

Full Length Research Paper

Web geographic information system (GIS) in accreditation and monitoring of professional training institutions for quality assurance: The case of Kenya Accountants and Secretaries National Examinations Board (KASNEB), Kenya

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Received 9 March, 2017; Accepted 25 April, 2017

Professional education is crucial not only in impacting citizens with skills and competencies in specific fields, but also in accelerating development in any country. Kenya aims at providing globally competitive quality education, training and research to her citizens. In line with these national goals and in order to maintain the quality of its qualifications, Kenya Accountants and Secretaries National Examinations Board (KASNEB) accredits training institutions. The integration of web geographic information system (GIS) is premised to enhance the accreditation process by use of visualization, cartographic classification, reduction of turnaround time and elimination of current manual processes among other functionalities. To realize these objectives, a survey of user requirements was undertaken. Spatial locations of training institutions were digitized using Google Earth geobrowser. An accreditation geodatabase was designed in ArcGIS, and used to store both spatial and attribute data. The data was then exported to ArcGIS Online where the use of web GIS technology ensured the creation of an *Accreditation Web App*. The web app can be shared and accessed using desktops, laptops or smart mobile devices. The app simplifies the accreditation process and offers accreditation officers, students and other stakeholders a web-based GIS enabled solution. It also provides management with the ability to perform market research, and integrate the app with other existing systems in order to enhance efficient use of resources.

Key words: Accreditation, professional education, visualization, Web App, Web GIS.

INTRODUCTION

In 2007, the government of Kenya published its long-term national planning strategy; *Kenya Vision 2030*. The vision

aims at transforming Kenya into a newly industrialised, middle-income country providing a high quality of life to

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all its citizens by the year 2030 (Government of Kenya, 2007).

Kenya Vision 2030 is anchored on three “pillars”; Economic, Social and Political. One of the key drivers under the social pillar is Education and Training. As an examination body, KASNEB plays a crucial role to the realization of the social pillar through its legal mandate to accredit tertiary training institutions offering its qualifications (Kenya Law Reports, 2012).

Accreditation is a process broadly aimed at recognising training institutions for the quality and integrity of their training programmes which entitles them to the confidence of stakeholders (KASNEB, 2016). Thomas (2007) postulated that the promise of the future would be the invention of web-based and mobile Geographical Information Systems (GIS) as tools to enhance curriculum delivery.

GIS generally refer to computer systems for storing, manipulating and displaying geospatial data (Westra, 2013). Fransen et al. (2014) assert that a GIS is an extremely efficient decision supporting tool for spatial analysis and data visualization and is crucial to the way thousands of people perform work in numerous disciplines including education (Committee on Beyond Mapping, 2006).

GIS can be used within the education sector for the determination of spatial distribution of training institutions, and the analysis of the spatially referenced data as well as in finding and determining the location and optimum route to a training institution (Agrawal and Gupta, 2016; Kuria et al., 2011; Albrecht, 2007).

According to Fu and Sun (2010), “everything that happens, happens somewhere.” Therefore, knowing what is where and why it is there can be critically important in making informed decisions. Consequently, while GIS is the enabling technology as well as the science for handling the where type of questions and for making intelligent decisions based on space and location, the web provides a means of doing so seamlessly across national as well as international boundaries (Fransen et al., 2014).

They further posit that parallel with the increased use of the Internet technology; more and more data become freely accessible. This has revolutionised the entire mechanism of GIS data delivery (Fazal, 2008) in the Internet domain, to what could be referred to as “buttonology” or a point and click procedure (Srivastava, 2013) spawning an era of “web GIS”. Web GIS uses technologies such as Hypertext Transfer Protocol (HTTP), Hypertext Markup Language (HTML), Uniform Resource Locator (URL), JavaScript, and WebSocket among others (Fu, 2015). By allowing users to access maps and data on the Internet, it provides a simpler interface than desktop GIS (Jo, 2016).

Further, web GIS engenders several advantages over the traditional GIS. These include use of diverse

applications, unified updates, better cross-platform capability, and wider accessibility to GIS (Fu, 2015). In the words of Fu and Sun (2012), “The web has unlocked the power of GIS - it has put GIS in the homes of millions and in the hands of billions and made it usable across all industries, from government and business to education and research”. Web GIS applications are characterized by standardization of data, metadata and services and cross-platform capabilities where the exchange and analysis of geographical information is easy, direct, economical and efficient (Pispidikis and Dimopoulou, 2015). It represents a significant milestone in the development of GIS by changing the way geospatial information is acquired, transmitted, published, shared and visualized (Fu and Sun, 2012).

