Full Length Research Paper

Monitoring the urban growth of Debre Markos Town (1984-2012), Ethiopia: Using satellite images and GPS

Abebaw Andarge

Department of Geography and Environmental Studies, Debre Markos University, College of Social Science and Humanities, P. O. Box 269, Debre Markos, Amhara Regional State, Ethiopia.

Received 25 October 2015; Accepted 2 December, 2015

Urban growth is a worldwide phenomenon. It is a process which takes place rapidly to occupy the adjacent land of an area and changes in land use pattern, demographic features and transforms the economic activities of the people. Over the years, Ethiopian cities have experienced tremendous expansion which generates a great concern for urban planners. The present study used Geographic Information System (GIS), Remote Sensing and Global Positioning System technologies to identify the nature of physical expansion in Debre Markos town during 1984 – 2012. The researcher discovered that Debre Markos town population has expansion of 170.50% between 1984 and 2012. The built-up area covered 6.78 sq. kms in 1984 and expanded to 12.76 sq. kms in 2012. The town grew at the rate of 3.15 sq. kms and 3.57% annually. As per the study, built-up area has grown from 6.78 to 10.93 during 1984-2004 and 10.93 to 12.76 sq. kms between 2004 and 2012. There is an increment of 44.04% boundary from 1984 to 2012. The city has encroached lots of precious agricultural and forest land areas during the study period. In order to monitor the physical growth of the towns, the researcher recommended the need to introduce modern technologies and use of proper management techniques by urban planning authorities.

Key words: Geographic Information System (GIS), remote sensing, Global Positioning System (GPS), urban growth.

INTRODUCTION

Urban areas represent built environments that are physically distinguishable from the natural environment, and are thus potentially identifiable through the use of remotely sensed sources such as satellite images, aerial photography. Nowadays, most of the world population lives in cities and metropolises. However, it is often the case that settlements grow irregularly under the pressure of masses coming to cities and these do not develop according to well-defined plans. Hence, it is necessary to monitor urban areas with frequent update.

Urbanization is inevitable when pressure on land is high, agriculture incomes are low and population

E-mail: abeandargie@yahoo.com.

Authors agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International License.
increase are excessive, as is the case in most of the
developing countries of the world. Urbanization has become
not only of the principal manifestation but also an
effect of change, and the 21st century which has
in a way urbanization is desirable for human
development. However, uncontrolled urbanization has been
responsible for many of the problems our cities experiences today, resulting in substandard living
environment, acute problems of drinking water, noise and
air pollution, disposal of waste, traffic congestion etc. To
improve these environmental degradations in and around
the cities, the technological development in relevant fields
has to solve these problems caused by rapid urbanization.
Only then the fruits of development will reach most of the
deprived ones (Urbanization, 2010; available on:
The modern technology of remote sensing which
includes both aerial as well as satellite based systems
allows us to collect lot of physical data rather easily, with
speed and on repetitive basis; GIS helps us to analyze
the data spatially, offering possibilities of generating
various options, thereby optimizing the whole planning
process. These information systems also offer
interpretation of physical (spatial) data with other socio-
economic data, and thereby providing an important
linkage in the total planning process and making it more
effective and meaningful. Recent technological advances
made in domain of spatial technology cause considerable
impact in planning activities. This domain of planning is of
prime importance for a country like Ethiopia with varied
gеographic patterns, cultural activities etc. The purpose
of using GIS is that maps provide an added dimension to
data analysis which brings us one step closer to
visualizing the complex patterns and relationships that
characterize real-world planning and policy problems.
Visualization of spatial patterns also supports change
analysis, which is important in monitoring of social
indicators. This in turn should result in improving need
assessment (Rahman, 2006).
Ethiopia, like many of the developing countries, has a
problem with urban expansion and the growth of
population in the main cities and towns. For example,
over the last decades Debre Markos, the capital of East
Gojjam has significantly expanded due to different
development activities and migration of people from rural
sites. Various changes have occurred in the town but
there are no regularly updated maps to indicate those
changes. In general, it should be interesting to study and
observe the urban growth of Debre Markos town in recent
years. Therefore, Debre Markos town was chosen for this
study to generate urban spatial database using Remote
Sensing, Geographical Information System, and Global
Positioning System technologies to help present and
future generations. Thus, this research paper is generally
an intention to identify the expanded areas in and around
Debre Markos town.

