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The dynamics of urban expansion and its impacts on land use/land cover change and small-scale farmers living near the urban fringe: A case study of Bahir Dar, Ethiopia

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ABSTRACT

This study evaluated the dynamics of urban expansion and its impacts on land use/land cover change and livelihoods of small-scale farmers living near the urban fringe of Bahir Dar in northwest Ethiopia. Aerial photos for the years 1957, 1984, and 1994 as well as field mapping using GPS for the year 2009 were employed and analyzed using GIS. Heads of 271 households affected by the expansion were interviewed to evaluate the impacts of expansion and compensation modalities in practice. Results showed that the urban area expanded annually by about 12%, 14% and 5% during the periods: 1957–1984, 1984–1994 and 1994–2009, respectively. The area showed an overall annual increment of 31%, from 279 ha in 1957 to 4830 ha in 2009. Built-up areas increased as a result of horizontal expansion, from 80 ha in 1957 to 848 ha in 1994, but also due to intensification at the expense of agricultural areas, from 80 to 155 ha, during the same period. A total of 242.2 ha of farmland was expropriated from 271 households between 2004 and 2009, and 96% of those interviewed believed that the compensation was insufficient, as the decision is influenced by the government's land ownership system. We predict that the current urban area will double by 2024. This will have far-reaching ecological, socio-economic and environmental impacts. A better understanding of the dynamics of urban growth and its associated impacts in the urban fringe can help form a basis for sustainable planning of future developments of areas experiencing urban expansion.

1. Introduction

The population of urban areas is expected to exceed 60% by 2030, with 90% of the projected increase occurring in low-income countries, which have urban settlements that are growing at five times the rate of those in developed countries (United Nations, 2005). Moreover, most urban growth over the next 25 years will occur in smaller cities and towns (Cohen, 2004).

Although urban areas cover a very small fraction of the world's land surface, their rapid expansion has significantly altered the natural landscape and created enormous environmental, ecosystem, and social impacts (Berling-Wolff & Wu, 2004; Grimm, Grove, Pickett, & Redman, 2000; Lambin & Geist, 2001; Mundia & Murayama, 2010; Nagendra, Munroe, & Southworth, 2004; Pickett et al., 2001; Weber & Puissant, 2003). These impacts are particularly important in rapidly changing (usually unplanned) areas, such as urban settlements in developing countries (Attua & Fisher, 2011; Farooq & Ahmad, 2008; Lopez, Bocco, Mendoza, & Duhau, 2001; Mohan, Pathan, Narendrareddy, Kandya, & Pandey, 2011; Muriuki et al., 2011; Weber & Puissant, 2003). As a result, rapid urbanization in the poorest countries is limiting the capacity of cities to provide basic services and facilities, degrading the quality of life, and the environment (Cohen, 2004; de Sherbinin & Martine, 2007).

The expansion of urban and suburban areas requires more land and promotes the conversion of rural to urban land use/land cover (LULC) (Farooq & Ahmad, 2008; Mohan et al., 2011; Xiaoqing & Jianlan, 2007). Hence, from the standpoint of LULC change, expansion of urban areas is of particular importance because of its strong effect on other LULC classes, such as agricultural lands (Attua & Fisher, 2011; Forkuor & Cofie, 2011; Himiyama, 2004; Mohan et al., 2011; Nunes & Auge, 1999).

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In recent years, studies have focused on urban systems (e.g., Fanan, Dlama, & Olusey, 2011; Grimm et al., 2000; Mohan et al., 2011; Pickett et al., 2001). However, the ecological consequences of urbanization are not yet fully understood (Berling-Wolff & Wu, 2004; He, Okada, Zhang, Shi, & Li, 2008). In general, the role of unplanned human settlements development, such as that occurring in developing countries, is not adequately documented (Cohen, 2004; Muriuki et al., 2011).

