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Application of Geo-informatics for Urban Agricultural Practices: A Case of Debre Markos, Ethiopia

Dr. Ajay Babu Gangidi[1], Dr. Kenate Worku[2]

[1]Associate Professor, Department of Geography and Environmental Studies, Jimma University, Federal Democratic Republic of Ethiopia

[2] Assistant Professor, Department of Geography and Environmental Studies, Jimma University, Federal Democratic Republic of Ethiopia

Abstract: ***Urban planning with spatial distribution of land uses in a systematic manner with smart growth structures and strategies as guiding principles is being increasingly accepted. In this effort, urban agriculture has been gaining focus especially as the peri-urban is losing its traditional value as the green belt supporting urban needs of perishable foods. Further, to ensure that the urban settlements have more lung spaces and carbon absorption centres, urban forestry is considered integral to urban planning and sustainable urbanization. Thus individuals and organizations are given weightage to urban agriculture and urban forestry in many forms. In order to deliver this exercise as more precise and forecastable, the use of geo-informatics technologies has been embraced and is gaining momentum. This paper is an effort to identify suitable locations in Debre Markos town for urban farming and forestry alike, using geo-informatics technologies. A survey of the land use and land cover enabled the identification of open spaces and remote sensing data helped assess the suitability of these spaces for different land uses especially urban agriculture. Such generated databases can be used by farmers and town administration for further analysis and planning. This methodology has great potential for replication through adaptation to other cities for various purposes***.

Keywords: Geo-informatics, Satellite Imagery, Urban, Agriculture

1. Introduction

Geo-informatics has developed at a remarkable pace over the past three decades and will play a key role in development of nations in the 21st Century; thereupon many countries have already prepared their strategic plans for application of Geo-informatics technology with huge financing endeavors. Now time has come for all decision makers to discuss the appropriateness of geo-informatics technologies and its applications to rural development, forest management, urban development planning, land information systems and agricultural development. This will also provide a suitable solution for the use of geo-informatics for educational infrastructure development with special emphasis on rural sector in Ethiopia. Information Technology has emerged as an inevitable phenomenon influencing every walk of life of people in all sections of this society. With the ease of availability of enormous computing power and convenient access to large volume and variety of data and information, the structure and functions of all human organizations will undergo profound transformation in this century (Himanshu 2010).

Urban Agriculture in the city areas is a phenomenon that can be observed worldwide. This is particularly true for cities of developing countries like Ethiopia, where food production for subsistence and marketing contributes to the improvement of food security and urban ecology (Smit et al. 1996, Mougeot 2005).

In spite of all ongoing research on urban agriculture, in most of the developing countries' cities few systematic studies have been carried out on urban agriculture in terms of inner city areas used for agricultural purposes. Also little is known on the spatial distribution of urban agriculture in the cities.

In the world-wide context, only very few studies with the application of geo-informatics to urban food production activities is available. For Santiago de los Caballeros (Dominican Republic) a GIS based database has been developed by the University of Santiago (Del Rosario et al. 1999). In Ouagadougou (Burkina Faso), a mapping of urban and peri-urban agricultural areas has been carried out based on IKONOS satellite imagery (Kemeling 2001). The 'Resource Center of Urban Agriculture and Food Security'(RCUAF) recently conducted mappings of the presence of urban agriculture and available open spaces in six cities: Villa Maria del Triunfo (Lima, Peru); Pikine (Dakar, Senegal); Accra (Ghana); Bulawayo (Zimbabwe); Hyderabad (India); and Beijing (China) (RCUAF 2006).

Therefore, this study has made a modest attempt to identify the suitable locations for urban agricultural activities by carrying out a survey by combining analysis of satellite images with field work, and using geo-informatics as a tool.

2. Description of the Study Area

Debre markos, the capital of East Gojjam Zone is located in the north west of the capital city of the Federal Democratic Republic of Ethiopia, Addis Ababa at a distance of 300Kms and 265 kms to the capital of Amhara Nation Regional State Bahir Dar (Fig. 1). The Geographical location of the study area is located between 10°17′ to 10°21′ N Latitudes and 37°42′ to 37°45′ E longitudes and its elevation ranges in altitude from 2350 - 2500 meters above sea level. The town has 1380 mm average annual rainfall and minimum and maximum temperatures of 15 C and 22 C respectively.

