ABOUT JGRP

Journal of Geography and Regional Planning (JGRP) is a peer reviewed open access journal. The journal is published monthly and covers all areas of the subject.

Journal of Geography and Regional Planning (JGRP) is an open access journal that publishes high-quality solicited and unsolicited articles, in all areas of Journal of Geography and Regional Planning such as Geomorphology, relationship between types of settlement and economic growth, Global Positioning System etc. All articles published in JGRP are peer-reviewed.

Contact Us

Editorial Office: jgrp@academicjournals.org
Help Desk: helpdesk@academicjournals.org
Website: http://www.academicjournals.org/journal/JGRP
Submit manuscript online http://ms.academicjournals.me/
Editors

Prof. Prakash Chandra Tiwari,
Department of Geography, Kumaon University,
Naini Tal,
Uttarakhand,
India.

Dr. Eugene J. Aniah
Department of Geography and Regional Planning,
University of Calabar
Calabar,
Nigeria.

Dr. Christoph Aubrecht
AIT Austrian Institute of Technology
Foresight & Policy Development Department
Vienna,
Austria.

Associate Editor

Prof. Ferreira, João J
University of Beira Interior - Portugal.
Estrada do Sineiro – polo IV
Portugal.

Prof. Helai Huang
Urban Transport Research Center
School of Traffic and Transportation Engineering
Central South University
Changsha,
China.

Dr. Rajesh K. Gautam
Department of Anthropology
Dr. H.S. Gour University
Sagar (MP)
India.

Dr. Martin Balej, Ph.D
Department of Development and IT
Faculty of Science
J.E. Purkyne University
Ústí nad Labem,
Czech Republic.

Dulce Buchala Bicca Rodrigues
Engineering of Sao Carlos School
University of Sao Paulo
Brazil,

Dr. Christoph Aubrecht
AIT Austrian Institute of Technology
Foresight & Policy Development Department
Vienna,
Austria.

Shaofeng Yuan
Department of Land Resources Management,
Zhejiang Gongshang University
China.

Editorial Board Members

Prof. Nabil Sayed Embabi
Department of Geography
Faculty of Arts
Ain Shams University
Cairo,
Egypt.

Prof. Nabil Sayed Embabi
Department of Geography
Faculty of Arts
Ain Shams University
Cairo,
Egypt.

Shaofeng Yuan
Department of Land Resources Management,
Zhejiang Gongshang University
China.
Editorial Board

Dr. S. K. Florentine
Centre for Environmental Management
School of Science and Engineering
University of Ballarat
Victoria
Australia.

Richard Ingwe
Centre for Research & Action on
Developing Locales, Regions and
Environment (CRADLE)
Calabar, Nigeria.

Dr. Eze B. Eze
Department of Geography and Regional Planning
University of Calabar
Calabar,
Nigeria.

Cosmina-Simona Toader
Faculty of Farm Management
Banat’s University of Agricultural Sciences and Veterinary Medicine
Timisoara,
Romania.

Ladislaus Chang’a
Tanzania Meteorological Agency
Tanzania.

Assoc. Prof. Shan-Zhong Qi
College of Population, Resources & Environment
Shandong Normal University
Jinan,
China.

Dr. Salman Qureshi
Department of Geography,
Humboldt University of Berlin
Germany.

Panagiotis Zervopoulos
Department of Economic and Regional Development
Panteion University of Athens
Greece.

Dr. Ghassem Habibi Bibalani
Islamic Azad University
Shabestar,
Iran.

Dr Emenike Gladys
Department of Geography and Regional Planning
University of Port Harcourt
Port Harcourt,
Nigeria.
# ARTICLES

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficacy of forest resources governance on REDD+ performance in Uvinza district, western Tanzania</td>
<td>119</td>
</tr>
<tr>
<td>John E. Makunga and Salome B. Misana</td>
<td></td>
</tr>
<tr>
<td>Spatial analysis of the petrol stations in Khan-Younis city using geographic information system (GIS) techniques</td>
<td>133</td>
</tr>
<tr>
<td>Odeh Jameel El Faleet</td>
<td></td>
</tr>
<tr>
<td>Geospatial based biofuels suitability assessment in Ethiopia</td>
<td>148</td>
</tr>
<tr>
<td>Tenaw Geremew, Mitiku Adisu and Tamene Mengistu</td>
<td></td>
</tr>
<tr>
<td>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</td>
<td>163</td>
</tr>
<tr>
<td>Majid Khan, Puangkaew Lurhathaiopath and Shusuke Matsushita</td>
<td></td>
</tr>
</tbody>
</table>
Full Length Research Paper

Efficacy of forest resources governance on REDD+ performance in Uvinza district, western Tanzania

John E. Makunga 1* and Salome B. Misana 2

1 Ministry of Natural Resources and Tourism, Pasiansi Wildlife Training Institute, Mwanza, Tanzania.
2 Department of Geography, University of Dar es Salaam, Dar es Salaam, Tanzania.

Received 13 February, 2017; Accepted 20 March, 2017

This paper presents findings of a study on the effectiveness of forest resource governance on the performance of the REDD+ project in the Masito-Ugalla ecosystem in Uvinza district, western Tanzania through transparency, accountability, participation and integrity. The study was conducted in Ilagala, Karago and Kirando villages with the objective of understanding the effects of forest resources governance on REDD+ project performance as well as examining the best ways of integrating forest resource governance with REDD+ projects. The methods used in the study included household interviews that used a structured questionnaire, semi-structured interviews and focus group discussions. Semi-structured interviews were used to gather qualitative data from key informants. The findings revealed that despite the efforts undertaken by REDD+ initiative in Masito-Ugalla ecosystem, its performance was generally average. Such performance was due to the support rendered by JUWAMMA, the inter-village community based organization, to the REDD+ project activities in the area. Poor forest resources governance had, however, continued to hamper its performance. Minimal duration of operation of the REDD+ Project and dominance of politics in conservation matters were the major reasons for its poor performance. Embezzlement of funds by politicians and senior government officials also contributed to the bad performance of the project. Villagers were also seldom engaged in decision-making. Implementing accountability by setting standards would have improved forest resources governance in the study area. The study concludes that more transparent budgeting and public procurement is inevitable for achieving good REDD+ performance. REDD+ activities also need to be addressed openly, with legal measures being taken by responsible authorities against corruption.

Key words: Forest resources governance, REDD+ in Tanzania, REDD+ projects performance, Masito-Ugalla ecosystem.

INTRODUCTION

Understanding the relationship between forest resources management governance and the needs of local communities is an essential step for successful REDD+ performance. Local communities are perceived as direct
users of forest resources, therefore, improving governance in such resources is inevitable. Forest resources governance aims at addressing governance issues regarding forest resources and the environment with the overall objective of ensuring sustainable economic growth, adaptation to climate change and variability, poverty alleviation, and improving environmental protection through avoided deforestation. The World Bank (2015) revealed that governance can be good or bad.

According to IFAD (1999), good governance is “the manner in which power is exercised in the management of a country’s economic and social resources for development”. In contrast, bad governance is the one associated with corruption, distortion of government budgets, inequitable growth, social exclusion, and lack of trust in authorities. Lipari (2011) for example, pointed out that poor governance was among the most important causes of state failure and underdevelopment.

Springate-Baginski and Wollenberg (2010) pointed out that achieving ‘good forest governance’ for REDD+ is an agenda that covers more than the institutional construction for administering funds and monitoring results. To them, good governance involved a range of issues, including recognition and enforcement of forest, land or carbon rights (including those of indigenous groups), participation of forest communities and civil society in policy processes, institutional arrangements and setting management priorities, transparency and accountability.

In Tanzania, URT (2013a) revealed that the national REDD+ strategy of 2013 and action plan have been developed to direct implementation of REDD+ activities in the country. Key issues addressed included:

1. Establishment of baseline, monitoring, reporting and verification system
2. Financial mechanism and incentive schemes
3. Stakeholders engagement
4. Coordination of REDD+ schemes
5. Financing options
6. Governance
7. Training and infrastructure for REDD+
8. Researches
9. Information and communication system and
10. Strategies to address drivers of deforestation and forest degradation.

The URT (2013a) further reported that the National Framework for REDD+ was the foundation for developing the REDD+ strategy. Burgess et al. (2010) reported that extensive forest cover and alarming deforestation rates in Tanzania were established as the key motivators for the establishment of REDD+ initiatives.

The Masito-Ugalla ecosystem (MUE) in Uvinza and Kigoma Districts has potential for carbon storage and sequestration, and thus significant for climate change and variability mitigation and poverty alleviation if forests are used in a sustainable manner (Indufor, 2014). Because of this potential, one of the pilot REDD+ projects in Tanzania namely, Building REDD+ Readiness in the Masito-Ugalla Ecosystem (MUE) Area in Support of Tanzania’s National REDD+ Strategy (the JGI pilot project), was implemented there.

A report by IUCN-Tanzania (2013), revealed that in most REDD+ Project sites, implementing non-governmental (NGOs) had successfully facilitated the development of village by-laws to guide the implementation of REDD+ pilot activities that were approved by District Councils. The development of by-laws was followed by the provision of training on good governance to members of the Village Natural Resource Council and Village Governments. In all forest communities, fines acquired from illegal forest activities as stipulated in by-laws were identified as a source of funds for conservation purposes. On the other hand, communities had been facilitated to form and register community-based forest organizations (CBOs) to carry out the management of forest resources now and after the end of pilot REDD+ activities. A good example of these community organizations was the "JUWAMMA" under JGI REDD+ in Kigoma Region. CIFOR (2014) reported that the objective of JUWAMMA in the study area was to reduce deforestation and forest degradation driven by a demand for agricultural land and fuel-wood. Another activity was a replicable methodology for remote sensing/GIS based forest and carbon accounting. Indufor (2014) mentioned such other activities as empowerment of cadre of local trainers comprised of stakeholders that facilitate broad stakeholder participation in REDD+ project design and management; provision of communities and CBOs with the tools and skills to monitor forest biomass and carbon stocks as well as development and practice of community based equitable benefit sharing mechanism.

The goal of this study was to improve understanding of the contribution of forest resources governance in reducing deforestation, achieving biodiversity conservation, reducing climate change and variability and alleviating poverty. Specifically, the study sought to investigate the effects of forest resources governance on the REDD+ project performance and examine the best ways of integrating forest resource governance with the REDD+ project.

MATERIALS AND METHODS

Study area

This study was conducted in Ilagala, Karago and Kirando villages along the shoreline of Lake Tanganyika, in Uvinza District, Western Tanzania (Figure 1). This district is confined within the Masito-
Ugalla ecosystem (MUE), which is an expansive forested landscape of approximately 10,827 km² (Deloitte, 2012). It is within this district, where the pilot REDD+ project has operated for three years (January, 2010 to December, 2012), in western Tanzania.

According to Svoboda and McNamara (2009), the study area is characterized by sedimentary rocks and well-cemented sandstones of the uppermost geologic formation, which are resistant to weathering. Other types of rocks include limestone, shale, siltstone, quartzite and volcanic rocks.

The topography of Masito-Ugalla Ecosystem is characterized by canyons, cliffs and flat-topped hills (Moyer et al., 2006). Much of the valley floor landscape contains actively flowing small streams, minerotrophic wetlands, and relatively forested areas. Accordingly, a large part of this ecosystem is drained by the Malagarasi and Lugufu river systems, which flow into Lake Tanganyika. Ugalla River is the major tributary to Malagarasi River in the east (Svoboda and McNamara, 2009) (Figure 1).

The area is characterized by seasonal tropical climate with a distinct long wet season beginning from late October to May and a short dry spell of 2 to 3 weeks in January or February followed by a prolonged dry season (URT, 1998; Svoboda and McNamara, 2009). According to URT (1998), annual rainfall varies from 600 to 1500 mm, being intense in the highlands, intermediate in lower slopes and low in valley bottom and lake-offshore areas. The mean maximum temperatures of between 21°C and 30°C and mean minimum temperatures of between 15°C and 21°C have been described within the larger eco-region (Svoboda and McNamara, 2009).

According to URT (1998) the soils along the lake shore are deep and well drained and comprise dark reddish brown fine sandy loam. The heavy black clay soils are found in permanently water logged areas. In the low relief areas the soils are dark reddish clay loams with fairly good internal drainage while the black and brown alluvial soils are mostly found in areas of high relief (URT, 1998).

