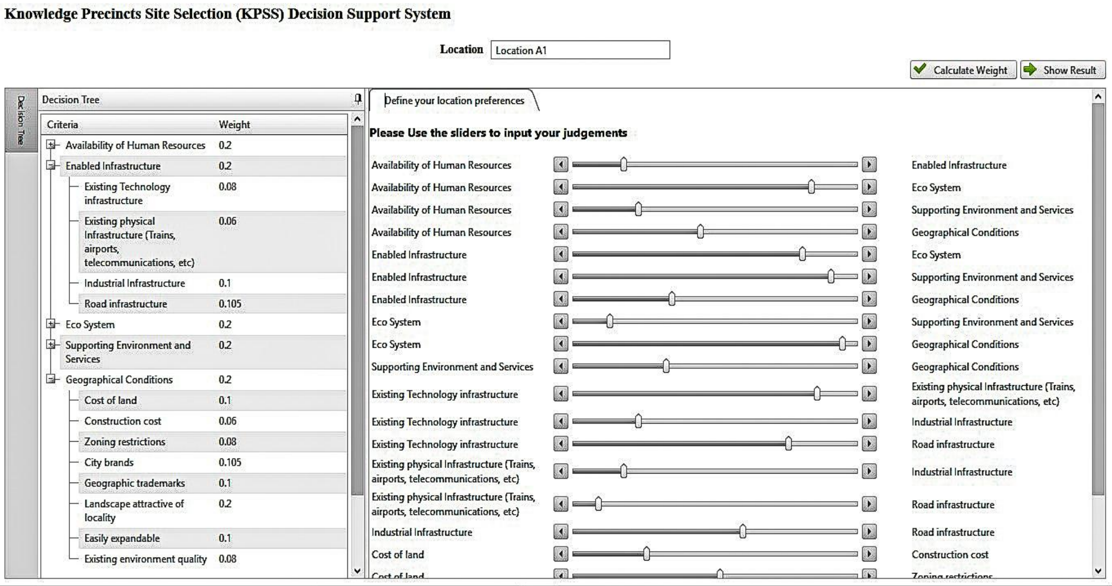

Figure 5. Pair-wise comparison.

Figure 5 presents the selected criteria and sub-criteria with weights for each of them in the decision tree view after AHP pair-wise comparison is completed.

Figure 6. Final result page.

Figure 6 presents the result of the prototype with set of alternatives, alternative A with the highest importance weight is suggested to be the best KP location. The ranking order of the alternatives with AHP method is A, B, C and D.

5. Conclusion and Future work

In this paper, a cloud-based DSS to help the decision makers in government to choose the best KPs location within a set of location alternatives was presented. In addition to cost reduction, due to economies of scale and scalability that have been a major advantage of cloud computing, there are other advantages of using cloud-based decision support systems including agility, accessibility, and availability on many diverse devices and backup that cloud infrastructure uses to protect against disasters. The logic, functionalities and implementation of the proposed Cloud-based DSS software tool are presented in detail in this paper. In this proposed prototype, AHP is used as a decision making method that allows the consideration of multiple criteria. This method helps decision makers to select the best location from several alternatives based on selection criteria. In order to select the best KP location, 5 main criteria and 34 sub-criteria were identified in a previous research and are used within the contributed prototype. After the result of the main and sub-criteria comparison and after comparing alternatives to each main and sub-criteria, the result with highest score is suggested to be the best location for setting up a new KP and other alternatives are ranked. The tool enables government decision makers analyze KP locations and make objective decisions. Future research will focus on enhancing the proposed solution and testing it in order to evaluate how beneficial it is to potential users.

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