Analyses and projections of LULC changes can provide a tool to assess ecosystem changes and their environmental implications at various temporal and spatial scales (Gregorio, 2005; Lambin, 1997). This topic has become a central component in strategies for managing natural resources and monitoring environmental changes (Lambin, 1997). Hence, a better understanding of urbanization is necessary to understand the mechanism of LULC change and the driving forces for such change (e.g., Nunes & Auge, 1999).

To understand the ecology of urban systems, it is necessary to quantify the spatial and temporal patterns of urbanization, which often requires spatial analysis (Berling-Wolff & Wu, 2004). Mapping urban growth by conventional methods is a slow and tedious process. Remotely sensed data and application of geographic information systems (GIS) technologies provide an alternative means of rapidly assessing the dynamics and development of urban sprawl so that timely action may be taken (Farooq & Ahmad, 2008; Foresman, Pickett, & Zipperer, 1997; Muriuki et al., 2011). Here, sprawl refers to some type of unplanned and uncoordinated horizontal expansion of urban area with impacts such as loss of agricultural land in the urban fringe areas.

Ethiopia, having the second largest population in Africa with a total population of 80 million and an annual growth rate of 2.3%, is experiencing an average annual urban growth rate of 4.6%, which is a high rate by world standards (Cohen, 2004). The city of Bahir Dar in northwest Ethiopia, where this study was conducted, is the fastest growing and the third largest city in the country. The urban area is believed to be in a dynamic state of expansion, especially since the city was selected as the capital of Awraja, an administrative unit or hierarchy next to a region used during the previous regimes, in 1948. Following the rise to power of the current Ethiopian government in 1991, Bahir Dar was selected to be the seat of the Regional Government of the Amhara National Regional State, which has a total population of about 17 million people. This increasing expansion, however, has posed serious threats to the livelihoods of the surrounding small-scale farmers who earn their living by farming the productive agricultural lands located at the urban fringe. Ethiopian small-scale farmers constitute about 80% of the total population of the country, and their landholdings are so small that farmers cannot allow the land to stay fallow. The quantity of dependable agricultural land available for agriculture has been declining in the region as is true throughout the world in recent decades, due to the consumption of agricultural land for urban uses and other non-agricultural uses (Hofmann, 2001).

However, most studies of LULC changes in Ethiopia, as is the case elsewhere, have focused on the relationship between deforestation and the expansion of cultivation to land degradation as well as the associated consequences (Amsalu, Stroosnijder, & de Graaf, 2007; Bewket & Stroosnijder, 2003; Feoli & Vuerich, 2002; Meshesha, Tsunekawa, & Tsubo, 2010; Taddese, 2001; Tekle & Hedlund, 2000; Tsegaye, Moe, Vedeld, & Aynekulu, 2010; Zeleke & Hurni, 2000). While urbanization growth and its impacts are relatively better studied in larger and megacities worldwide (e.g., Fanan et al., 2011; Farooq & Ahmad, 2008; Foresman et al., 1997; Li, Sato, & Zhu, 2003; Lopez et al., 2001; Lv et al., 2011; Mohan et al., 2011; Murakami, Zain, Takeuchi, Tsunekawa, & Yokota, 2005; Xiao et al., 2006), they were however less studied with regard to towns and small cites where most urban growth over the next 25 years is expected to occur (Cohen, 2004).

The specific objectives of this study were therefore: (1) to determine the extent, rate, and direction of Bahir Dar city expansion from 1957 to 2009, (2) to assess the areal extent and conversion of LULC induced by the horizontal urban expansion as well as intensification of the built-up areas from 1957 to 1994, and (3) to assess to what extent the livelihoods of small-scale farmers living in the urban fringe have been affected by urban expansion.