The vegetation in Uvinza district comprise closed and open woodlands, which cover about 70% of the land area, as well as bushy grassland and swamps of various coverage (Svoboda and McNamara, 2009). The study area is a dry area dominated by miombo woodlands with Isoberlinia, Julbernadia and Brachystegia trees, with Brachystegia bussei often found on the steep slopes of the eroded canyons (Moyer et al., 2006). In valleys, which are generally steep walled along streams, there are gallery forests, which remain green throughout the year and it is where chimpanzees obtain much of their food. Grasslands or sclerophyllous vegetation are adapted for low rainfall (Moyer et al., 2006; Svoboda and McNamara, 2009).

Agriculture is the predominant economic activity in the study area. The major food crops grown in the district are maize, paddy, cassava, bananas, beans and sorghum while cash crops include cotton, coffee, tobacco, oil palm and groundnuts (URT, 1998). Livestock keeping is another major economic activity in the study area, the most important types of livestock being cattle, sheep and goats.

Forestry products include timber, building materials, charcoal, fuel wood, honey and beewax. According to the URT (1998), the study area has plenty of fish in the Lake Tanganyika and Malagarasi River. Beekeeping is also another socio-economic activity conducted in the study area. Deloitte (2012) reported that promoting beekeeping as an income generating activity had achieved significant success providing training to villages on improved techniques reaching over 425 beekeepers and financing over 210 bee hives. URT (1998) revealed that people in the study area
area were also involved in industrial and trade activities including the Uvinza salt mine, soap making, palm oil and palm kernel oil extraction and printing to mention but a few.

Sigungu, Sunuka and Ilgala wards, in which the study villages were sampled have a population of 20,455, 36,023 and 47,026 people, respectively (URT, 2013b). The main indigenous ethnic group for Uvinza District (including all other districts in the region) is the Waha. Other tribes are Bembe, Tongwe and a mixture of ethnic groups such as Nyamwezi, Sukuma, and Fipa from Tanzania mainland and some people with origins from the neighbouring countries such as Congo, Rwanda and Burundi (URT, 1998).

Data collection methods

Different data collection methods and techniques were employed. The methods included household interviews, semi-structured interview and focus group discussion. The use of different methods (that is, triangulation) was meant to allow verification of the results and improve confidence in the research findings. According to Patton (1999), triangulation also has been viewed as a qualitative research strategy to test validity (that is, checking out the consistency of findings) through the convergence of information from different sources.

Household Interviews

Household interviews were conducted using structured questionnaires in order to capture quantitative information about socio-economic data and other relevant information. The questionnaire consisted of both open and closed-ended questions. Different types of data were collected using this method, including elements of forest resources governance such as participation, transparency, integrity, accountability and institution structures. Other types of data were concerned with effects of natural resources governance on REDD+ performance. The sample size was drawn at 90% confidence interval corresponding to a level of significance α. With such level of significance, the margin of error (E) or the probability of committing an error was therefore ± 10% or ± 0.1 (Smith, 2013). Households were used for drawing the sample size (n). The total number of households (N) in the three villages was 11,632. This study was conducted without knowing the population's behaviour, (that is, it was not possible to quantify the population standard deviation).

Therefore, Slovin’s formula (Word Press, 2014) was adopted for obtaining the sample size, such that: \( n = \frac{N}{1 + Ne^2} \), where “n” is the sample size, “N” is the total population (for this case, the households) and “e” is the error tolerance or margin of error.

The sample size was thus determined as follows:

\[
\begin{align*}
    n &= \frac{N}{1 + Ne^2} \\
    &= \frac{11,632}{1 + 11,632 \times 0.1^2} \\
    &= \frac{11,632}{117.32} \\
    &= 99.15
\end{align*}
\]

Therefore, 99 respondents were considered as the sample size for this study. Two more respondents were included above the calculated sample size, giving a total of 101 respondents due to easy availability of extra respondents before accomplishment of the questionnaire survey exercise. The sampling procedure was accomplished using non-probability random sampling. The sample population was drawn from a list of households obtained from Kigoma Regional Commissioner’s Office, each household representing one respondent. In every household only one adult respondent was picked. The actual population was not preferred due to the fact that it included people of different ages, even those aged below 18 years, which was the lower limit of the respondent’s. Thus every household which was accessed was picked and included in the sample population.

Semi-structured interviews

Semi-structured interviews were used to gather qualitative data from key informants. In this study, the key informants comprised of one village chairperson, two village executive officers, one ward executive officer; one “JUWAMMA” leader, one forest monitor responsible for conducting field patrols, one fire breaker responsible for controlling wildfires and a district natural resources officer (DNRO). There were eight (8) key informants from whom information was obtained. Different types of data were collected using this method; these included; benefits obtained from the project and effects of natural resources governance on REDD+ performance.

Focus group discussions (FGDs)

Focus group discussions were used to collect qualitative data. The FGDs involved two processes, which were brainstorming and discussions. There were four focus groups comprising 10 individuals each. The first group included farmers; the second one represented women as the major forest resource users; the third group consisted of businessmen; and the last focus group represented honey gatherers. The units of data, which included statements from the focus groups, were recorded using a smart phone; digital camera; notebook and pen. The types of data, which were collected using the FGD method, were the effects of natural resources governance on REDD+ performance. FGDs method (Patton, 1999), was used for comparing viewpoints of different people.

Data analysis

Both quantitative and qualitative data analysis approaches were used in the analysis of the data collected to allow easier interpretation of numerical and respondents’ perceptions, respectively. Quantitative data analysis was accomplished using IBM Statistical Package for Social Sciences (SPSS), version 20.0. Qualitative data, which involved those obtained using FGDs and semi-structured interviews, were analyzed using content analysis (GAO, 1989; Stewart and Shamdasani, 2017).

As reported by Hsieh and Shannon (2005) content analysis is a widely used qualitative research technique, and one of the approaches used under this kind of analysis is conventional content analysis in which coding categories were derived directly from the text data.

RESULTS AND DISCUSSION

Performance of REDD+ project in the study area

There were mixed feelings about the performance of
REDD+ in the Masito-ugalla ecosystem. For example when asked whether REDD+ project attained a good performance or not, 24.4% of the respondents revealed that it resulted into a good performance, 22.9% reported that it performed poorly, while only 0.5% were not sure. However, 52.2% of the respondents did not respond on whether or not REDD+ project had attained good performance. Based on the responses on REDD+ performance, respondents were asked to state the reasons for good performance of REDD+ as well as its poor performance. For the good performance, majority (67.3%) said that it had provided them with conservation education, 28.8% of the respondents said it had empowered people to conduct income generating activities. Very few reported that the project had improved social services and also maintained soil fertility.

On the contrary, 53.2% of the respondents revealed that the major reasons for REDD+ project’s poor performance was its minimal operation duration. Another dominant reason reported by 23.4% of the respondents was the dominance of politics in conservation matters. Some 14.9% reported about leaders’ selfishness. Other reasons such as inadequate facilities, insufficient education about REDD+ and lack of benefits to people were reported by very few respondents.

Some key informants explained that during REDD+ activities, there was a conflict of interest between Kigoma District Council and JUWAMMA leaders, especially on the setting of allowances during joint meetings, which were held in Kigoma District involving JUWAMMA and government leaders. The District Council allegedly wanted to control the funds for the REDD+ project, based on the fact that Masito forest, which was the focus of REDD+ pilot project was not a village forest; rather it was a general land, meaning that village authorities had less control. Such conflict affected villagers’ sense of ownership of the forest, such that they continued engaging in illegal utilization of the forest resource, thus affecting REDD+ performance. In terms of the success attained by the REDD+ project, 42.6% of the respondents said that it had helped villagers in construction of classrooms and village offices (Figure 2). The other success which was reported by 33.7% of the respondents was improvements in conservation awareness. Improving people’s income through establishment of entrepreneurship groups was mentioned by 23.8% people (Figure 2).

**Effects of natural resource governance on REDD+ Performance**

Natural resource governance parameters that were analyzed were integrity (corruption), transparency, accountability and participation. According to Gberevbie et al. (2014) and O’Donnell (1999), good governance is supposed to be characterized by the respect for the rule of law, transparency, very limited corruption and accountability of all state officials. The findings from the REDD+ project in the Masito-Ugalla ecosystem, however, revealed that implementation of the project was marred by corruption, lack of accountability and limited
participation of the local communities as revealed in the sections that follow.

Existence of corruption during REDD+ project implementation

Corruption was one of the impediments to the performance of REDD+ project next to selfishness among government leaders. Majority of the respondents (81.2%) were aware about the existence of corruption during REDD+ project implementation. Only 14.9% of the respondents reported that corruption was not experienced and 4% were not sure whether corruption was experienced or not. When asked about the types of corruption which were experienced during REDD+ implementation, a number of the respondents (30.7%) reported that embezzlement of funds by politicians and senior government officials dominated during REDD+ project implementation (Table 1). This had the detrimental consequences of accelerating the violation of forest resource conservation by-laws among others. One key informant, for example, supported the idea that embezzlement existed during the REDD+ project implementation. He pointed out that such a situation was evident during the construction of Kabuyange Primary School, in Ilagala Village, where village leaders were allegedly involved in embezzlement of the project funds.

Out of Tsh 20 million which were allocated for construction of two classrooms and one staff office, Tsh 10 million were allegedly embezzled by a number of local leaders in comparison to other similar activities in other villages within the project area. The above results clearly indicate that some social development projects in the study area, which were supported by REDD+, were mainly constrained by embezzlement.

Fraud was mentioned by a few respondents. Other types of corruption such as land grabbing, nepotism and favouritism were also mentioned by some respondents (Table 1). An example of nepotism was Kabuyange Primary School, whose construction was assigned to a son of one of the government leaders at Ilagala Village, contrary to local contract procedures.

Although Tanzania continues to perform extremely poorly in Transparency International's Corruption Perceptions Index (CPI), ranked 102nd out of 180 with a score of 3.0, the 2006 afrobarometer survey indicated that the public perceived the level of corruption to have declined between 2003 and 2005. The World Bank's 2007 Worldwide Governance Indicators as reported by Anti-corruption Resource Centre (2009) also showed positive trends in terms of control of corruption, with a score of 43 compared to 19 in 2003. Progress has also been recorded in terms of voice and accountability while rule of law indicators remained stable (Kaufmann et al., 2008).

The main negative consequences of corruption, which were experienced during implementation of REDD+ project in the study area included an increase in violation of forest resources conservation by-laws, presence of income poverty and lack of social services. Other consequences mentioned were destruction of water catchment areas and deprivation of land tenure rights (Table 2).

The aforementioned findings are supported by Marmon (2009) who reported that in forest management corruption contributed to the uncontrolled depletion of forests and undermined on large scale political efforts to sustainably manage forests. Accordingly, it deformed public policies, leading to the misallocation of public funds. Illegal logging due to corruption caused social disruption due to the destruction of the living space of people and the ensuing deterioration of rural living conditions. It also affected the functioning of environmental services and the people who directly depended on them for their survival (Marmon, 2009).

Bivariate correlation analysis between reasons for the poor performance of REDD+ and existence of corruption (Table 3) indicated that there was a strong, positive correlation ($r = 0.135$, N = 46 to 97, $p<.371$). The strong positive correlation is revealed by the value of ‘$r’”, which is above 0.05, implying corruption was among the principal factors which exacerbated the poor performance of the REDD+ project (Table 3).

Transparency in sharing REDD+ Information

When asked about transparency criteria during sharing REDD+ information with local communities, 24.9% of the respondents showed that REDD+ information was accessed at minimal or sometimes without any cost. Others reported that transparency was relevant in terms of language and formats (11.2%). Very few individuals reported that information was timely to permit analysis and evaluation (2%) and accurate (1.5%). Also, very few respondents (2.9%) revealed that all four transparency
Table 2. Negative consequences of corruption during REDD project (N = 101).

<table>
<thead>
<tr>
<th>Negative impacts of corruption</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence of income poverty</td>
<td>29</td>
<td>28.7</td>
</tr>
<tr>
<td>Increase in violation of natural resources conservation laws</td>
<td>41</td>
<td>40.6</td>
</tr>
<tr>
<td>Lack of social services</td>
<td>9</td>
<td>8.9</td>
</tr>
<tr>
<td>Depletion of water catchment areas</td>
<td>5</td>
<td>5.0</td>
</tr>
<tr>
<td>Deprivation of land tenure rights</td>
<td>17</td>
<td>16.8</td>
</tr>
<tr>
<td>Total</td>
<td>101</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: Field data, 2014.