However, a normative inclusion of GIS, let alone, web GIS as a consistent component of education policy and planning is not yet reached (Fransen et al., 2014). An analysis of a number of studies in education planning using GIS shows that most of them have concentrated in mapping and optimal distribution of pre-school, primary and secondary schools (Kuria et al., 2011; Mulaku and Nyandimo, 2011; Shahraki et al., 2015). Those delving in higher education have largely restricted their work to teaching with and about GIS, and to a larger extent in universities (Sinton, 2009; Jo et al., 2016; Bearman et al., 2016; Srivastava, 2013). It can be argued that the traditional role of educational planners is not only shifting from merely planning for school places to that of improvement of quality of education, but also to a “quasi-market” where there is open enrolment in training institutions (Langley, 2010). This presupposes provision of up-to-date data on training institutions to prospective candidates.

Cognizance of the aforementioned developments, the management in the case study undertaken in this study set up the Accreditation and Quality Assurance (AQA) function to spearhead accreditation, monitoring and analysis of the quality of training.

METHODOLOGY

Study area

The study area comprised the 47 counties of Kenya. Kenya lies approximately between 5°26'19.21"N to 4°41'37.54"S and 33°54'18.46"E to 41°42'19.46"E latitude and longitude respectively, and has an area of 581,309 square kilometres (km²). Purposive sampling, a non-probability sampling technique was used in which all the training institutions in Kenya (equivalent to 96.67%) were selected (Table 1). The study area was chosen for two reasons; the majority of training institutions were located in Kenya and that the number of institutions was not large enough to warrant the use of probability sampling techniques.

To provide the context for *Accreditation Web App*, Kenya counties map (Figure 1) was customised using ArcGIS for Desktop application and used as the secondary base map upon which the other operational layers such as the accredited training

Table 1. Proportions of training institutions in and outside Kenya (Source: Prepared by authors from data provided by KASNEB).

Total number of accredited training institutions	Number of training institutions based in Kenya	Number of training institutions outside Kenya
180	174	6
100%	96.67%	3.33%

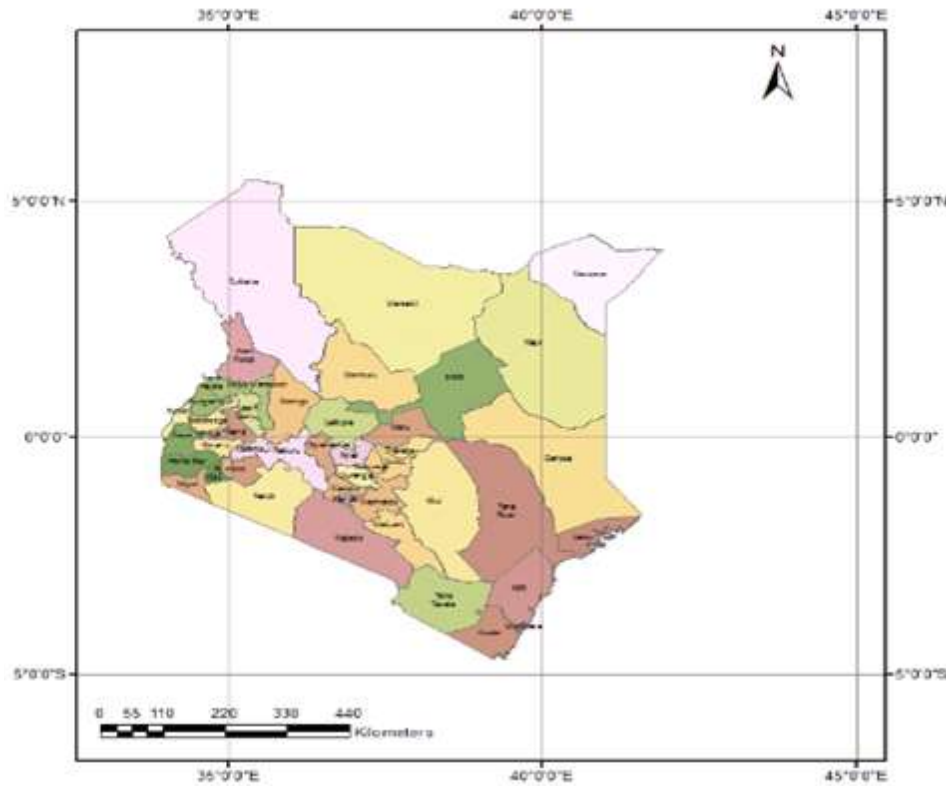


Figure 1. Map of Kenya showing the administrative boundaries of counties (source: OpenStreetMap).

institutions and examination centres were overlaid.

Methods and data

Figure 2 shows the steps followed in the development of the accreditation web app. The first stage of this research project was qualitative in nature. It focused on establishing the user requirements for the web GIS application by exploring the process of accreditation. This was carried out through actual visits to the AQA function and through unstructured individual interviews with personnel in the section.