2. Materials and methods

2.1. Description of the study area

The study area – Bahir Dar – is the capital of Amhara National Regional State which is located on the southern shore of Lake Tana, the source of Blue Nile (Abay) river, in the northwestern part of Ethiopia (Fig. 1). It is located at 11°38′N latitude and 37°10′E longitude and has an average elevation of 1801 m above sea level. Topographically, the city lies on a flat surface with almost no slope gradient except for small increases in elevation in the eastern and western peripheries. Temperature records for the period 1961–2008 obtained from the Bahir Dar (Ginbot 20) International Airport meteorological station showed that the average daily minimum and maximum temperatures were 7 °C and 29 °C, respectively. The average annual rainfall calculated for the same period was 1445 mm, of which about 84% occurs from June to September. The soils are dominantly fine soils (i.e., clays and siltyclays) developed on basaltic bedrocks. According to the Population and Housing Census results obtained from the Ethiopian Central Statistical Authority (CSA, 2008), the total population of Bahir Dar was 54,766 in 1984, 96,140 in 1994, and 180,094 in 2007.

The historical foundation of Bahir Dar is associated with the establishment of Kidane Miheret church at the present site of St. Giorgis church in the fourteenth century. The name Bahir Dar, which implies a periphery of a body of water, is directly related to the physical proximity to Lake Tana. The village was transformed into a modern township during the brief Italian occupation (1928–1933), primarily because it was used as a major military base for expeditions in the region. The occupying forces changed the land-holding system and implemented different land use systems to introduce residential and commercial areas. However, the kind of colonial-heritage land tenure relation pertinent in other sub-Sahara African countries and societies is not found in Ethiopia (Crewett, Bogale, & Korf, 2008). The same study indicated that Ethiopia has had rather a long legacy of state intervention in land tenure relations. Immediately after the Italian evacuation, feudal nobles increased interest to inhibit the area and was selected as the Awuraja capital in 1948 (Bahir Dar City Administration, 2011).

2.2. Assessment of urban expansion

The extent and direction of Bahir Dar expansion were assessed by delineating its administrative boundary for the years 1957, 1984, 1994, and 2009. The availability of aerial photos of the first three periods dictated the choice of the respective study periods. Furthermore, the current (2009) has been included by field mapping of the urban boundary with a Garmin global positioning system (GPS) with the main aim to show the extent of urban expansion and hence to capture more accurately the impacts associated with the recent expansion on the farmers living in the urban fringes. No aerial photos were taken of the area after 1994.