Table 3. Bivariate correlation analysis between reasons for REDD+ poor performance and existence of corruption (N = 101).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Reasons for REDD+ poor performance</th>
<th>Existence of corruption during REDD+ activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reasons for REDD+ Poor performance</td>
<td>Pearson correlation</td>
<td>0.135</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.371</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>47</td>
</tr>
<tr>
<td>Existence of corruption during REDD+ activities</td>
<td>Pearson correlation</td>
<td>0.135</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.371</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>46</td>
</tr>
</tbody>
</table>

Source: Field data, 2014.

Table 4. Bivariate correlations analysis between transparency and success of REDD+ in addressing deforestation, climate variability and people’s livelihoods (N = 101).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Transparency</th>
<th>Success of REDD+ in addressing deforestation, climate variability and people’s livelihoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparency</td>
<td>Pearson correlation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>101</td>
</tr>
<tr>
<td>Success of REDD+ in addressing deforestation, climate variability and people’s livelihoods</td>
<td>Pearson correlation</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.803</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>101</td>
</tr>
</tbody>
</table>

Source: Field Data, 2014.

criteria were met during the REDD+ pilot project implementation. However, more than a half of the respondents (57.6%) did not know whether or not there was transparency.

When asked about the reasons as to why transparency was not fully implemented during the REDD+ project in the study area, 93.7% of the respondents had no idea. However, very few of them (4.4%) felt that some beneficiaries restricted some information to be accessed by local communities for reasons known to them. Other reasons were lack of effective communication channels and strategies (1.5%) and inadequacy of experts to meet information demands of local communities (0.5%).

The bivariate correlation analysis of transparency and success of REDD+ in addressing deforestation, climate variability and people’s livelihoods (Table 4) revealed that there was a weak positive correlation ($r = 0.025$, $N = 101$, $p<.803$). The weak positive correlation was manifested by the value of “r”, which was below 0.05, implying that transparency was not the major factor for the success of
REDD+, thus other factors with negative consequences might have impinged the project implementation. Transparency international (TI) (2013) research into the governance of REDD+ in recipient countries has revealed challenges in terms of transparency and accountability of developing REDD+ policy and project implementation and highlighted concerns regarding risks of corruption. For example, TI’s governance assessments of the multi-lateral REDD+ funding mechanisms, the UN-REDD programme, the forest carbon partnership facility and the climate investment fund’s forest investment programme showed that gaps existed in terms of transparency at the policy level and in particular sanctions for corruption (Transparency International, 2013).

An annual report by Byrn et al. (2013) indicated a general lack of disclosure in areas such as land concession contracts, forest management plans and the relationship between provided goods and services and generated revenue. Information on REDD+ financing and benefits was often fragmented and was dependent on often inadequate reporting by financing agencies. Accordingly, transparency in the forest sector was relatively poor.

Accountability

When respondents were asked about ways in which people were accounting for their actions, they mentioned setting standards, answerability and sanction (that is, enforcement) (Table 5) as the major ways. Majority of the respondents (53.5%) said that accountability was implemented only by setting standards. Very few respondents (7.9%) reported that it was very rare for people to be answerable and to be sanctioned (2.0%) due to their actions. However, 34.7% said that accountability was not implemented.

Partial correlation analysis of corruption risks and REDD+ performance while controlling the ways in which accountability was implemented during REDD+ operation, revealed that there was a weak positive partial correlation between the two variables \(r=.231, N=101, p<.038\), with REDD+ performance being slightly affected by risk of corruption. The zero order correlation \(r=.231\) suggests that controlling for accountability had no effect on the strength of the relationship between these two variables.

A report by Williams and De Koning (2016) pointed out that in the context of REDD+ programs, broad approaches to accountability incorporate in particular, the importance of institutional frameworks, answerability, and oversight. The authors used the Peru example to show that it would be useful for REDD+ countries to clarify how they would take advantage of existing resources and capacity to resolve conflicts while also designating an entity responsible for overall management and oversight. Such institutions could play a role in providing guidance to existing mechanisms on addressing REDD+-related grievances, standardizing procedures for processing and reporting complaints, and analyzing the types of conflicts that are occurring in order to better understand the impacts of REDD+ decisions in practice and develop solutions.

Local community participation

For good governance to be sustainable, it requires partnerships between government and civil society. Thus, people in the study area were asked about the kind of activities in which they participated. The activities mentioned included planning for management of forest resources, revenue collection, benefit sharing planning, election of leaders, decision making and participation in other activities. Majority of the respondents (60.4%) reported that villagers were mainly involved in planning for forest resources management (Figure 3). Very few reported that people were involved in decision-making. Other activities in which the involvement of local people was limited were election of leaders, revenue collection and benefit sharing planning. The focus group discussions revealed that villagers were mainly involved in protection of forest resources against illegal activities, but majority of them were not involved in decision making and managing the project funds, activities which were controlled by project officials and top leaders from the village, district and regional levels.

The aforementioned findings are corroborated by the findings from Ratsimbazafy et al. (2012) in the Makira conservation project in Madagascar, Isagar et al. (2013) in India, Griffiths (2007) and Freudenthal et al. (2011). In Madagascar, for example, majority of the respondents claimed that decision making was centered on the management committee members, leaving behind majority of the local people. Isagar et al. (2013) observed that a key lesson of the Joint Forest Management (JFM) experience in India was that involving local communities in forest management could lead to more effective forest protection. Also successful conservation depended on

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting standards</td>
<td>54</td>
<td>53.5</td>
</tr>
<tr>
<td>Answerability</td>
<td>8</td>
<td>7.9</td>
</tr>
<tr>
<td>Sanction (that is, enforcement)</td>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>None of the Above</td>
<td>35</td>
<td>34.7</td>
</tr>
<tr>
<td>No response</td>
<td>2</td>
<td>1.9</td>
</tr>
<tr>
<td>Total</td>
<td>101</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: Field data, 2014.
cooperation from the local people and forestry officials, and on legal and institutional backing from the State. Many development projects in the past failed to meet their objectives due to lack of popular participation (Isagar et al., 2013).

Griffiths (2007), noted that communities need to be part of the solution if REDD+ project implementation is to be successful. This is due to the risk that REDD+ schemes may result in government, companies, conservation NGOs or speculators carving up forest lands and pursuing forest protection approaches that marginalize forest people. UNREDD programme stresses the importance of Free, Prior and Informed Consent (FPIC) as an operational guideline for the engagement of indigenous people and other dependent communities in the implementation of the UN Declaration on the Rights of Indigenous Peoples (UN-REDD Programme, 2013).

It was revealed by Freudenthal et al. (2011) in Cameroon that there was lack of information sharing even at the national policy-making level, both within the government and between external agencies. Within the government, the Ministry of Environment and Nature Protection (MINEP) was responsible for negotiations at the UNFCCC, while the Ministry of Forests and Wildlife (MINFOF) was involved in the implementation of sub-national projects. The dialogue between the two ministries was found to be weak so that experiences from so-called pilot projects would not necessarily feedback the policy-making process at the national and international level. Such situation of lacking public information, meaningful community participation and mechanisms to seek FPIC was also contrary to the institutional obligations and operational policies of many conservation and finance agencies involved in REDD+ project development in Cameroon.

Land tenure conditions in Uvinza district during REDD+ Project

When asked whether they owned land or not, 98.0% of the respondents in the study area affirmed that they owned some land. Only 2% of the respondents reported that they did not own any land at all. However, the largest majority (98%) of the respondents revealed that they did not own title deeds to their land. Respondents mentioned various reasons for them not to own land. The most dominant narrative was lack of knowledge in interpreting the Land Act and Village Land Act, which was supported by 28.7% of the respondents. Other reasons included weak legal frameworks, weak institutions in solving land disputes, high cost in accessing land tenure instruments, land grabbing and more favourable consideration for investors than local communities (Figure 4).

The aforementioned findings were variously supported by scholars such as Veit et al. (2012), Sunderlin et al. (2013), Okamoto et al. (2012), Mbow et al. (2010), Unruh (2008), McKenzie and Childless (2011) and Dokken et al. (2014). Veit et al. (2012), for example, observed a number of challenges relating to land tenure and forest governance in Tanzania. One of these was the recognition of village land. The Land Act (Section 4(3) recognizes customary rights of occupancy even if the land is not registered and the landholder has no
certificate for the land. Despite the law, government officials do not always recognize village land, especially land that has not been demarcated or for which there is no land use plan.

**Institutional contribution for JGI REDD+ good performance**

A large majority (92.7%) of the respondents did not know any central government institution that contributed or could contribute to REDD+ good performance. Only 7.3% reported that central government institutions had contributed for the REDD+ performance. Few respondents (2%) reported that Uvinza District Council supported the project to attain good performance and only 7.3% reported that central government institutions had contributed to the REDD+ performance. However, 81.9% of the respondents said they knew the Community-Based Organization that played a big role in supporting REDD+ project to acquire a good performance. These were probably referring to the role played by the local JUWAMMA. Strangely enough, some respondents (3.2%) mentioned United Nations Agencies to have helped the REDD+ project attain a good performance (Figure 5).

Different focus group discussions and key informants specifically mentioned JUWAMMA, the inter-village CBO to have highly supported REDD+ project in its activities in the study area. They reported that JUWAMMA, made up of seven village representatives, worked in close association with village leaders and the Uvinza District Council to manage forests and organize field patrols in the Masito-Ugalla Ecosystem. Furthermore, one of the key informants emphasized that the survival of the natural forest resources in the ecosystem would be assured if JUWAMMA persisted.

Such views concur with those of Indufor (2014). Accordingly, JUWAMMA used existing village bodies such as the environment committee and village government to undertake community based forest management activities, leading to increased effectiveness. The CBO and village governments were assisted to secure certified credits for carbon emission reductions from REDD+ projects in the voluntary carbon markets. Indufor (2014) further explained that the implementation of the project was clearly based on a collaborative and consultative approach. This was evident from the involvement of the village government, CBO, District Council staff and officials from central government and Sokoine University of Agriculture (SUA).

On the other hand, the UNDP (2012) reported that in Indonesia, the success of the REDD+ agenda was highly dependent on the preparedness of Indonesian institutions and citizens to meet the challenges of achieving the goals set out in the Draft National REDD+ Strategy. The Participatory Governance Assessment (PGA) aimed at assessing factors related to the successful implementation of the REDD+ agenda, which included legal and regulatory frameworks, capacities of key stakeholders (including the government, judicial and legislative bodies, civil society organizations, “adat” (that

![Figure 4. Reasons for local communities not legally owning land. (Source: Field Data, 2014).](image-url)
is, for indigenous communities), the private sector as well as forest management performance.

**Best options for using forest resource governance in attaining good REDD+ performance**

The study also examined how best forest resource governance could be used to enhance good performance of the REDD+ project. Specific focus was on transparency and accountability. Majority of the respondents (64.4%) revealed that more transparent budgeting and public procurement would help achieve the objectives of the REDD+ project. Only 22.8% preferred independent audit functions as an appropriate means of transparency for achieving REDD+ project, while 12.9% of the respondents reported that formulation of external committee could work better in revealing information necessary for a successful REDD+ project.

Upon being interviewed, key informants and focus groups discussants had different views about the best options in which forest resource governance could improve REDD+ performance. The majority reported that all the principles of forest resources governance, such as transparency, participation, accountability and integrity needed to be integrated. They reported, however, that more transparent budgeting and public procurement would work much better to make REDD+ project successful.

Transparency is essential if government policy processes are to be made more accountable to stakeholders. Transparency provides information that supports public participation and improves planning (Tan et al., 2008). When there is no information about laws and institutions governing forest management, predatory agents or dishonest officials can easily manipulate the law to their advantage (Tan et al., 2008). It was for these reasons that the need for transparency as the element of forest resources governance was crucial for REDD+ performance.

In addition to transparency, majority of the respondents (65.3%) revealed that horizontal accountability was the most reliable type of accountability that would help improve REDD+ performance in the study area. Other types of accountability as reported by respondents were vertical and both horizontal and vertical (Figure 6). All the focus groups discussants and majority of the key informants reported that horizontal accountability (for example, institutions such as judiciary) was the most reliable tool compared to vertical accountability (for example, media and civil society). A member of the focus group had this to say:

“...there is more enforcement in the governmental bodies like courts than using the media.” (Personal communication, 13th September, 2014).