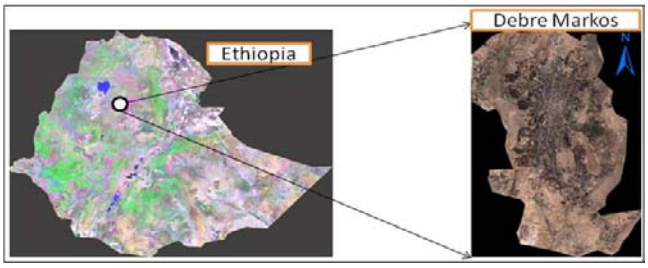

Figure 1: Location map of the Study Area

Based on figures from the Central Statistical Agency in 2009, Debre Markos has an estimated total population of 85,597, of whom 43,229 are men and 42,368 are women. The town has an estimated area of 21.54 square kilometers, which gives Debre Markos a density of 3,973.70 people per square kilometer.

3. Database and Methodology

In this study, both primary and secondary data sources were used. Most of the data were obtained from primary sources such as satellite images, GPS, field survey and observation. Secondary data was collected through review of available existing literature from different sources.

This study made use of SPOT satellite image dated: Jan 22, 2015 and GPS points from the town to locate geographical coordinate points on satellite imagery. In the first stage latitudes and longitudes of the town were collected from the field with the help of GPS instrument. Then control points were used to georeference the satellite images to adjust latitudes and longitudes with the help of ArcGIS 9.3 software to build relationship between satellite images and ground control points (GCPS). In order to achieve the result, a step-by-step procedure as given below is adopted. (fig.2)

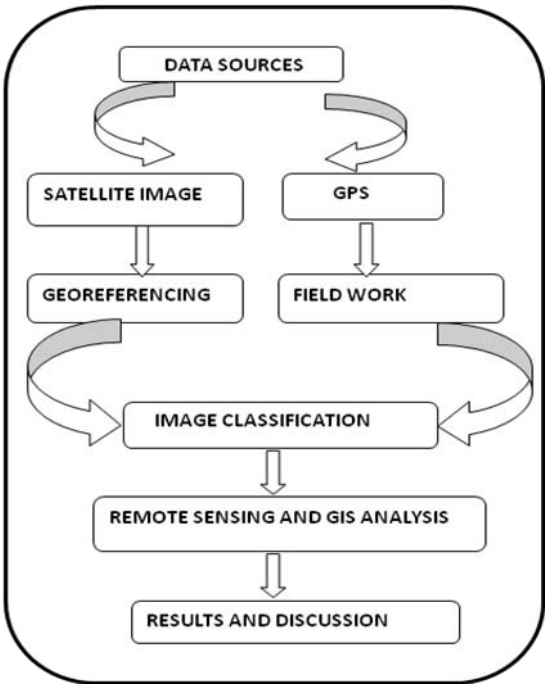

Figure 2: Flow chart of the Methodology

In and around Debre Markos, a total area of 30.25 km² (2015) was surveyed using Global Positioning System to identify exact locations. The following different working techniques were used:

(1) Georectifcation of Satellite Images
(2) Classification and analysis of results
(3) Field work

4. Georectification and Classification of Satellite Images

This was the first step which made it possible to map a large area in a short time, and to get accurate results. The analysis was based on recently available satellite Images of the Debre Markos Town. The images were georectified with the help of ArcGIS 9.3 software and classified with ERDAS 9.2 software in order to land use and land cove map of the study area. To obtain ground control points, several field visits were made to get accurate data.

Then supervised classification technique was used to analyze the satellite images by using software ERDAS 9.2. The classification method was used to extract different layers of data from the study area. The final layout and analysis of classified data was performed with the help of ArcGIS 9.3 software.

5. Field work (using GPS)

All important sites were identified and photographed. However, some sites turned out to be inaccessible (e.g. defense areas). With the help of Global Positioning System instrument the latitudes and longitudes of agricultural open spaces were measured and recorded. Experience showed that it was more appropriate to work with GPS receivers for the purpose of the study.

6. Survey of open space agriculture in Debre Markos, Ethiopia

Open spaces play an important role in urban areas regarding micro-climate and can be important for food security in times of crisis. Since the study aimed to identify all open spaces used for vegetable production in and around Debre Markos (Fig 3, 4, 5 & 6) according to 2015 satellite data, the exact locations were identified and integrated into the GIS database of Debre Markos.