For this purpose, a snowball sampling procedure was used where the researcher approached the head of Examinations Division and requested him to provide a staff member within the AQA function who possessed in-depth knowledge on the accreditation process. The data collected was both spatial and attribute data. ArcGIS for desktop application was used to create feature classes (Table 2) of the data collected.

In addition, the authors carried out desktop investigations in order to fully understand the instruments used in accreditation and also to obtain the various tools used in the process such as Accreditation Guidelines. The data collected at this stage constituted the primary data for this research project. The process of accreditation was summarised as shown in Figure 3.

A vital component of planning an information system is the review of the existing and required data to match the needs of the system that we wish to set up (Attfield et al., 2002). In the second stage, data was collected on training institutions. Data on accredited/non accredited training institutions were available on hard copy documents contained in files while the accreditation reports were in form of word documents. The data collected during this stage were both spatial and quantitative in nature.

Thirdly, spatial data collected were digitized using Google Earth application. This application uses the Keyhole Markup language (KML) encoding standard. KML is an XML which focuses on the visualization of geographic information, including notes on maps and images (Pispidikis and Dimopoulou, 2015). KML is recognised

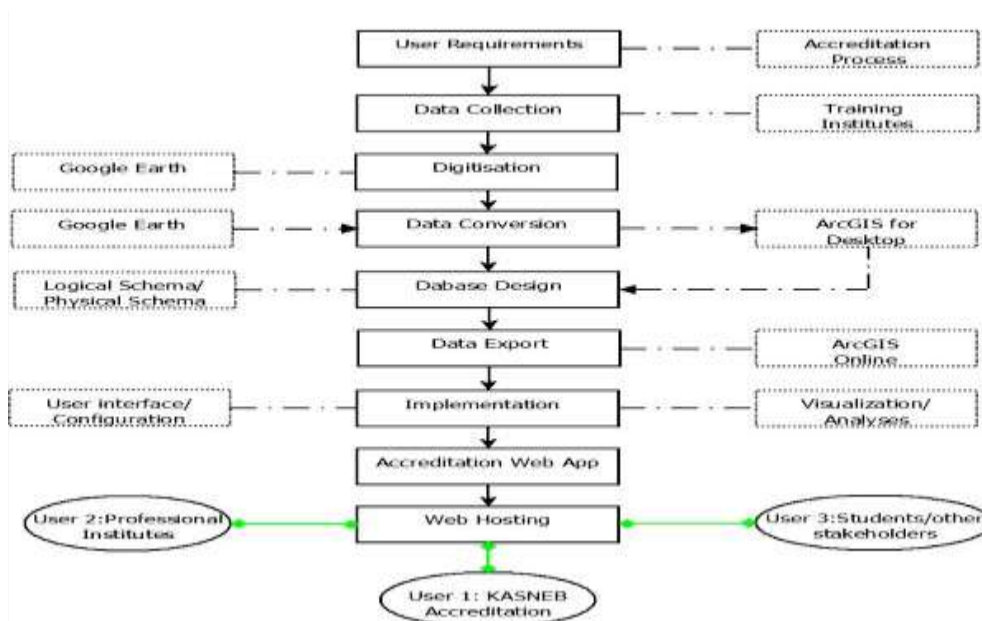


Figure 2. Phases in the development of the web application.

Table 2. Feature classes used to create the accreditation Web App database.

Feature class	Field	Field type
Training institution	Name	Text
	ObjectId	OID
	Shape	Point
	County	Category
	Town	Text
	Telephone	Text
	E-mail	Text
	PopUpInformation	Text
Accreditation details	ObjectId	OID
	Status	Category
	Certificate No.	Short Integer
	Date Issued	Date
	Expiry Date	Date
	Courses Approved	Text
Accreditation visits	ObjectId	OID
	Visit type	Subtype
	Date Visited	Date
	Grading	Category
County	Name	Text
	ObjectId	OID
	Shape	Polygon
	Area	Float
Roads	Name	Text
	ObjectId	OID
	Shape	Line

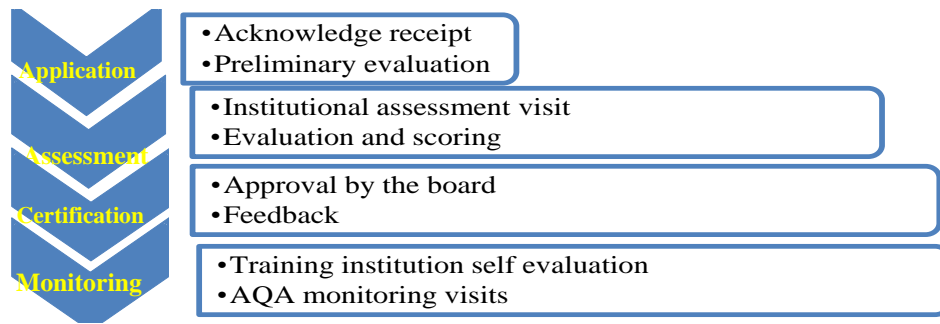


Figure 3. Simplified diagram showing the accreditation process (Source: designed by authors).