According to UNDP (2010), vertical accountability is imposed externally on governments, formally through electoral processes or indirectly through citizens and civil
society, including the mass media. These external actors seek to enforce standards of good performance on officials. On the other hand, horizontal accountability is imposed by governments internally through institutional mechanisms for oversight and checks and balances. It refers to the capacity of state institutions to check abuses by other public agencies and branches of government, or the requirement for agencies to report sideways (UNDP, 2010). World Bank (2009) reported that bureaucratic accountability relates to personal ethics, professionalism, commitment, and the promotion of representative bureaucracy. It also can ensure the legitimacy of rule of law and the concept of the public administrator as the servant of the people. Governments should adopt clear forest policies, disseminate them, and hold officials accountable for implementing them.

**Conclusion**

Data from this study has shown that regardless of the efforts undertaken by REDD+ initiative in the Masito-Ugalla ecosystem, forest resources governance has continued to hamper the REDD+ project’s performance. Among the major impediments were corruption and selfishness among government leaders. Embezzlement of funds by politicians and senior government officials dominated during REDD+ implementation, leading to detrimental consequences in accelerating the violation of natural resource conservation laws. Accountability was reported to be implemented only by setting standards, such that very rarely people were being answerable and sanctioned due to their actions. However, local community participation was reported to be implemented, mainly in planning for natural resources management, but seldom villagers were engaged in decision-making.

In order to attain good REDD+ performance, it was suggested by majority of the respondents that more transparent budgeting and public procurement had to be considered. The issue of integrity in implementation of REDD+ activities must be addressed openly and legal measures against corruption should be appropriately taken by responsible authorities.

Establishment of an independent or external committee is recommended for REDD+ projects, which are being implemented in order to investigate misuse of funds and other unethical actions so that appropriate legal measures can be taken to build trust among people. Besides, leaders mandated to represent the large majority are to be accountable for contravening ethical issues and project performance standards.

**CONFLICT OF INTERESTS**

The authors have not declared any conflict of interests.
REFERENCES


Full Length Research Paper

Spatial analysis of the petrol stations in Khan-Younis city using geographic information system (GIS) techniques

Odeh Jameel El Faleet

Al Quds Open University, Palestinian Territory Occupied, Palestine.

Received 27 February, 2017; Accepted 28 March, 2017

This study was conducted in Palestine, the Gaza strip in Khan Younis City. The study aimed at analyzing petrol stations locations in Khan Younis City. It used geographic information system (GIS) based multi standard analysis. 25 petrol stations are available in Khan Younis City, distributed in 11 neighborhoods. A preview was created about the different petrol stations in Khan Younis City. This outline includes the actual status map, default geographical status map, the standard distance for the distribution map, the directional distribution map, and Areas of specialization areal map, the Petrol stations in Khan Younis City. Spatial analysis of the distribution of Petrol stations was performed through basic 4 standards. The first standard is "The minimum distance between the location of the station and facilities of services (schools, hospitals, wedding halls, nursing homes, factories) for 80 m" show that there are 16 petrol station committed to the first standard, while 11 petrol station in violation of the first standard of 25 petrol station. The second standard is "The minimum distance between the location of the station and craft shops that use flame in its work for 10 m", show that there are 19 petrol station committed to the second standard, while the 6 petrol station in violation of the second standard of 25 petrol station. The third standard " The minimum distance between the location of the station and the limits of military facilities for 300 m, counted from the outer limits of the station" show that there are 21 petrol station committed to the third standard, while the 4 petrol station in violation of the third standard of 25 petrol station. The fourth standard is “The horizontal distance between the station boundaries and the electricity high pressure lines not less than 10 m” show that there are 24 petrol station committed to the fourth standard, while the 1 petrol station in violation of the fourth standard of 25 petrol station standard. And finally the researcher found a direct correlation relationship between population density and the number of stations in every neighborhood.

Key words: Spatial analysis, geographic information system (GIS), petrol, station, Khan-Younis.

INTRODUCTION

A petrol station, petrol station, fueling station, or service station is a facility which sells fuel and lubricants for vehicles; the most common fuel sold is petrol and kerosene. Petrol station is a retail establishment where
motor vehicles are refueled, lubricated, serviced, and sometimes repaired. Petrol stations should be located not only where they are in fact accessible but where they can be easily located by strangers and that, in details, they should be placed where they will be little danger and congestion as possible. Most petrol stations sell petrol or diesel, some carry specialty fuels such as liquefied petroleum gas (LPG), natural gas, hydrogen, biodiesel, kerosene, or butane while the rest add shops to their primary business, and convenience stores (Ayodele, 2011; Abdul Hamid et al., 2009).

Problem statement

The increase in urban population and the growth of the number of cars and other vehicles generate various kinds of demands, one of which is fuel. A considerable amount of cars fuel is wasted due to the long urban paths and unnecessary trips. Increase in vehicles triggered increasing demands for fuel and by extension fuel station, since engines are made to use petroleum products and Petrol station are the places where fuel is sold. Petrol station, petrol station, gas station or petroleum outlet is defined as any land, building or equipment used for the sale or dispensing of petrol or oil for motor vehicles or incidental thereto and includes the whole of the land, building or equipment whether or not the use as a petrol station is the predominant use or is only a part thereof. Most petrol stations sell petrol or diesel, some carry specialty fuels such as liquefied petroleum gas (LPG), natural gas, hydrogen, biodiesel, kerosene, or butane while the rest add shops to their primary business (Ayodele, 2011; Abdul Hamid et al., 2009).

Geographic information systems (GIS) approaches and related products have been widely used in the people’s daily life. GIS provide the appropriate tools for analyzing the effective factors on spatial data and non-spatial data (Keeble, 1968). It is powerful computer-based tools for the capture, storage, management, retrieval, query, analysis and presentation of spatial data. GIS ability as spatial data processing and analyses tools available can be used to manage a wide range of Information (Keeble, 1968; Mc-Lafferty, 2003; Richards et al., 1999; Mohammed et al., 2005; Palestinian Central Bureau of Statistics, 2007).

Aim of the study

The main aim of this study is to analyze the spatial distribution of petrol stations in Khan Younis City using GIS-based Multi-Criteria Analysis (MCA). The aim of this research can be summarized as analysis of petrol stations locations in Khan Younis City.

Study area

This study was conducted in Palestine, Gaza strip, Khan Younis City. Khan Younis is a Palestinian city, the center of Khan Younis, located in the southern part of the Gaza Strip, and Jerusalem away from the distance of 100 km to the south-west. It is bordered to the south of Rafah and north of Deir El-Balah, a coastal province overlooking the Mediterranean Sea to the west and on the east by Israel. considered Khan Younis, the second largest city in the Gaza Strip in terms of population and area after the Gaza City, where the number of today its population nearly 200,000 people, which represents 17% of the population of the Gaza Strip. As an area of 54 km², making it one of the most densely populated Palestinian cities (Palestinian Central Bureau of Statistics, 2007).

Khan Younis City is one of the five Governorates in the Gaza Strip which is administered by Palestine, aside from its border with Israel, airspace and maritime territory. According to the Palestinian Central Bureau of Statistics, the City had a population of 280,000 in 2007; its land area is 69.61% urban, 12.8% rural and 17.57% comprising the Khan Younis refugee camp (Palestinian Central Bureau of Statistics, 2007) (Figure 1 and 2).

METHODOLOGY

There are several steps in this study as follows:

1. A preliminary survey was carried out to identify and document Petrol station in Khan Younis City. This acquainted the researcher with the knowledge of the area and provide guide on how to source the data, types of data needed and preparation for the field work.
2. Transform all the above mentioned data in an appropriate way with ArcGIS software.
3. Preparing the basic maps for the study area including Khan Younis City GIS maps to create preview of Khan Younis City in 2016 of:
   a. The actual status of the Petrol stations in Khan Younis City.
   b. The default geographical status (the default status) of the Petrol stations in Khan Younis city.
   c. The standard distance for the distribution of the Petrol stations in Khan Younis city.
   d. The directional distribution of the Petrol stations in Khan Younis City.
   e. Areas of specialization areal of the Petrol stations in Khan Younis City.
4. Spatial analysis of the distribution of Petrol stations through the four basic standards:
   a. The minimum distance between the location of the station and facilities of services (schools, hospitals, wedding halls, nursing homes, factories) for 80 m.
   b. The minimum distance between the location of the station and craft shops that use flame in its work for 10 m.
   c. The minimum distance between the location of the station and the limits of military facilities for 300 m, counted from the outer limits of the station.
   d. The horizontal distance between the station boundaries and the electricity high pressure lines not less than 10 m.
5. Perform statistical techniques on the data to investigate the relations between (density of Neighborhoods population with petrol stations numbers, neighborhoods distances with number of Petrol
Figure 1. Khan Younis City displaying through geographical information systems. Source: By Researcher.

Figure 2. Gaza strip displaying through geographical information systems. Source: By Researcher.
Table 1. Distribution of petrol stations on Khan Younis neighborhoods

<table>
<thead>
<tr>
<th>Neighborhood</th>
<th>Number of stations</th>
<th>POP_Coun</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Center neighborhood</td>
<td>1</td>
<td>9900</td>
</tr>
<tr>
<td>Al Sheikh Nasser neighborhood</td>
<td>1</td>
<td>6576</td>
</tr>
<tr>
<td>Khan Younis Camp neighborhood</td>
<td>1</td>
<td>52615</td>
</tr>
<tr>
<td>AL Amal neighborhood</td>
<td>1</td>
<td>13153</td>
</tr>
<tr>
<td>Maain neighborhood</td>
<td>1</td>
<td>14250</td>
</tr>
<tr>
<td>Jort Allout neighborhood</td>
<td>2</td>
<td>10431</td>
</tr>
<tr>
<td>Gizan Alnajar neighborhood</td>
<td>2</td>
<td>3288</td>
</tr>
<tr>
<td>AL Manara neighborhood</td>
<td>3</td>
<td>10139</td>
</tr>
<tr>
<td>AL Mahata neighborhood</td>
<td>5</td>
<td>21923</td>
</tr>
<tr>
<td>AL Katiba neighborhood</td>
<td>2</td>
<td>7673</td>
</tr>
<tr>
<td>AL Satar neighborhood</td>
<td>4</td>
<td>9900</td>
</tr>
<tr>
<td>AL Mauasi neighborhood</td>
<td>2</td>
<td>7000</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

A preliminary survey of petrol stations in Khan Younis City

A preliminary survey of Khan Younis City petrol stations was carried out to identify, document and create GIS preview of Khan Younis City in 2016. Khan Younis City contains 25 petrol stations distributed on all Khan Younis neighborhoods (Table 1).

GIS maps

The basic maps for the study area including Khan Younis City GIS maps prepared to create actual and default geographical status (the default status), the standard distance for the distribution, directional distribution, and areas of specialization area of the petrol stations in Khan Younis City.

The entire field survey has been done for the city of Khan Younis, according to the division of neighborhoods by the Khan Younis Municipality maps, to determine the number and distribution of petrol station and its locations on the GIS map are shown in Figure 3, petrol stations distributed on all Khan Younis neighborhoods.

Khan Younis City has 25 petrol stations distributed on 12 neighbors. The center of spatial gravity of the petrol stations which is located in Al Sheikh Nasser neighborhood (Figure 4 and 5).

Through a measuring mechanism of the geographical center by using GIS programs possibilities and through which the monitoring the various elements of the current situation for the distribution of petrol stations at the city of Khan Younis and the geographic center of the petrol stations was located in the neighborhood of Sheikh Nasser (Figures 6, 7, 8 and 9).

Spatial analysis of the distribution of petrol stations through the four basic standards

The minimum distance between the location of the station and facilities of services (schools, hospitals, wedding halls, nursing homes, factories) was 80 m.

As shown in Figure 10, the petrol stations are classified in terms of the first standard, which stipulates that the minimum distance between the location of the station and facilities of services (schools, hospitals, wedding halls, nursing homes, factories) for 80 m calculated from the outer limits of the station.

As shown that there are 16 petrol station is committed to the first standard, while the 11 petrol station in violation of the first standard of 25 petrol station.