The town is surrounded by three swampy areas (flood plains) and ridges, escarpments and streams associated with gullies. There are major slope categories which are as follows:

- Land with 0 – 2.5 percent slope: this area refers to the swampy areas which cover 20% of the urban landscape.
- Land with 2.6 – 20 percent slope: land with this slope constitutes 75% of the area of the town. This is suitable for settlement.
- Land with > 20 percent slope: this refers to the land occupied by gullies, ridges and escarpments which accounts for 5% of the land resources.

Figure 3

Figure 4

Figure 5

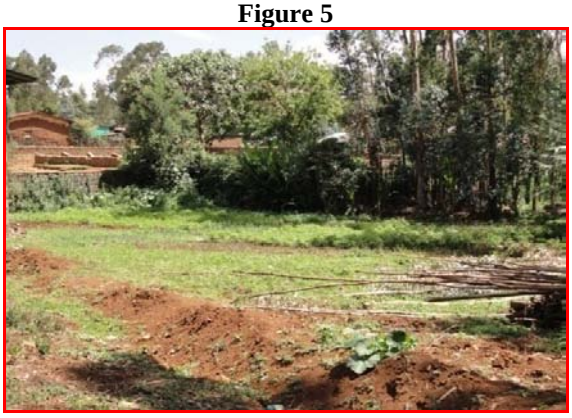

Figure 6

Figure 3, 4, 5 & 6: Open spaces used for urban agriculture in the city (photos 2015)

Figures 3, 4, 5 & 6 show open spaces used for agricultural activities in the city of Debre Marko in 2015. In most of the places urban farmers are cultivating vegetables which are essential in daily life such as local cabbage(gomman), potato(dinich), green chilli(karia), onion(shinkurth), carrot and tomatoes. Majority of the open spaces have small quantity of land especially in the middle of the town. The study shows that some of the areas are changed form one activity to another activity. For example the land in fig. 3 & 4 are recently converted from grasslands to agricultural land. These grasslands have a greater potential for growth of crops, vegetables and livestock (fig. 4).

Table 1: Selected open Spaces and its latitudes, longitude and elevations of Debre Markos Town

Figure No	*Location Name*	*Latitude*	*Longitude*	*Elevation in meters (above MSL)*
2	Summerland park	10°20′30″ N	37°44′19″ E	2407
3	Mkutia(around kella)	10°18′04″ N	37°44′30″ E	2390
4	Peacock	10°20′59″ N	37°43′45″ E	2489
5	Cattle market	10°20′50″ N	37°44′30″ E	2415

Table. 1 shows latitudes, longitude and elevations of open spaces used for vegetable production in the study area. These areas are located between the altitudes of 2390 and 2420 meters above sea level. The majority of these open spaces are located around streams and rivers.

7. Results and Discussions

Fig .7 above shows the exact geographical coordinates of each location in and around Debre Markos town. The city is passing through by 10° N Latitude and 37° E longitude. The total study area has an estimated area of 36.25 square kilometers. The majority of area is covered by undulated topography. Distance from north to south and west to east of the town is 8.50 and 5.32 kms respectively. The major flood plains (low lands) are located in NW, NE and SE directions of the town. Fig. 8 shows the settlement locations in the town. The majority of these settlements are located within the boundary of 11.43 sq kms and remaining are sparsely distributed in the study area. The geographical coordinates of this area is located within 10°18′ to 10°21′ N latitudes and 37°43′ to 37°45′ E longitudes.