**METHODOLOGY OF THE STUDY**

For the purpose of monitoring the physical growth, pattern detection
and mapping this study utilizes different methods for data collection,
data analysis and presentation. Among these, participatory
mapping, GIS and RS techniques were the main techniques. In
addition, GPS instrument was used to collect recent ground control
points from the field.

**Study area**

Debre Markos, the capital of East Gojjam Administrative Zone is
located in the North west of the capital city of the Federal
Democratic Republic of Ethiopia, Addis Ababa at a distance of 300 Kms and 265 kms to the capital of Amhara Nation Regional State
Bahir Dar. The geographical location of the study area is located
between 10°17′00″ to 10°21′30″ N Latitudes and 37°42′00″
to 37°45′30″ E longitudes and its elevation ranges in altitude from
2350-2500 meters above the sea level. The town has 1380 mm
annual average rainfall and minimum and maximum temperatures
of 15 C and 22 C respectively (Debre Markos Town Administration,
2011).
The area is dissected by three swampy areas (mainly flood plains)
and to some extent ridges, escarpments, and streams
associated with gullies. There are three main major slope
categories that can be classified, according to the document
obtained from the town municipality office.
1. Land with 0-2.5 percent slope: this area refers to the swampy
areas which cover 20% of the total urban land.
2. Land with 2.6-20 percent slope: land with this slope class
constitutes 75% of the area of the town. This is suitable for
settlement and other functions.
3. Land with > 20%: this refers to the land characterized by gullies,
ridges and escarpments which account 5% of the land resources
(Debre Markos town municipality, 2009).
The town is bounded by two woredas. In the East, it is bounded by
Anebed Wolita and the remaining three directions (to the West,
North and South); it is bounded by Gizo woreda. The total
study area has an estimated area of 30.5 square kilometers. The
location map of the study area is shown in Figure 1.

**Data sources**

Data for this research are obtained from both primary and
secondary sources. The primary data was collected from the field
with the help of GPS instrument and secondary data was obtained
from different sources details as summarized in Table 1.
The secondary data used for this research is satellite image of
IRS 1D (LISS IV) of 2004 from National Remote Sensing Agency
(NRSA), Topographical Map of 1984 at a scale of 1:50,000 from
Ethiopian mapping Agency (EMA) and Statistical data from Central
Statistical Agency (CSA), and Debre Markos City Administration.
Data on population growth was collected from Debre Markos Town
Administration, published and unpublished documents, reports,
books and internet (Figure 2).

Figure 3 shows the methodology of the study. The researcher
used different data acquisition methods to collect data from the
field. In this study, satellite imagery of 2004 and topographical
map
of 1984 were registered or geo-referenced. Debre Markos town’s boundaries and major roads were digitized with using ArcGIS 9.2 software. GARMIN 60 GPS instrument was used for field survey to gather recent information (2012) on town’s boundary. The recent boundary map of Debre Markos town was generated by using DNR Garmin software. Finally, all the digitized maps were overlaid to know the physical expansion of the town during 1984 – 2012 (Figure 4).

RESULTS AND DISCUSSION

Physical status of the town in 1984

In 1984, the urban area of Debre Markos town was 6.78 square kilometers with a population of 39,808 and the total length of the city boundary was 21.5 km. The town has stretched from the North to South direction. National highway number three from Addis Ababa to Gondar is passing through the center of the town. Figure 5 shows built-up area of the town in 1984.

Physical status of the town in 2004

According to Figure 6 built-up area of the town was 10.93 sq. kms and length of the town boundary was 27.13 kms in 2004. For the period of 1984 – 2004 population of the town rose up to 85,597 est.(115.02 %). During the period 1984-2004 the length and area of the town increased by

Table 1. Baseline data

<table>
<thead>
<tr>
<th>S/No</th>
<th>Data type</th>
<th>Data source</th>
<th>Date</th>
<th>Other characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Debre Markos topographical map</td>
<td>Ethiopian Mapping Agency</td>
<td>1984</td>
<td>Scale of 1:50,000</td>
</tr>
<tr>
<td>2</td>
<td>Satellite image of Debre Markos</td>
<td>IRS 1D (LISS IV)</td>
<td>2004</td>
<td>Spatial Resolution : 23 meters</td>
</tr>
<tr>
<td>3</td>
<td>GPS data</td>
<td>Field Survey</td>
<td>2012</td>
<td>Model No : GARMIN 60</td>
</tr>
</tbody>
</table>
26.18 61.20%, respectively.