The minimum distance between the location of the station and craft shops that use flame in its work for 10 m.

As shown in Figure 11, the petrol stations are classified in terms of the second standard, which stipulates that the minimum distance between the location of the station and craft shops that use flame in its work for 10 m.

As shown that there are 19 petrol station is committed to the second standard, while the 6 petrol station in violation of the second standard of 25 petrol station.

The minimum distance between the location of the station and the limits of military facilities for 300 m, counted from the outer limits of the station.

As shown in Figure 12, the petrol stations are classified in terms of the third standard, which stipulates that the minimum distance between the location of the station and the limits of military facilities for 300 m, counted from the outer limits of the station.

As shown that there are 21 petrol station is committed to the third standard, while the 4 petrol station in violation of the third standard of 25 petrol station.
Figure 3. Khan Younis City neighborhoods borders.

Figure 4. The center of spatial gravity of the Petrol stations in Khan Younis 2016. Source: By Researcher.
Figure 5. Default geographical status (the default status) of petrol stations in the neighborhoods of the city of Khan Younis 2016. Source: By Researcher.

Figure 6. The standard distance for the distribution of petrol stations in the neighborhoods of the city of Khan Younis 2016. Source: By Researcher.
Figure 7. The standard distance for the distribution of petrol stations in the neighborhoods of the city of Khan Younis 2016. Source: By Researcher.
Figure 8. Directional distribution areas of specialization areal of petrol stations in the neighborhoods of the city of Khan Younis 2016. Source: By Researcher.
Figure 9. Areas of specialization areal of petrol stations in the neighborhoods of the city of Khan Younis 2016. Source: By Researcher.
Figure 10. Classification petrol stations in terms of the standard the minimum distance between the station, factories, schools site and wedding halls, hospitals, nursing homes about eighty meters.

Figure 11. Classification petrol stations in terms of the standard the minimum distance between the station site and shops that use flame sources at work about ten meters.
The horizontal distance between the station boundaries and the electricity high pressure lines was less than 10 m.

As shown in Figure 13, The petrol stations are classified in terms of the fourth standard, which stipulates that the horizontal distance between the station boundaries and the electricity high pressure lines not less than 10 m.

As shown that there are 24 petrol station committed to the fourth standard, while 1 petrol station in violation of the fourth standard of 25 petrol stations.

Perform statistical techniques on the data to investigate the relations between densities of neighborhoods population with petrol stations numbers

A preliminary survey of the city of Khan Younis that it
contains 25 petrol stations spread over 12 neighborhoods, here, the researcher will investigative and identify the relationship between density of neighborhoods population with petrol stations numbers, based upon the researcher will clarify whether the distribution of stations geographically proportional to the population density of each neighborhood or not.

As shown in the Table 2, the number of stations geographically proportional with the population density of each neighborhood of city of Khan Younis, where higher the population density in a given neighborhood has increased the number of stations it and lower the population density decreases the number of stations.

Based on that, the relationship between population...
density and the number of stations in every neighborhood is a direct correlation, due to the planning and organization in Khan Younis municipality and the licensing authority.

**Proposed locations for new petrol stations**

The proposed location for new petrol stations is given in Figure 14.

**Conclusion**

This study was conducted in Palestine, Gaza strip, Khan Younis City. The aim of this study was to analyze the petrol station locations in Khan Younis City using the GIS based multi standard analysis. 25 petrol stations founded in Khan Younis City distributed on 11 neighborhoods, preliminary preview created of petrol stations in Khan Younis City, which include the actual status map, default geographical status map, the standard distance for the distribution map, the directional distribution map, and areas of specialization area map the petrol stations in Khan Younis City. Spatial analysis of the distribution of petrol stations performed through basic 4 standards.

The first standard is "The minimum distance between the location of the station and facilities of services (schools, hospitals, wedding halls, nursing homes, factories) for 80 meters" shown that there are 16 petrol station is committed to the first standard, while the 11 petrol station in violation of the first standard of 25 petrol station.

The second standard "The minimum distance between the location of the station and craft shops that use flame in its work for 10 m", shown that there are 19 petrol station is committed to the second standard, while the 6 petrol station in violation of the second standard of 25 petrol station.

The third standard "The minimum distance between the location of the station and the limits of military facilities for 300 m, counted from the outer limits of the station" shown that there are 21 petrol station is committed to the third standard, while the 4 petrol station in violation of the third standard of 25 petrol station.

The fourth standard "The horizontal distance between the station boundaries and the electricity high pressure lines not less than 10 meters" shown that there are 24 petrol station is committed to the fourth standard, while the 1 petrol station in violation of the fourth standard of 25 petrol station standard. And finally the researcher found a direct correlation the relationship between population density and the number of stations in every neighborhood.

**RECOMMENDATIONS**

1. Commitment when establishing new fuel stations to be proposed in areas that have been clarified in the search results.
2. Applying geographic analyzes of all petrol stations in the governorates of the Gaza Strip as one unit, in order for researchers, scholars and professionals to benefit from the analyzes.
3. Documenting GIS maps, plans and results of this research in the information base of the Ministry of National Economy and the Municipality of Khan Younis, so that they can return them in case of giving a license to set up a new petrol station.
4. Tightening of the legal proceedings and intimidating the owners of petrol stations to be in conformity with the standards laid down.
5. Continuing monitoring by the licensing department and the Ministry of National Economy up, and inform the violation stations need to correct their wrongdoing.
6. Creation of green areas surrounding the petrol stations.
7. Harmonization of work between the electricity company
and the Ministry of the Interior and the Ministry of National Economy and the Municipality of Khan Younis, to promote and raise the commitment level of the petrol stations owners.

8. Conducting seminars and workshops for the owners of petrol stations, to strengthen the spirit of cooperation with
CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES


Geospatial based biofuels suitability assessment in Ethiopia

Tenaw Geremew*, Mitiku Adisu and Tamene Mengistu

The Ethiopian Civil Service University. Addis Ababa. Ethiopia.

Received 28 June, 2016; Accepted 20 October, 2016

Due to the rising demands of fuels combined with efforts in reducing greenhouse gas emission, countries all over the world are looking for alternative clean energy sources such as biofuel. Ethiopia imports a huge amount of fuel each year and to supplement its energy needs efforts are underway for biofuel development. Despite this, comprehensive assessments of the suitable sites for biofuel feedstocks are lacking. This study is designed to map suitable sites for selected biodiesel feedstocks (Jatropha, Castor, Croton, and Cottonseed) and bioethanols (Cassava and Sweet Sorghum) and estimating the potential productions in Ethiopia. The spatial representations of the requirements (Soil, Elevation, Rainfall, and Temperature) of the feedstocks were created and processed to eventually map the suitable sites. About 16, 30, 28, 34%, 6, 83% of the country is highly suitable (HS) for Jatropha, Castor, Croton, Cassava, Cottonseed and Sweet Sorghum, respectively. The suitability assessments were also made by excluding environmentally sensitive lands (e.g. marshy areas, parks, wildlife sanctuaries and forests) and areas that can compromise crop production (e.g. cultivated lands). Accordingly, 6, 9, 7, 10, 2 and 36% of the country remains HS, thus large scale biofuel production can be conducted without affecting food security and the environment in these areas. Hence, the country can produce up to 355.44 and 225.09 billion liters of biodiesel and bioethanol, respectively, returning up to 53 billions USD overall revenue.

Key words: Biofuel, biodiesel, bioethanol, suitability, HS.

INTRODUCTION

The negative externality and rising prices of fossil fuel have resulted in ever-increasing efforts to look for alternative energy sources, and the particularly due emphasis is given for biodiesel and bioethanol in order to contribute to solving economic, environmental and social problems (Nadew, 2014). In addition to its ample water resource as energy sources, Ethiopia is viewed as one of the most suitable countries in Africa for tapping other renewable sources of energy including biodiesel and bioethanol because of its location and favorable climate condition (Zenebe et al., 2014).

Ethiopian government developed Climate Resilient Green Economy (CRGE) Strategy in the year 2011 having the vision to achieve middle-income status by 2025 in a
sustainable way. The biofuels industry in Ethiopia can contribute a lot to ensuring rural food security by diversifying the livelihood source (Gebreeziabher et al., 2013). Besides its economic benefit, biodiesel and bioethanol production has a great role in the reduction of GHGs and shifting towards clean energy. Among the four abatement potential of the transport sector, which are stated in CRGE strategy, one of the green growth initiatives is changing the fuel mix using a combination of adding biodiesel to the diesel mixture, increasing the amount of ethanol in the gasoline mixture, and promoting the adoption of hybrid and plug-in electric vehicles has a combined abatement potential of nearly 1.0 Mt CO2e (FDRE, 2011). Biofuel could be mixed together into transport fuels, and replace some of the kerosene currently used for cooking predominantly in urban areas and for lighting in rural areas that lack electricity (Steve et al., 2011).

Findings of Zenebe et al. (2014) revealed that bioethanol production in Ethiopia is quite viable whereas the viability and competitiveness of biodiesel production will largely depend on the cost and price of feedstock. The negative effect of biodiesel and bioethanol production might be high as biofuel production competes with the use of land for traditional crops (Tadele et al., 2013). This, in turn, could affect the food security of the rural community. Allocation of land for biodiesel development should not affect the livelihoods of pastoralists in the lowland areas; and in the highlands, it should be coordinated with other farming activities without jeopardizing the farmers’ food production needs. In addition, direct and/or indirect land-use changes that result from their cultivation can cause emissions due to carbon losses in soils and biomass and could reverse any eventual greenhouse gas (GHG) reduction benefit (Achten and Verchot, 2011).

Little researches have been conducted regarding suitability analysis of biodiesel and bioethanol in Ethiopia. Even though those studies tried to map suitability of biofuel in Ethiopia, they lack the sustainable issue since the suitable lands may be laid on productive farmland, wetland or other sensitive areas. Habtamu (2014), in the study suitability analysis for Jatropha curcas production using spatial modeling methods recognized that from the total land of the country 15.07% (166,082 km2), 76.57% (844,040 km2) and 8.36% (92,114 km2) of the land as highly suitable, moderately suitable and not suitable for Jatropha production, respectively. However, his study did not exclude the sensitive areas. Production of Jatropha even on highly suitable land could have a negative effect on food security as well as on the environment so that its production would not be sustained. The results of suitability analysis would be good when sensitive lands are excluded otherwise even those suitable areas would have negative externalities. Environmental effects of biofuel crop cultivation include reduced wetland areas and their functions, declining water quantity, declining water quality and increased risk of eutrophication and it ends up with biodiversity loss and ecosystem damage (Sven and Offermans, 2008). The exact nature and magnitude of these effects depend on the biofuel crop characteristics and the agricultural practices applied. To this end, this research assessed sustainable biodiesel and bioethanol suitability in Ethiopia by taking into account sensitive lands that can affect food security and areas that require protection include croplands, forest lands, national parks and wildlife sanctuaries and water bodies.

Biofuel is a liquid fuel produced from biomass; it excludes treatments of solid biomass as a source of energy. The two most important biofuels are ethanol and biodiesel. Ethanol is manufactured from the microbial conversion of biomass materials through fermentation whereas, biodiesel is oil extracted from oil seeds by mechanical crushing or solvent extraction (MoME, 2007).

**General agronomic requirements of biofuel feedstocks**

**Biodiesels**

Among the many species, which yield as a source of energy in the form of biodiesel, Jatropha (Jatropha curcas) has been identified as the most suitable oil seed bearing plant due to its various favorable attributes like hardy nature, short gestation period, adaptability in wide range agro-climatic conditions, high oil recovery and quality of oil, etc (Pranab, 2011). Jatropha curcas grows in tropical and sub tropical regions and in lower altitudes of 0-500 meters above sea level. It can survive with as little as 250 to 300 mm of annual rainfall; at least 600 mm is needed to flower and fruit. The optimum rainfall for seed production is considered between 1000 and 1500 mm (FAO, 2010). Optimum temperatures are between 20 °C and 28 °C. The best soils for Jatropha are aerated sands and loams of at least 45 cm depth (Gour, 2006).

Another crop species for biodiesel production, Castor (Ricinus communis) is growing in different localities in Ethiopia and it is an indigenous plant. The suitable condition for castor crop growing zone is between 1600 and 2600 m.a.s.l and rainfall distribution between 600 and 700mm with warm and dry climatic condition. The yield is estimated between 260 and 1250 kgs per hectare (MoME, 2007).