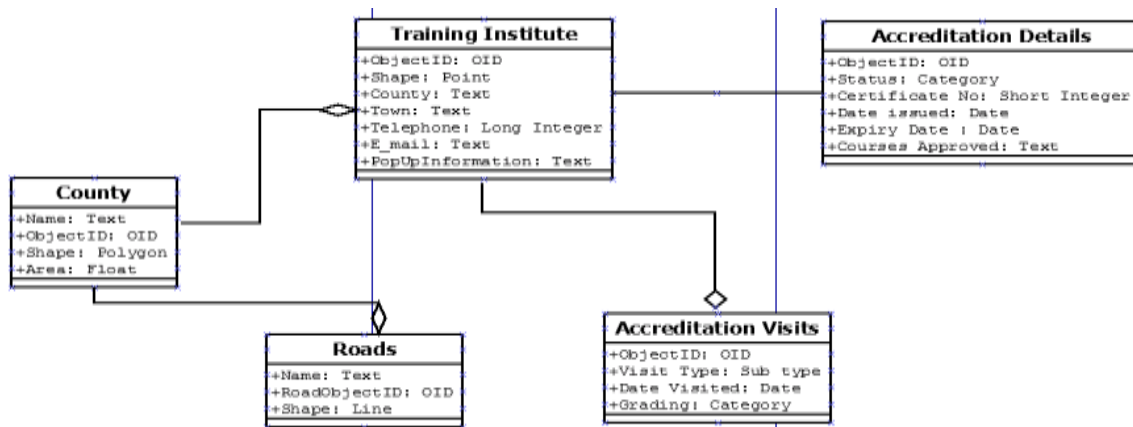


Figure 4. Logical database design.

by World Wide Web consortium (W3C). In addition, Google Earth uses a standard spatial reference system; WGS 1984 Web Mercator in which GPS is also based. The data captured above was then converted into layers and feature datasets using ArcCatalog application. For this purpose, a “KML into Layer” geoprocessing conversion tool was employed. In order to maintain data consistency the same spatial reference system was used in the conversion stage. The projection used for all the spatial reference data in this study was WGS 1984 Web Mercator (auxilliary sphere).

In the fourth stage, a logical database design (Figure 4) was created that informed the physical design for this project. The logical design was then converted to a physical design using ArcGIS for Desktop application. Next, a design for the web map was created. This included creating a base map and operational layers and framing how layers would be overlaid.

Finally, the web map was exported to ArcGIS Online. The ArcGIS Online platform’s rich and flexible infrastructure was leveraged to customize the web map created in ArcGIS for Desktop application. This included further editing and organization of the content and related operational layers. HTML pop ups were also used to customize the application in order to render it user friendly on the web. The web app was configured into a web app application – The accreditation web app to be used by KASNEB Accreditation and Quality Assurance unit, professional institutes, students and interested stakeholders. A user downloads the web app using a

desktop computer, a laptop or a mobile device. The application features pop-ups that provide accreditation and institute details including geotagged images. The application further enables a user to perform queries, filters, and reports and provides usage statistics.

RESULTS

A mashup web application was created depicting the training institutions. Figure 5 shows part of the interface to this application. On accessing the Accreditation web app, a user can click on any of the three tabs; About, Legend and Layers. The first tab provides more details on the app, the third shows the app layers from where a user can navigate to other functionalities, and the second provides a legend for the currently selected layer.

The application features various forms of visualization. Figure 6 shows that training institutions cluster around Nairobi County, the counties in central and north of Rift Valley and those of Western and Nyanza regions. In the other counties of Kenya, training institutions are either sparsely distributed or are non-existent. Figure 7 provides a comparison between spatial locations of training