Physical status of the town in 2012

Figure 7 shows the boundary of the town in 2012. Global positioning system instrument was used to collect ground control points of the town. In this figure, major roads and recent boundary of the town can be observed. Based on the field survey results, the total area occupied by the town in 1984 and 2012 is 6.78 and 12.76 sq. kms respectively. There is an increment of 44.04% boundary from 1984 to 2012.


Figure 8 shows physical growth of the town from 1984 to 2004. According to the figure much of the physical growth is observed towards Northern and Southern direction of the town and there is no change in Western and Eastern directions.

During the period 1984-2004 the city population has increased to 85,597(115.02%) and physical expansion of the town showed a speedy increase with 10.93 sq. kms (61.20%). At the same time the total length of the boundary increased from 21.5 to 27.13 kms.

Physical expansion of Debre Markos (2004-2012)

According to Figure 9 the town growth can be observed towards North, North-East, East and Southern directions. The total population of the town was 85597 in 2004 and 107684 in 2012 with an increase of about 25.80 per cent; eventually the town area also rises from 10.93 to 12.76 sq. km, showing a remarkable expansion in town area.


Table 2 shows the physical growth and population expansion of the town from 1984 to 2012. The built-up area covered 6.78 sq. kms in 1984 and expanded to 12.76 sq. kms (88.20%) in 2012. At the same time, built-up area has grown from 6.78 to 10.93 during 1984-2004 and 10.93 to 12.76 sq. kms between 2004 and 2012. The town grew at the rate of 3.15 sq. kms (3.57%) annually. The population growth rate was 170.50% during 1984-2012.

In 1984, 2004 and 2012 city's expansion was mapped
using topographic maps, landsat imagery and GPS points. Garmin GPS 60 instrument was used in field survey to obtain ground control points of the town. The study revealed that the rate of physical expansion of Debre Markos town was not the same in all the decades; it was fluctuating. Finally, all the maps were overlaid to know the physical expansion of the town during 1984-2012.

Figure 10 shows physical expansion of the town from time to time. During 1984-2012 the city showed a tremendous growth of population as well as area. The area is 12.76 (88.20%) and the population is 107684 (170.50%) and length of the boundary increased to 30.97 kms. The minimum and maximum expansion of the town was noticed during 2004 – 2012 and 1984 – 2004 respectively.

CONCLUSION AND RECOMMENDATIONS

The physical growth of urban centre is a contemporary phenomenon in developing countries like Ethiopia. Over the years, Ethiopian cities have experienced tremendous expansion which generates a great concern for urban planners. During the study period, the town experienced the positive growth rate in area as well as population. The area of the city increased from 6.78 to 12.76 sq. kms

Figure 4. Flow chart of the methodology.
Figure 7. Debre Markos town map in 2012.

Figure 8. Physical growth of the town during 1984-2004.
and almost it is doubled within 28 years. On the other hand, the population of the city grew from 39,808 in 1984 to 107,684 in 2012 shows 67,876 increment within a span of 28 years.

As per the study, built-up area has grown from 6.78 to 10.93 during 1984-2004 and 10.93 to 12.76 sq. kms between 2004 and 2012. There is an increment of 44.04% boundary from 1984 to 2012. The minimum and maximum expansion of the town was noticed during 2004 – 2012 and 1984 – 2004 respectively.

The researcher discovered that Debre Markos town population expansion of 170.50% between 1984 and 2012. The town grew at the rate of 3.15 sq. kms and 3.57% annually. The city has encroached lots of precious agricultural and forest land areas during the study period. Therefore, Planners need the whole data and information of a map and information related to these aspects for perspective planning and management at the edge of Debre Markos town. Hence, there is need to create an information system of Debre Markos city to overlay, analyze and create various planning scenarios for decision making. Global Positioning System (GPS), Remote Sensing (RS) and Geographic Information System (GIS) are appropriate tools for creating such type of information system. Urban planning authorities need to explore the use of remote sensing, geographical information and global positioning system technologies for monitoring the physical growth of the towns. This would provide support to planners in development of planning. Cities growth and developments are to be mapped, stored and displayed so as to understand whether they are maintaining sustainability or not. The acquisition of recent satellite images need to be introduced for monitoring the activities of developers. This will help in reducing unplanned urban spread out and the associated loss of natural surrounding and biodiversity. There is a need to encourage and plan for balanced growth in our cities. This is to be achieved by
marking some areas for growth and environmental protection. The growth management legislations need to be introduced at various levels of governments to identify lands with high natural resource, economic and environmental value and protect them from development.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

This research work was sponsored by Debre Markos University. The author thus, would like to express their heartfelt gratitude to the university for the financial support.

REFERENCES