Cotton (Gossypium hirsutum and Gossypium herbaceum) is also considered in this study for the production of biodiesel and it can be grown in areas where mean annual rainfall ranges from 600 – 1300 mm and temperature 20-30OC. It also grows well on elevation up to 1400 m a.s.l with black cotton soils (ICRAF, 2009). It requires a long, sunny growing season, is not frost tolerant, and prefers well-drained loose soils. Nowadays, cotton seed oil is mainly used in industries to produce
soap and glycol lubricants besides being used as edible oil. Therefore, compared to soybean oil, palm oil, and colza oil, cottonseed oil is an appropriate raw material of biodiesel because of its advantages in origin and uses (Niu et al., 2010). The biodiesel comes as a new source of remuneration for the cotton crop.

According to ICRAF (2009), croton (Codiaeum variegatum) is also used to extract biodiesel. It is cultivated in areas with mean annual rainfall of 800-1900 mm and mean temperature of 11-26°C. Altitude 1200-2450 and light deep and well-drained soils are very suitable for croton production.

Bioethanols

Cassava (Manihot esculenta Crantz) is a tropical root crop, requiring at least 8 months of warm weather to produce a crop. In drought prone areas it loses its leaves to conserve moisture, producing new leaves when rains resume. It takes 18 or more months to produce a crop under adverse conditions such as cool or dry weather. Cassava does not tolerate freezing conditions. It tolerates a wide range of soil pH 4.0 to 8.0 and is most productive in full sun (Legese and Gobeze, 2013). In Ethiopia, cassava was introduced to drought prone areas of Southern part of the country such as Amaro, Gamogofa, Sidama, Wolaita, Gedeo and Konso primarily to fill food gap for subsistence farmers due to the failure of other crops as a result of drought. In these areas, farmers usually grow cassava in small irregular scattered plots either sole or intercropped mainly with taro, enset, maize, haricot bean and sweet potato (Eyasu, 1997). Cassava finds the most favorable growing conditions in humid-warm climates at temperatures of between 25 - 29°C and precipitations of between 1000 - 1500 mm which ideally should be evenly distributed (Owwueme, 2014). Cassava likes light, sandy loam soils with medium soil fertility and good drainage.

Sweet sorghum (Sorghum bicolor (L.) Moench) is an alternative energy crop supported by the European Commission under the 7th Framework Programme to exploit the advantages as a potential energy crop for bioethanol production. For developing countries, it provides opportunities for the simultaneous production of food and bioenergy, thereby contributing to improved food security as well as increased access to affordable and renewable energy sources (Khawaja, 2014). Sweet sorghum needs moderate rainfall and an average temperature of 80 – 90°F for grain production and maturity. It can be grown in a variety of soils heavy and light alluviums, red, gray, yellow loams and also sandy soils (Panhwar, 2005).

METHODS

Description of the study area

Ethiopia is a tropical country located in the Eastern parts of Africa. It extends between 330E - 480 E longitude and 30 N - 150N latitude (Figure 1) and has a total area of 112,867,369.97 Ha. The country is a home of about 104.4 million people [36]. Its landscape is dissected into two parts by the Great East African Rift. The landscape is characterised by undulating terrain and rugged topography and constitutes diverse agroecological zones supporting a variety of fauna and flora. Ethiopia’s climate is typically tropical in the south-eastern and north-eastern lowland regions, but much cooler in the large central highland regions of the country. Mean annual temperatures are around 15-20°C in these high altitude regions, whilst 25-30°C in the lowlands. Most parts of Ethiopia experience one main wet season (called ‘Kiremt’) from mid-June to mid-September (up to 350mm per month in the wettest regions) when the ITCZ (Inter Tropical Convergence Zone) is at its northern most position. Parts of northern and central Ethiopia also have a secondary wet season of sporadic, and considerably lesser, rainfall from February to May (called the ‘Belg’). The southern regions of Ethiopia experience two distinct wet seasons which occur as the ITCZ passes through this more southern position. The March to May’Belg’ season is the main rainfall season yielding 100-200 mm per month, followed by a lesser rainfall season in October to December called ‘Bega’ (around 100mm per month). The eastern most corner of Ethiopia receives very little rainfall at any time of year.

Customizing agronomic requirements of biofuel feedstocks

The suitability assessments made are made for selected biodiesel and bioethanol feedstocks. In the biodiesel category, the feedstocks include, Jatropha (Jatropha curcas), Castor (Ricinus communis), Cottonseed (Gossypium hirsutum and Gossypium herbaceum), Croton (Codiaeum variegatum) while the bioethanols include, Cassava (Manihot esculenta Crantz) and Sweet sorghum (Sorghum bicolor (L.) Moench).

The environmental requirements of these feedstocks for optimum growth are identified after thoroughly reviewing the literature (Table 1). The requirements are related to soil, rainfall, temperature, elevation. Since the biofuel production areas should not affect food security by consuming the croplands, the land use /land cover conditions of the country were also considered in the suitability analysis. With respect to each of these environmental factors, the cutoff points for suitable and non-suitable values vary considerably from place to place. As a result of this, the cutoff points are determined by giving more weight to researchers’ findings conducted in Ethiopian and the neighboring regions. Thus, all factors were classified as suitable and given a value of 1 and the non-suitable as 0. Table 1 indicates the customized crop requirements for each feedstock.

Despite this, we acknowledge the the subjectivity that might be introduced in setting the cutoff points.

Spatial data acquisition and representation of agronomic requirements

The data needed for representing agronomic requirements are collected from different sources. The data include rainfall, temperature, land use/land cover, soil, elevation, National Parks and Wildlife Sanctuaries (Table 2).

Land cover/land use, national parks and wildlife sanctuaries

In line with the countries priority of food security and promoting climate resilient green economy (CRGE), biofuel productions should not compromise food security and protected lands. Such areas include croplands, forests, water bodies, marshy areas, national...
parks and wildlife sanctuaries and are categorized as sensitive lands.

The land cover map of the country is derived from mosaics of Landsat satellite images processed through supervised classification of the maximum likelihood classifier. The classification and mapping were conducted by the Ethiopian Mapping Agency. The croplands and forested areas acquired from the land cover map were considered in the suitability analysis to address food security and environmental protection.

These data were acquired from the Ethiopian National Parks Wildlife Authority in a polygon shape file format.

Rainfall and Temperature

These data were provided by the Ethiopian Ministry of Agriculture and it was the result of interpolation of the long-term rainfall and temperature records of the countries meteorological stations. The data were available in vector data model form (polygon shapefile).

Elevation

The elevation data were acquired from the shuttle radar topographic mission (SRTM) and were available from the United States Geological Survey (USGS) website (https://www.usgs.gov). It provides Digital Elevation Model (DEM) at a spatial resolution of 30 m for free for any part of the world. The DEM Scenes covering the country were downloaded and mosaic to get the DEM representing the country.

Soil

The Food and Agriculture Organization (FAO) has mapped the major soils of the country but the methodology and the year of publication were not documented either in the metadata or elsewhere but the year of publication was estimated to be around 2007. The data had no soil texture information while the agronomic requirements are related to soil texture information. Hence the soil textures were inferred from the major soil types.

As the data were found from different sources, they had different coordinate systems, formats and sometimes different extents. All the data were preprocessed to overcome the anomalies through geometrical co-registration and format integration among themselves. For example, all the data were projected into WGS 1984 geographic coordinate system and co-registered to align points of the same location together. As raster data models are suitable for overlay operations, which is the GIS analysis used to evaluate the suitability in this study, vector data formats were
**Table 1. Customized crop requirements.**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Jatropha</th>
<th>Castor</th>
<th>Croton</th>
<th>Cottonseed</th>
<th>Cassava</th>
<th>Sweet sorghum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Suitable</strong></td>
<td><strong>Not suitable</strong></td>
<td><strong>Source</strong></td>
<td><strong>Source</strong></td>
<td><strong>Source</strong></td>
<td><strong>Source</strong></td>
</tr>
</tbody>
</table>

GIS model and suitability analysis

Six separate GIS model for suitability mapping were developed for the six biofuel feedstocks considered. Each model constitutes data representing the agronomic requirements and procedures to bring all the requirements together through intersection overlay analysis (Figure 2). The model is built in the model builder environment in ArcGIS 10.2. The intersection overlay takes the following form.

\[
\text{Suitability} = \sum_{(n=0)}^{1} \Box \text{Soil} \cap \sum_{(n=0)}^{1} \Box \text{Temp} \cap \sum_{(n=0)}^{1} \Box \text{RF} \cap \sum_{(n=0)}^{1} \Box \text{Elev}
\]
Table 2. Data source and types.

<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil (2007)</td>
<td>FAO. 2007</td>
<td>Shapefile</td>
</tr>
<tr>
<td>Land use/land cover 2013</td>
<td>Ethiopian Mapping Agency</td>
<td>Tiff/Raster</td>
</tr>
<tr>
<td>Rainfall</td>
<td>Ethiopian Meteorological Agency</td>
<td>Shapefile</td>
</tr>
<tr>
<td>Temperature</td>
<td>USGS</td>
<td>Raster DEM</td>
</tr>
<tr>
<td>Elevation (30m Resolution)</td>
<td>USGS</td>
<td>Raster DEM</td>
</tr>
<tr>
<td>National parks and wildlife sanctuaries (2014)</td>
<td>Ethiopian National Parks Wildlife Authority</td>
<td>Shapefile</td>
</tr>
</tbody>
</table>

Figure 1. GIS-based model for biofuel suitability assessment.

The suitability had five values of 4, 3, 2, 1 and 0, which indicate the number of requirements met among all the factors considered. These values then classified into suitability classes as, 4=Highly Suitable, 3 = Moderately Suitable, 2 and 1= Marginally Suitable and 0=Not Suitable.

The suitability analysis is conducted two times for each biofuel feedstocks, the first one is without excluding sensitive lands and the second one is by considering the sensitive lands as a constraint areas for biofuel production. This will create an insight into the decision and policy makers about the overall potential of the country for biofuel production and production without affecting food security and environmental production.

Despite this, biofuel production can also be conducted at small scale in general land uses classified as croplands by planting biofuels at the boundaries of the croplands as an agroforestry practice without affecting food production. In this case, it would have multiple benefits beyond biofuel production as it can serve as soil and water conservation, ameliorate the local climate and serve as boundary demarcation of fragmented farmlands common in the Ethiopian landscapes.

Once the suitability map is produced for each biofuel feedstock, the maps were validated visually by overlaying the location of existing plantations. This validation technique, however, limited to Jatropha as some of the plantation areas for this feedstock were known. The overall methodological workflow of the suitability mapping and analysis is summarized in Figure 3.

RESULTS AND DISCUSSION

The biofuels suitability distribution varies spatially all over the country and there are also considerable variations across the biofuels feedstocks under consideration though some of them exhibit a similar pattern of distribution. For Jatropha, the western Benishangula and Amhara regional states, north and central Tigray, southern parts of southern nations and nationalities people (SNNP), the western and eastern escarpments of the rift valley region and eastward side of the southwestern highlands of the country are HS. The visual inspection of the actual Jatropha...
Growing regions well fits with the suitability map produced for Jatropha. For example, there is a plantation of Jatropha along the western escarpments of the rift valley regions including such woredas as Kalu, Bati, Kobo, Guba lafto, Alamata and Chefi Golina. In the Northern and central Tigray region, Kola Temben and Abergale are some of the woredas growing Jatropha and are mapped as HS areas. The existing plantation areas for other biofuel feedstock, however, were unavailable to validate the suitability map with. However, the HS area for castor takes the similar pattern with that of Jatropha, except the HS area is stretched in all directions. Croton grows well in most central parts of the country, western Oromiya and the southeastern highlands of the country. Cassava and castor can grow well in similar environmental conditions. That is why both of these feedstocks have a similar spatial pattern of HS areas. The only difference is that the environmental requirements of cassava are met in more areas than castor in the country. Cottonseed grows in patchy areas in western Amhara and Tigray, Northern Somalia and North Western SNNP. Sweet sorghum grows in the highland and lowland areas of the country. Except eastern and southern Somalia, northeastern Afar and some parts of Oromiya and SNNP, it grows well in all parts of the country (Figure 4 a-f).