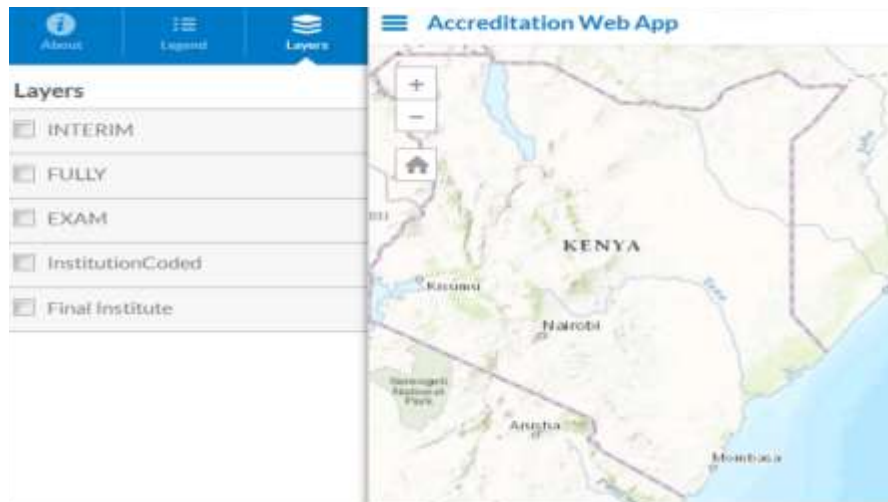


Figure 5. Layers interface showing how to populate the map with accredited institutions and exam centres.

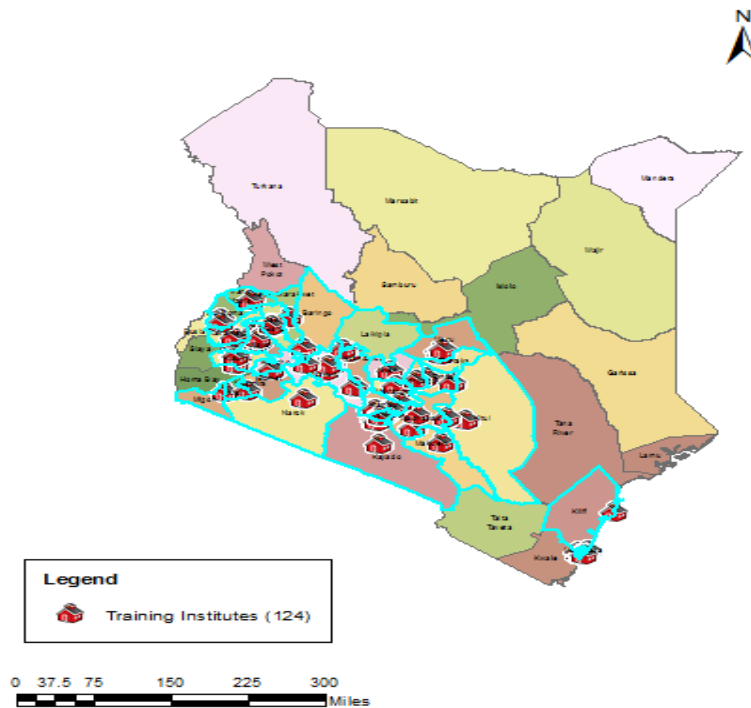


Figure 6. Distribution of training institutions in Kenya with a cyan outline showing the counties with at least a training institution.

centres *vis a vis* examination centres. While the spatial distribution patterns of examination centres largely mirror that of training institutions, Figure 7 shows that examination centres are more sparsely distributed. Similarly, a user could also use the app to visually display

using contrasting symbology fully accredited training institutions versus those with interim accreditation.

Pop-ups were used to display basic information and accreditation status. When a user points to a feature representing a professional institute, details on the type