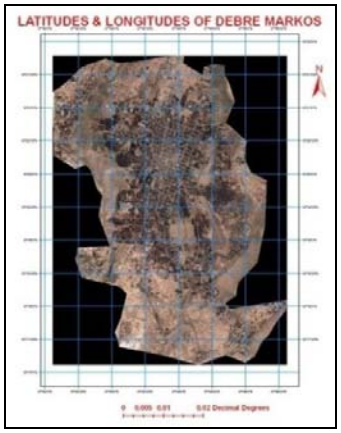

Figure 7: Latitudes and Longitudes of Debre Markos

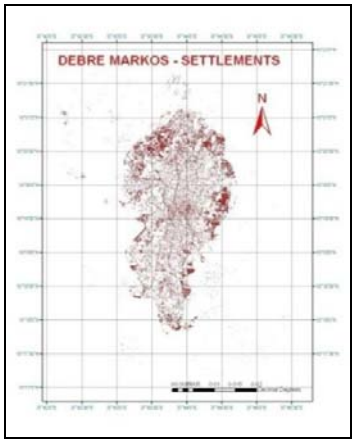

Figure 8: Settlements of Debre Markos

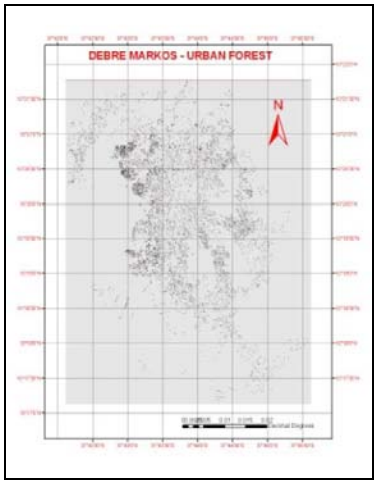

Figure 9: Urban Forest in Debre Markos

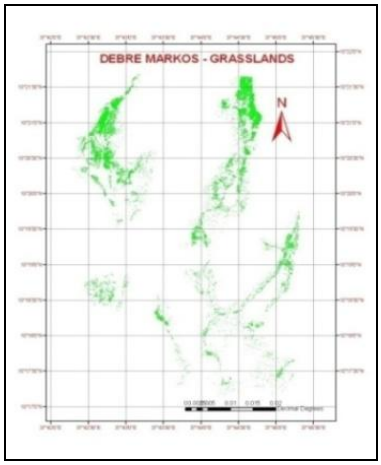

Figure 10: Grasslands in Debre Markos

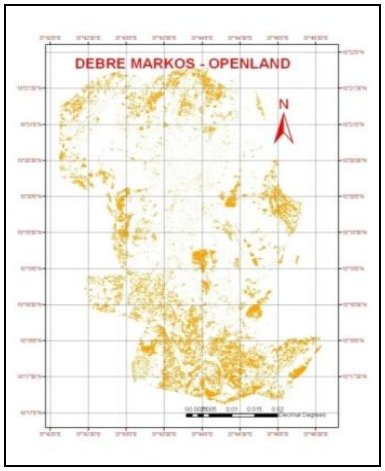

Figure 11: Open lands in Debre Markos

According to Fig. 9 the study area has covered with plenty of trees and majority of these are covered with eucalyptus plants and are unevenly distributed. Some parts of the town are covered with dense trees which are located between 10°19′ to 10°21′ N latitudes and 37°42′ to 37°44′ E longitudes. Fig. 10 and 11 shows the areas which are covered by grass lands and open areas in and around the study area. The majority of the grasslands were located in NW, NE and SE directions of the town, whereas open lands are located in northern and southern part of the town. Naturally, the town is located in high rain fall zone and there is no scarcity for water. Majority of the open spaces were found around low lands in swampy areas. According to the study, it is possible to consider both grasslands and open lands as open spaces which are suitable for urban agricultural activities.

8. Conclusion

Urban farming and forestry are common livelihood strategy for residents of cities in developing countries. In Debre Markos town, urban agriculture comprises the production of crops, livestock and vegetables. Over the past few decades, Geo-informatics (Remote Sensing, GIS and GPS) techniques have been increasingly used to support the urban land use studies because of their cost-effectiveness and technological advancement. This study has surveyed the status of Geo-informatics and its applications in developing broad scale land use and land cover for identifying the open spaces which are suitable for urban agriculture or other purposes. The generated database can be used by urban farmers and town administration for further research and planning, and can be used to make overlays with other relevant spatial data. There is a high potential to use the developed methodology in other cities and to expand it to other topics of interest.

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Author Profile

Dr. Ajay Babu Gangidi working as Associate Professor in Department of Geography and Environmental Studies, Jimma University, Ethiopia

Dr. Kenete Worku working as Assistant professor in Department of Geography and Environmental Studies, Jimma University, Ethiopia. He is also serving the university at academic administration position (V/Dean of the College of Social Sciences and Humanities), Jimma University, Ethiopia