Most of the sensitive lands such as croplands are dominating the central parts of the country and the remaining forests which are part of the sensitive lands are concentrated in the western and southwestern highlands of the country. In all the biofuel feedstocks considered, HS areas in these regions will become none suitable because of food security and environmental protection issues.

Among all the biofuels, most of the study area is Highly Suitable (HS) for sweet sorghum by covering about 93 m Ha. Cassava, castor, croton, Jatropha and Cottonseed being the other biofuels that most of the country is HS and constitutes about 38, 33, 31, 18, and 6 m Ha of the study area, respectively (Table 3). As compared to other regional states, Oromiya is the region where the largest HS areas are available for all the biofuels under considerations. This is directly proportional to its areal coverage of the region.

The HS area left when sensitive lands are excluded from the biofuel assessment is considerably reduced. Only About 15,11,10,8,7 and 2 m Ha lands of the country is HS for sweet sorghum, castor, cassava, Jatropha, and cottonseed, respectively. Except Somali region where the largest HS area for sweet sorghum is available, for all other biofuels the largest HS area is found in Oromiya regional state (Table 4). The results of the suitability assessments are presented in Tables 3 and 5 and Figures 4 and 5.

Ethiopia imports fuel on average at the expense of 768 million USD per annum and this covers 77% of the total export earnings. The demand for fuel will increase when...
Table 3: Overall Suitability of Biofuels in the Country

<table>
<thead>
<tr>
<th>Biodiesel</th>
<th>REGION</th>
<th>NS</th>
<th>MaS</th>
<th>MoS</th>
<th>HS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall (Ha)</td>
<td>%</td>
<td>Overall (Ha)</td>
<td>%</td>
<td>Overall (Ha)</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>Tigray</td>
<td>10,937.13</td>
<td>1.50</td>
<td>1,673,348.00</td>
<td>3.94</td>
</tr>
<tr>
<td></td>
<td>AMHARA</td>
<td>428,129.68</td>
<td>58.81</td>
<td>7,330,680.00</td>
<td>17.25</td>
</tr>
<tr>
<td></td>
<td>Benishangul-G</td>
<td>0.00</td>
<td>0.00</td>
<td>359,548.00</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>Oromia</td>
<td>223,946.10</td>
<td>30.76</td>
<td>12,936,512.00</td>
<td>30.45</td>
</tr>
<tr>
<td></td>
<td>Dire Dawa</td>
<td>0.00</td>
<td>0.00</td>
<td>160</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Harari</td>
<td>0.00</td>
<td>0.00</td>
<td>2,704.00</td>
<td>0.01</td>
</tr>
<tr>
<td>Jatropha</td>
<td>Total</td>
<td>728,045.97</td>
<td>100.00</td>
<td>42,489,040.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>Tigray</td>
<td>0.00</td>
<td>0.00</td>
<td>660,878.00</td>
<td>2.73</td>
</tr>
<tr>
<td></td>
<td>AMHARA</td>
<td>0.00</td>
<td>0.00</td>
<td>2,160,379.00</td>
<td>8.93</td>
</tr>
<tr>
<td></td>
<td>Benishangul-G</td>
<td>0.00</td>
<td>0.00</td>
<td>13,909.00</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>Oromia</td>
<td>2763.670057</td>
<td>0.94</td>
<td>4,939,143.00</td>
<td>20.40</td>
</tr>
<tr>
<td></td>
<td>Dire Dawa</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Harari</td>
<td>0.00</td>
<td>0.00</td>
<td>68</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>294,219.97</td>
<td>100.00</td>
<td>24,205,566.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>Tigray</td>
<td>0.00</td>
<td>0.00</td>
<td>922,472.00</td>
<td>1.76</td>
</tr>
<tr>
<td></td>
<td>AMHARA</td>
<td>35,261.97</td>
<td>100.00</td>
<td>3,446,688.00</td>
<td>6.57</td>
</tr>
<tr>
<td></td>
<td>Benishangul-G</td>
<td>0.00</td>
<td>0.00</td>
<td>591,084.00</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td>Oromia</td>
<td>0.00</td>
<td>0.00</td>
<td>9,466,680.00</td>
<td>18.05</td>
</tr>
<tr>
<td></td>
<td>Dire Dawa</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Harari</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>35,261.97</td>
<td>100.00</td>
<td>52,435,512.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>Tigray</td>
<td>0.00</td>
<td>0.00</td>
<td>707,952.00</td>
<td>2.68</td>
</tr>
<tr>
<td></td>
<td>AMHARA</td>
<td>35,289.78</td>
<td>99.18</td>
<td>3,734,996.00</td>
<td>14.12</td>
</tr>
<tr>
<td></td>
<td>Benishangul-G</td>
<td>0.00</td>
<td>0.00</td>
<td>10,220.00</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>Oromia</td>
<td>0.00</td>
<td>0.00</td>
<td>5,598,620.00</td>
<td>21.17</td>
</tr>
<tr>
<td></td>
<td>Dire Dawa</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Harari</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Geremew et al.
the economic growth of the nation increases. In order to ensure the country’s continued development program and the national fuel security, it is important to increase fuel utilization and substituting the demand for locally

### Table 3: Contd.

<table>
<thead>
<tr>
<th>Biodiesel</th>
<th>REGION</th>
<th>NS</th>
<th>MaS</th>
<th>MoS</th>
<th>HS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall (Ha)</td>
<td>%</td>
<td>Overall (Ha)</td>
<td>%</td>
<td>Overall (Ha)</td>
</tr>
<tr>
<td>Cotton Seed</td>
<td>TIGRAY</td>
<td>316,400.79</td>
<td>16.01</td>
<td>1,464,628.00</td>
<td>2.39</td>
</tr>
<tr>
<td></td>
<td>AMHARA</td>
<td>368,509.22</td>
<td>18.65</td>
<td>6,374,412.00</td>
<td>10.41</td>
</tr>
<tr>
<td></td>
<td>BENISHANGUL-G</td>
<td>0</td>
<td>0.00</td>
<td>227,448.00</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>OROMIA</td>
<td>356,417.74</td>
<td>18.04</td>
<td>14,919,784.00</td>
<td>24.37</td>
</tr>
<tr>
<td></td>
<td>DIRE DAWA</td>
<td>0</td>
<td>0.00</td>
<td>8,724.00</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>HARARI</td>
<td>0</td>
<td>0.00</td>
<td>8,668.00</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>SNRP</td>
<td>247,858.18</td>
<td>12.54</td>
<td>4,233,096.00</td>
<td>6.91</td>
</tr>
<tr>
<td></td>
<td>GAMBELLA</td>
<td>0</td>
<td>0.00</td>
<td>491,100.00</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Afar</td>
<td>686,592.04</td>
<td>34.75</td>
<td>7,691,276.00</td>
<td>12.56</td>
</tr>
<tr>
<td></td>
<td>SOMALI</td>
<td>0</td>
<td>0.00</td>
<td>25,744,596.00</td>
<td>42.06</td>
</tr>
<tr>
<td></td>
<td>ADDIS ABEBA</td>
<td>0</td>
<td>0.00</td>
<td>52,564.00</td>
<td>0.09</td>
</tr>
<tr>
<td>Total</td>
<td>1,957,779.97</td>
<td>100.00</td>
<td>61,216,296.00</td>
<td>100</td>
<td>42,766,152.00</td>
</tr>
</tbody>
</table>

### Table 4. Average production per hectare and prices of the selected biofuel.

<table>
<thead>
<tr>
<th>Biofuel types</th>
<th>Yield (kg/Ha)</th>
<th>Production (Liter/Ha)</th>
<th>Price (USD/Ha)</th>
<th>Total Revenue (Billion USD)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biodiesel</td>
<td>Jatropha</td>
<td>1590</td>
<td>400-2.200</td>
<td>600-3.300</td>
<td>4.27-23.49</td>
</tr>
<tr>
<td></td>
<td>Castor</td>
<td>838</td>
<td>1413</td>
<td>246</td>
<td>2.56</td>
</tr>
<tr>
<td></td>
<td>Croton</td>
<td>2500</td>
<td>840</td>
<td>150</td>
<td>1.15</td>
</tr>
<tr>
<td></td>
<td>Cottonseed</td>
<td>273</td>
<td>325</td>
<td>160</td>
<td>2.29</td>
</tr>
<tr>
<td>Bio ethanol</td>
<td>Sweet-Sorghum</td>
<td>3.00-6.000</td>
<td>800</td>
<td>0.27</td>
<td>(FAO. 2008)</td>
</tr>
<tr>
<td></td>
<td>Cassava</td>
<td>1.750-5.400</td>
<td>200</td>
<td>32.72</td>
<td>(FAO. 2008)</td>
</tr>
</tbody>
</table>
Table 5. Suitability of Biofuels in the country excluding sensitive lands

<table>
<thead>
<tr>
<th>Biodiesel</th>
<th>REGION</th>
<th>NS</th>
<th>MaS</th>
<th>MoS</th>
<th>HS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ESL</td>
<td>%</td>
<td>ESL</td>
<td>%</td>
</tr>
<tr>
<td>Jatropha</td>
<td>TIGRAY</td>
<td>2,845,113.42</td>
<td>4.57</td>
<td>455,174</td>
<td>3.37</td>
</tr>
<tr>
<td></td>
<td>AMHARA</td>
<td>118,853.17</td>
<td>19.00</td>
<td>296,289</td>
<td>2.19</td>
</tr>
<tr>
<td></td>
<td>BENISHANGUL-G</td>
<td>364,233,5</td>
<td>5.82</td>
<td>1262</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>OROMIA</td>
<td>259,516,63,35</td>
<td>41.48</td>
<td>987,403</td>
<td>7.31</td>
</tr>
<tr>
<td></td>
<td>DIRE DAWA</td>
<td>49,898,279,93</td>
<td>0.08</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>HARARI</td>
<td>34,621,159,19</td>
<td>0.06</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>SNNP</td>
<td>914,867.31</td>
<td>14.62</td>
<td>367,015</td>
<td>2.72</td>
</tr>
<tr>
<td></td>
<td>GAMBELLA</td>
<td>140,134,44</td>
<td>2.24</td>
<td>598,187</td>
<td>4.43</td>
</tr>
<tr>
<td></td>
<td>Afar</td>
<td>244,919,85,1</td>
<td>3.91</td>
<td>279,975</td>
<td>20.73</td>
</tr>
<tr>
<td></td>
<td>SOMALI</td>
<td>511,269,19,90</td>
<td>8.17</td>
<td>799,695</td>
<td>59.22</td>
</tr>
<tr>
<td></td>
<td>ADDIS ABEBA</td>
<td>492,183,93,98</td>
<td>0.08</td>
<td>2402</td>
<td>0.02</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>625,650,94,97</td>
<td>100.00</td>
<td>135,066,96</td>
<td>100.00</td>
</tr>
<tr>
<td>Castor</td>
<td>TIGRAY</td>
<td>2,838,774,32</td>
<td>4.56</td>
<td>314,880</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>AMHARA</td>
<td>118,853,86</td>
<td>19.08</td>
<td>561,192</td>
<td>1.64</td>
</tr>
<tr>
<td></td>
<td>BENISHANGUL-G</td>
<td>3,643,027</td>
<td>8.57</td>
<td>181,760</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>OROMIA</td>
<td>25,946,505,62</td>
<td>41.45</td>
<td>4,367,516</td>
<td>12.73</td>
</tr>
<tr>
<td></td>
<td>DIRE DAWA</td>
<td>49,158,34</td>
<td>0.08</td>
<td>2,264</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>HARARI</td>
<td>34,563,71</td>
<td>0.06</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>SNNP</td>
<td>9,149,306,69</td>
<td>14.69</td>
<td>824,056</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>GAMBELLA</td>
<td>1,407,941,23</td>
<td>2.25</td>
<td>901,252</td>
<td>2.63</td>
</tr>
<tr>
<td></td>
<td>Afar</td>
<td>2,312,114,94</td>
<td>3.71</td>
<td>6,304,504</td>
<td>18.37</td>
</tr>
<tr>
<td></td>
<td>SOMALI</td>
<td>4,990,872</td>
<td>8.01</td>
<td>20,845,092</td>
<td>60.75</td>
</tr>
<tr>
<td></td>
<td>ADDIS ABEBA</td>
<td>49,190,36</td>
<td>0.08</td>
<td>2,408</td>
<td>0.01</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>62,300,841,97</td>
<td>100.00</td>
<td>34,310,724</td>
<td>100.00</td>
</tr>
<tr>
<td>Cassava</td>
<td>TIGRAY</td>
<td>2,838,774,32</td>
<td>4.56</td>
<td>441,380</td>
<td>3.15</td>
</tr>
<tr>
<td></td>
<td>AMHARA</td>
<td>11,885,386,31</td>
<td>19.08</td>
<td>553,300</td>
<td>3.95</td>
</tr>
<tr>
<td></td>
<td>BENISHANGUL-G</td>
<td>3,643,027,88</td>
<td>8.55</td>
<td>1,172</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>OROMIA</td>
<td>25,946,505,56</td>
<td>41.45</td>
<td>1,011,700</td>
<td>7.22</td>
</tr>
<tr>
<td></td>
<td>DIRE DAWA</td>
<td>49,158,34</td>
<td>0.08</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>HARARI</td>
<td>34,563,71</td>
<td>0.06</td>
<td>0</td>
<td>0.00</td>
</tr>
</tbody>
</table>
produced fuels such as biofuel (MoME, 2007).