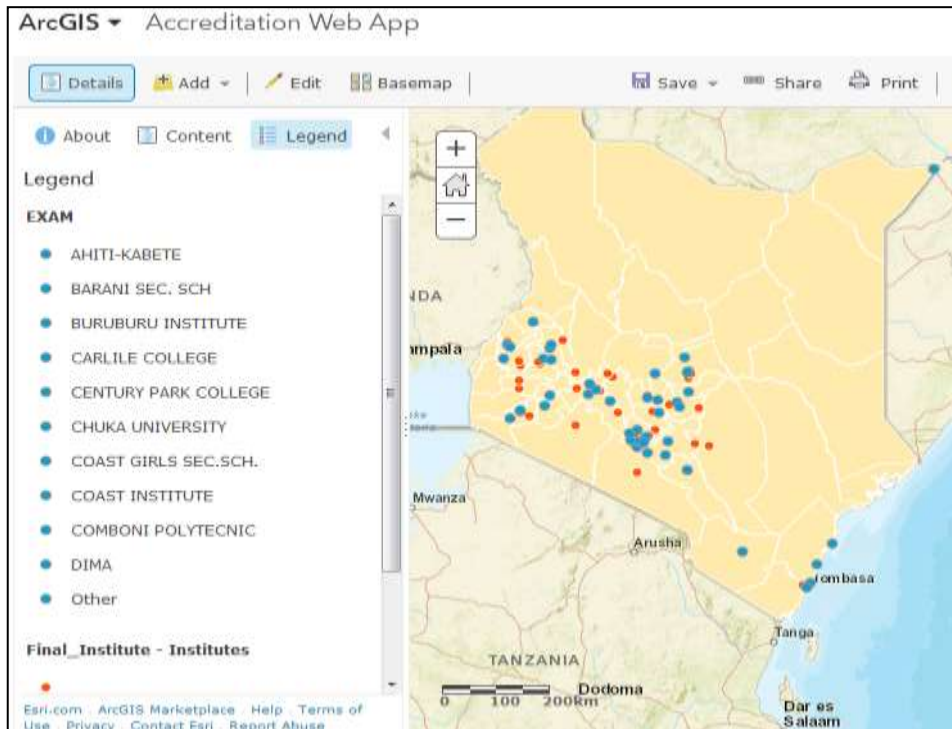


Figure 7. An extract map showing relative proximity of training institutes (pink) from examination centres (blue).

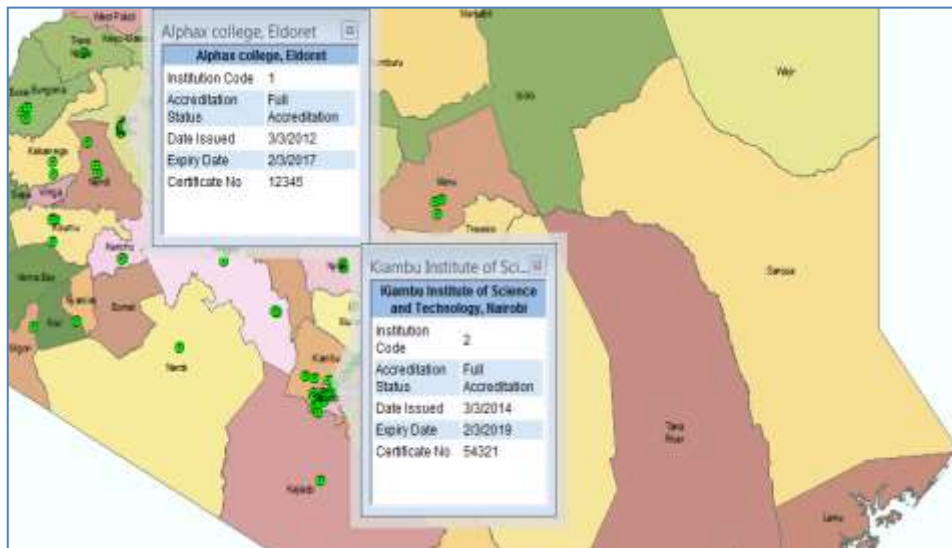


Figure 8. HTML pop-up menus showing basic information and accreditation status of a training institution.

of accreditation, the date of accreditation, expiry date and certificate number are displayed (Figure 8). Pop-ups also include linked attachments that display the institute's

premises as well as the certificate of accreditation (Figure 9).