Based on the suitability analysis of the biofuel feedstock considered, the country has huge potential for generating biofuel energy. With an estimated average yield of feedstock per hectare, the country can produce a total of 355.44 and 225.09 billion liters of biodiesels and bioethanols on HS lands alone, respectively. This is equivalent to 53 billion USD. The amount of average production per hectare and prices of the selected biodiesel and bioethanol feedstocks are presented in Table 5. The amount of earning from biofuel can also increase by planting on MoS and MaS area as well as planting the margins of croplands; the biofuels serving as fences. Overall, the production would count towards reducing the amount of fuel the country imports. It also promotes the CRGE strategies of the country without affecting food security.

As the country is also striving for creating conducive environment for local and international investors, it would be a source of foreign currency through direct foreign investment in addition to playing a role in creating job opportunities for the local people.

**Conclusion**

Ethiopia has a huge potential for biofuel development. Given the country’s conducive agro-ecology, availability of ample suitable sites and cheap labor force for biofuel production, part of the fuel energy needs of the country

<table>
<thead>
<tr>
<th>Biodiesel</th>
<th>REGION</th>
<th>NS (ESL)</th>
<th>%</th>
<th>MaS (ESL)</th>
<th>%</th>
<th>MoS (ESL)</th>
<th>%</th>
<th>HS (ESL)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet Sorghum</td>
<td>TIGRAY</td>
<td>3,050,830.16</td>
<td>4.84</td>
<td>908,592.00</td>
<td>2.61</td>
<td>1,475,292.00</td>
<td>11.13</td>
<td>172,872.00</td>
<td>10.13</td>
</tr>
<tr>
<td></td>
<td>AMHARA</td>
<td>11,914,747.24</td>
<td>18.9</td>
<td>1,155,928.00</td>
<td>3.32</td>
<td>1,932,220.00</td>
<td>14.58</td>
<td>324,020.00</td>
<td>18.99</td>
</tr>
<tr>
<td></td>
<td>BENISHANGUL-G</td>
<td>3,638,283.75</td>
<td>5.77</td>
<td>28,432.00</td>
<td>0.08</td>
<td>1,051,648.00</td>
<td>7.93</td>
<td>144,776.00</td>
<td>8.49</td>
</tr>
<tr>
<td></td>
<td>OROMIA</td>
<td>25,923,665.89</td>
<td>41.12</td>
<td>4,774,860.00</td>
<td>13.7</td>
<td>4,244,716.00</td>
<td>32.02</td>
<td>548,492.00</td>
<td>32.15</td>
</tr>
<tr>
<td></td>
<td>DIRE DAWA</td>
<td>49,092.01</td>
<td>0.08</td>
<td>8,420.00</td>
<td>0.02</td>
<td>93,140.00</td>
<td>0.7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>HARARI</td>
<td>34,517.07</td>
<td>0.05</td>
<td>1,044.00</td>
<td>0</td>
<td>3,788.00</td>
<td>0.03</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>SNNP</td>
<td>9,192,986.20</td>
<td>14.58</td>
<td>769,300.00</td>
<td>2.21</td>
<td>1,594,160.00</td>
<td>12.03</td>
<td>132,368.00</td>
<td>7.76</td>
</tr>
<tr>
<td></td>
<td>GAMBELLA</td>
<td>1,401,052.52</td>
<td>2.22</td>
<td>140,736.00</td>
<td>0.4</td>
<td>946,792.00</td>
<td>7.14</td>
<td>65,660.00</td>
<td>3.85</td>
</tr>
<tr>
<td></td>
<td>Afar</td>
<td>2,808,059.71</td>
<td>4.45</td>
<td>5,757,388.00</td>
<td>16.52</td>
<td>738,168.00</td>
<td>5.57</td>
<td>51,340.00</td>
<td>3.01</td>
</tr>
<tr>
<td></td>
<td>SOMALI</td>
<td>4,986,887.45</td>
<td>7.91</td>
<td>21,308,952.00</td>
<td>61.13</td>
<td>1,175,236.00</td>
<td>8.87</td>
<td>266,588.00</td>
<td>15.63</td>
</tr>
<tr>
<td></td>
<td>ADDIS ABEBA</td>
<td>49,123.98</td>
<td>0.08</td>
<td>3,396.00</td>
<td>0.01</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>63,049,045.97</td>
<td>100</td>
<td>34,857,048.00</td>
<td>100</td>
<td>13,255,160.00</td>
<td>100</td>
<td>1,706,116.00</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>REGION</th>
<th>ESI (ESL)</th>
<th>%</th>
<th>ESL (ESL)</th>
<th>%</th>
<th>ESL (ESL)</th>
<th>%</th>
<th>ESL (ESL)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet Sorghum</td>
<td>TIGRAY</td>
<td>2,835,895.48</td>
<td>4.55</td>
<td>12,524.00</td>
<td>1.98</td>
<td>61,752.00</td>
<td>0.84</td>
<td>2,697,576.00</td>
</tr>
<tr>
<td></td>
<td>AMHARA</td>
<td>11,866,331.74</td>
<td>19.05</td>
<td>143,352.00</td>
<td>22.67</td>
<td>166,404.00</td>
<td>1.84</td>
<td>3,150,740.00</td>
</tr>
<tr>
<td></td>
<td>BENISHANGUL-G</td>
<td>3,638,243.65</td>
<td>5.84</td>
<td>0</td>
<td>0</td>
<td>7,444.00</td>
<td>0.08</td>
<td>1,217,412.00</td>
</tr>
<tr>
<td></td>
<td>OROMIA</td>
<td>25,911,311.17</td>
<td>41.6</td>
<td>12,284.00</td>
<td>1.94</td>
<td>121,840.00</td>
<td>1.35</td>
<td>9,446,016.00</td>
</tr>
<tr>
<td></td>
<td>DIRE DAWA</td>
<td>49,091.47</td>
<td>0.08</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>101,560.00</td>
</tr>
<tr>
<td></td>
<td>HARARI</td>
<td>34,516.69</td>
<td>0.06</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,832.00</td>
</tr>
<tr>
<td></td>
<td>SNNP</td>
<td>9,183,577.34</td>
<td>14.75</td>
<td>2,912.00</td>
<td>0.46</td>
<td>59,436.00</td>
<td>0.66</td>
<td>2,442,796.00</td>
</tr>
<tr>
<td></td>
<td>GAMBELLA</td>
<td>1,401,037.08</td>
<td>2.25</td>
<td>0</td>
<td>0</td>
<td>5,996.00</td>
<td>0.07</td>
<td>1,147,192.00</td>
</tr>
<tr>
<td></td>
<td>Afar</td>
<td>2,326,677.41</td>
<td>3.74</td>
<td>461,156.00</td>
<td>72.92</td>
<td>1,365,604.00</td>
<td>15.1</td>
<td>5,201,924.00</td>
</tr>
<tr>
<td></td>
<td>SOMALI</td>
<td>4,986,632.50</td>
<td>8.01</td>
<td>0</td>
<td>0</td>
<td>7,255,772.00</td>
<td>80.22</td>
<td>15,495,004.00</td>
</tr>
<tr>
<td></td>
<td>ADDIS ABEBA</td>
<td>49,190.36</td>
<td>0.08</td>
<td>3,372.00</td>
<td>0.02</td>
<td>24</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>62,282,437.97</td>
<td>100</td>
<td>632,404.00</td>
<td>100</td>
<td>9,045,048.00</td>
<td>100</td>
<td>40,907,480.00</td>
</tr>
</tbody>
</table>
Figure 4. Overall suitability of biofuels: Jatropha (a), Castor (b), Croton (c), Cassava (d), Cottonseed (e) and Sweet Sorghum (f)
Figure 5. Suitability of biofuels excluding sensitive lands: Jatropha (g), Castor (h), Croton (i), Cassava (j), Cottonseed (k) and Sweet Sorghum (l)
can be satisfied by domestic biofuel production in addition to its potential for export earnings.

CONFLICT OF INTERESTS
The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS
We would like to acknowledge all the organizations that provided data for this research.

REFERENCES
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

Daniel Ndambiri Ngunyi* and Godfrey O. Makokha

Dedan Kimathi University of Technology, Kenya.

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

*Corresponding author. E-mail: gakengedani@gmail.com.

Author agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International License
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).

<table>
<thead>
<tr>
<th>Total number of accredited training institutions</th>
<th>Number of training institutions based in Kenya</th>
<th>Number of training institutions outside Kenya</th>
</tr>
</thead>
<tbody>
<tr>
<td>180</td>
<td>174</td>
<td>6</td>
</tr>
<tr>
<td>100%</td>
<td>96.67%</td>
<td>3.33%</td>
</tr>
</tbody>
</table>

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

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

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.

<table>
<thead>
<tr>
<th>Feature class</th>
<th>Field</th>
<th>Field type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training institution</td>
<td>Name</td>
<td>Text</td>
</tr>
<tr>
<td></td>
<td>Objectld</td>
<td>OID</td>
</tr>
<tr>
<td></td>
<td>Shape</td>
<td>Point</td>
</tr>
<tr>
<td></td>
<td>County</td>
<td>Category</td>
</tr>
<tr>
<td></td>
<td>Town</td>
<td>Text</td>
</tr>
<tr>
<td></td>
<td>Telephone</td>
<td>Text</td>
</tr>
<tr>
<td></td>
<td>E-mail</td>
<td>Text</td>
</tr>
<tr>
<td></td>
<td>PopUpInformation</td>
<td>Text</td>
</tr>
<tr>
<td></td>
<td>Objectld</td>
<td>OID</td>
</tr>
<tr>
<td></td>
<td>Status</td>
<td>Category</td>
</tr>
<tr>
<td>Accreditation details</td>
<td>Certificate No.</td>
<td>Short Integer</td>
</tr>
<tr>
<td></td>
<td>Date Issued</td>
<td>Date</td>
</tr>
<tr>
<td></td>
<td>Expiry Date</td>
<td>Date</td>
</tr>
<tr>
<td></td>
<td>Courses Approved</td>
<td>Text</td>
</tr>
<tr>
<td></td>
<td>Objectld</td>
<td>OID</td>
</tr>
<tr>
<td></td>
<td>Visit type</td>
<td>Subtype</td>
</tr>
<tr>
<td>Accreditation visits</td>
<td>Date Visited</td>
<td>Date</td>
</tr>
<tr>
<td></td>
<td>Grading</td>
<td>Category</td>
</tr>
<tr>
<td>County</td>
<td>Name</td>
<td>Text</td>
</tr>
<tr>
<td></td>
<td>Objectld</td>
<td>OID</td>
</tr>
<tr>
<td></td>
<td>Shape</td>
<td>Polygon</td>
</tr>
<tr>
<td></td>
<td>Area</td>
<td>Float</td>
</tr>
<tr>
<td>Roads</td>
<td>Name</td>
<td>Text</td>
</tr>
<tr>
<td></td>
<td>Objectld</td>
<td>OID</td>
</tr>
<tr>
<td></td>
<td>Shape</td>
<td>Line</td>
</tr>
</tbody>
</table>
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
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
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
ability to visually display spatial data allows us to see patterns that would have otherwise been less clear were it 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.

REFERENCES