Polygon features representing counties are linked to a

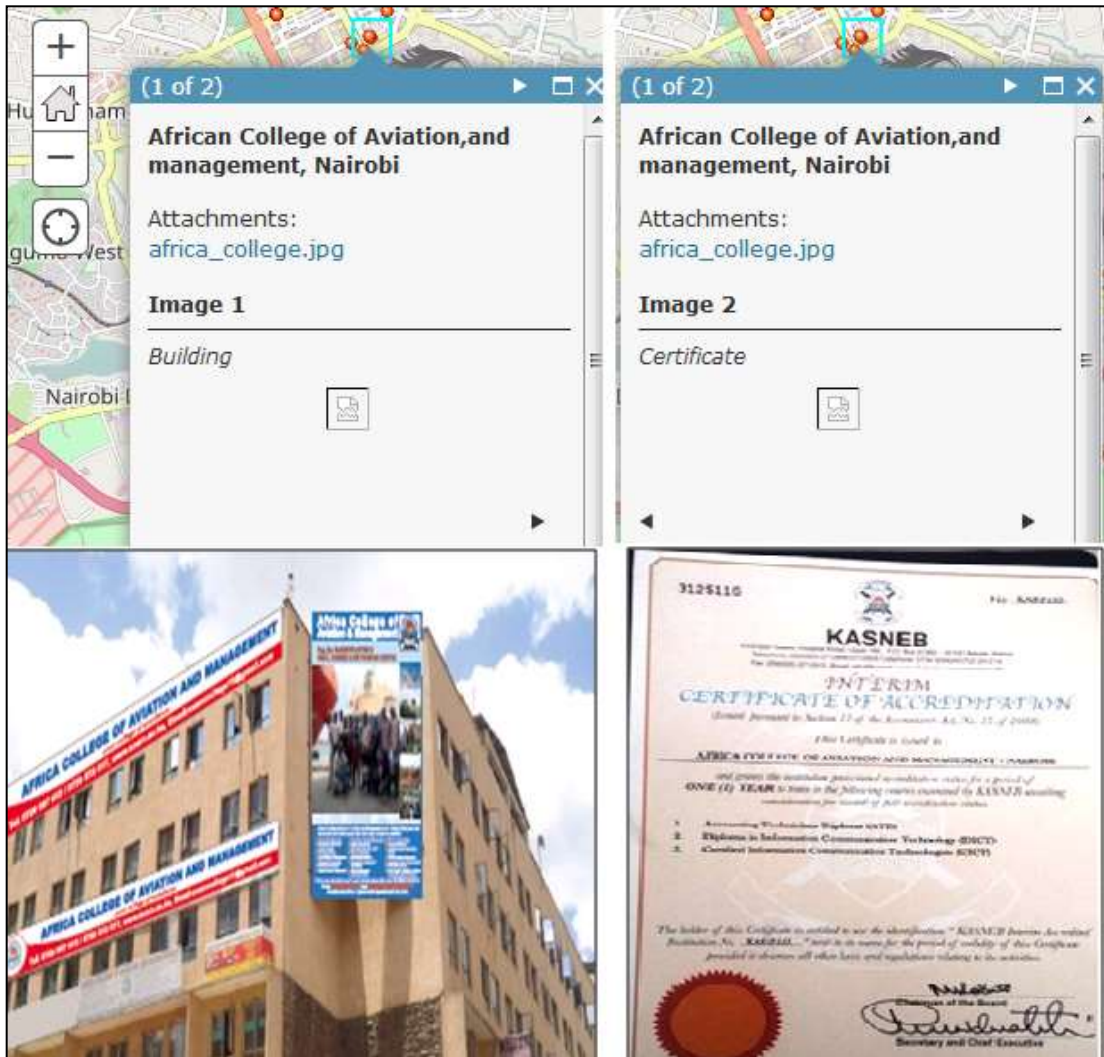


Figure 9. Linked attachments showing institute building and the accreditation certificate.

universal corresponding resource locator (URL) that provides a user with more details on a specific county (Figure 10). This will require a user to click anywhere within a polygon representing an institution. Alternatively the search button enables one to key in the name of institution or county and the system searches for the respective object.

The application also provides routing services that are critical to officers conducting accreditation visits. Figure 11 demonstrates how a user can key in the name of a training institution and receive route directions. By zooming in on an identified location, a user can view the road network to the training institution, the adjacent buildings among other street view options (Figure 12). This will make it easy for the accreditation assessment team visiting an institution to quickly locate the institution

by using the web app. Other functions provided by the application include queries and filters that could be used to create various reports for the Accreditation and Quality Assurance function. For example, a filter could be generated of all fully accredited institutions grouped by county.

DISCUSSION

According to Fu (2015), a web GIS application should “enhance necessary functionality with a pleasant user experience that makes it fast, easy and fun to use”. During the design of this app, effort was geared towards providing the user with as pleasant an experience as possible without losing the necessary functionality. The



Figure 10. HTML pop-up that links a user to more details of a county.

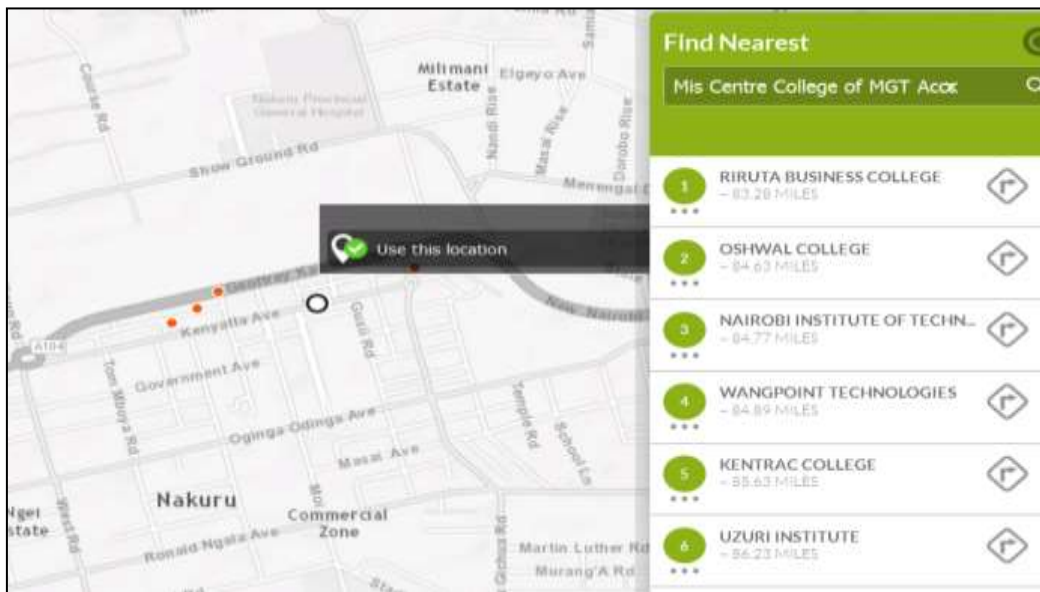


Figure 11. Use of the application to find the route to a training institution.

ability to visually display spatial data allows us to see patterns that would have otherwise been less clear were it is to be presented orally, in text format or using tables and graphs. The resulting spatial pattern could facilitate a more efficient and effective decision making. Steinberg and Steinberg (2015) argue that this enables an organization to “gain spatial advantage” as the potential impact of the ability to share information visually and verbally could be much greater. In Figure 6 for instance, the following Select function was used to disaggregate

and show counties where there was at least training institute using a cyan outline:

```
SELECT by location features from Target = County
WHERE Source layer = Training Institute SpatialMethod
= Intersect the source layer feature
```

The distribution pattern could indicate that majority of citizens in other counties were not aware of KASNEB examinations, there were no investors in these counties



Figure 12. Pop-up showing road networks on zooming in on a training institution .

or the level of income was too low to allow students to enroll for the courses. It is therefore an indicator that further investigation needs to be carried out in order to establish the facts leading to this pattern. The existence of examination centres in areas with no training institutions (Figure 7) could inform the planning of examinations centres.

The main use of GIS is the easy visualization of data (Langley, 2010). GIS software displays digital images of mapped objects and their attributes, allowing us to easily visualize spatial patterns from large, complex, multi-layered data sets (Sinton, 2009). The prototype app developed in this study combined several operational layers. From these layers, ArcGIS for Desktop for Developer geoprocessing tools were used to show various patterns that could serve as catalysts for further investigation. Subsequently, they could become useful tools for making informed decisions. For example, the patterns seen in Figure 6 indicate that training institutions are established in cities and big towns. This analysis could be used to feed into market research on the causes of this trend.

A simple yet quite powerful analytical tool is cartographic classification (Steinberg and Steinberg, 2015). This is a scheme used to classify different types of features or data. In this study, symbology in ArcGIS was used with dots in different colours depicting the spatial distribution of accredited training centres and examination centres (Figure 7). Similar depictions such as juxtaposing fully accredited and interim accredited institutions on one map can be executed using the app.

Further customization of the application could include ratios on teachers/students, students/toilets, books/students, library/students among others. Performance of various training institutions could also be analysed visually so that investigations may be undertaken on weak institutions and benchmarks recommended for well performing institutions.

CONCLUSION

A web GIS application, *The Accreditation web App*, was developed. The application was developed using various GIS software. For spatial locations of training institutions, Google Earth was used. ESRI's ArcGIS for Desktop and ArcGIS Online applications were then employed in designing and editing a geodatabase and configuring the application respectively. The app has shown that various patterns can easily be gleaned and therefore serve as catalysts for further investigation and subsequently be used in making informed decisions. It serves as an enabling factor in planning the assessment and monitoring of professional institutes for quality assurance.

The application affords policy makers at KASNEB an instant grasp of the spatial distribution patterns of the accredited training institutions. This visualization is critical to the organization in terms of taking spatial advantage through crafting informed marketing strategies as well as in developing informed policies. It makes assessment and monitoring of institutions not only easier, but also efficient by use of route analysis. Training institutions

applying for accreditation could use the application to track their accreditation status. In addition, training institutions can use the app to apply for accreditation online by uploading the relevant forms. For fully accredited institutions, they could query the app for expiry dates of their accreditation certificates. Further, they could easily upload the annual self-monitoring forms.

On the other hand, current and potential students looking for a training institution can quickly search for an accredited institution within a given county offering a specific course. The app also addresses some of the current challenges at the AQA function by among others, reducing to a minimum the tedious paper work inherent in the current system. Further, it reduces the turnaround time between an institution's application for accreditation and issuance of an accreditation certificate from the current period of twelve months to at most three months making the process not only efficient but also effective.

This research demonstrates the important role web GIS could play not only in accreditation of training institutions but also in other fields in education with the overall goal of improving the quality of education. Further work involving integration of the app with existing systems and enhancing security of the application could be undertaken to give the user a delightful accreditation experience.

ACKNOWLEDGEMENT

The authors wish to thank KASNEB for providing the data required to undertake this study.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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