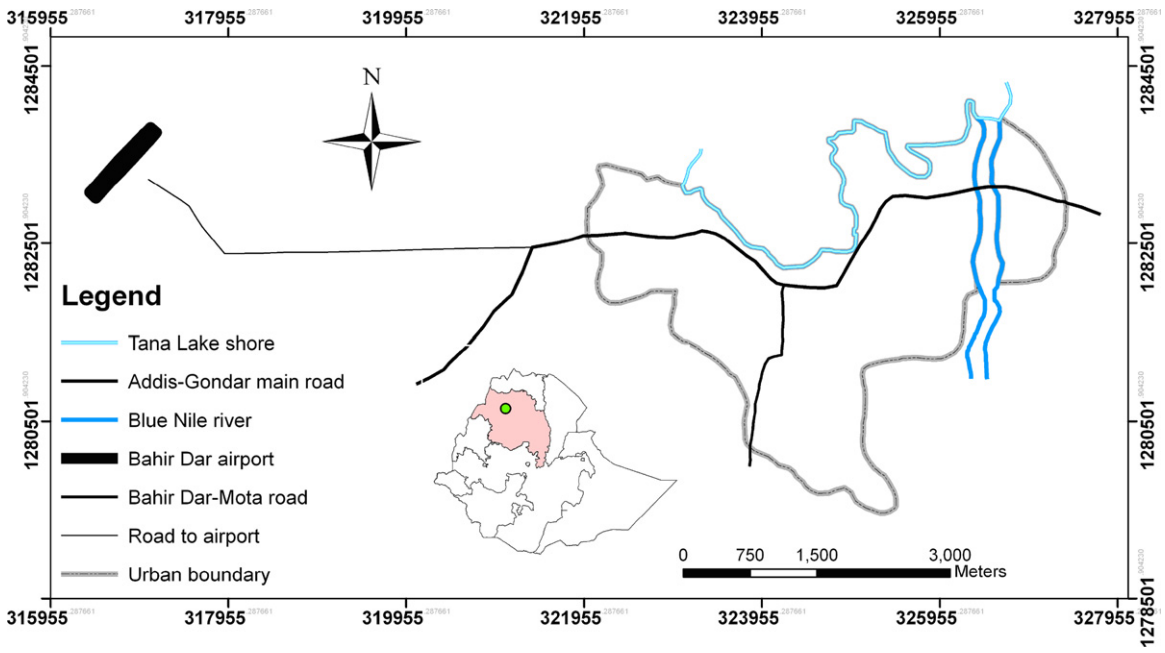

Fig. 1. Location map of Bahir Dar.
Processed from the 1994 topographic map, scale 1:50,000; obtained from the Ethiopian Mapping Agency.

Parts of four black-and-white aerial photographs for the years 1957 and 1984 (scale 1:50,000) and 21 black-and-white aerial photographs for the year 1994 (scale 1:10,000) were acquired from the Ethiopian Mapping Authority. Each photo was scanned, then the digital image was orthorectified and registered to a coordinate system and map projection (UTM projection, Clarke 1880 spheroid, Adindan [datum], Zone 37 N) in ERDAS IMAGINE 9.1. Rectification consisted of image-to-aerial photo registration. A minimum of four spatially distributed ground control points (GCPs) for each piece of aerial photographs, taking references such as churches, canal reaches from Debanki hill to Bahir Dar University main campus, small islands in Abay River channel and some other physical features were selected and located based on a geometrically corrected 2004 QuickBird satellite image of Bahir Dar as a reference image. The error accepted was limited to 10 m or less. Then the rectified pieces of images were mosaiced and finally the area of interest (AOI) has been clipped out.

For the AOI, LULC classes and areas were mapped for the three years (1957, 1984, and 1994) by manual digitization and stereoscopic interpretation depending on the key characteristics of the aerial photos (tone, texture, shape, pattern, and size). The minimum mapping unit was set at 3 mm on the base map which correspond to real features of 30 and 150 m of areal photographs of scales 1:10,000 and 1:50,000, respectively. Four LULC classification schemes were chosen (Table 1) considering the standard classes defined by the US Geological Survey as well as the study detail and objectives (Mohan et al., 2011). Thompson (1996) outlined the need to contextual the LULC classification systems to the local situation for the reason that no universally accepted classification system exists as it is influenced by the specific users' objectives and also often by geographic location. Finally, the result of interpretation of aerial photographs was checked by ground truth like physical features and GPS reading points as proposed in Foody (2002) and found an accuracy level of 87%.

The extent and direction of the city's expansion for the years 1957, 1984, 1994, and 2009 were analyzed by superimposing the different time-series maps and by calculating the corresponding areas in a GIS environment. Annual rate of urban area expansion (RUE) for the periods: 1957–1984, 1984–1994, 1994–2009, and 1957–2009 was calculated using the following relationship (modified after Mohan et al., 2011):

$$RUE = \frac{UA_{i+n} - UA_i}{n \times UA_i} \times 100, \quad (1)$$

where UA_{i+n} and UA_i are the urban area in ha at time $i+n$ and i, respectively, and n is the interval of the calculating period (in years).

Similarly the area covered by each LULC class was calculated and subsequently the changes were compared for the periods 1957–1984, 1984–1994, and 1957–1994. The LULC changes were analyzed from two perspectives. The first refers to the changes in LULC as a result of the sprawl of the city, which is hereafter called horizontal expansion. The second refers to changes in LULC that

Table 1
Land use and land cover (LULC) classification schemes used in this study.

LULC class	Description
Built-up area	Include areas with all types of artificial surfaces, including residential, commercial, and industrial areas as well as transportation infrastructures.
Forest land	Include areas with dense vegetation cover, such as those covered with shrubs forming closed canopies and trees including *Erica arborea* and others, which are relatively tall and dense. The category also included scattered remnant plots of *Juniperus procera*, *Ficus vasta*, and *Ficus sur* as well as areas covered with both indigenous and exotic (*Eucalyptus globulus* and *Cupressus lusitanica*) trees.
Water bodies	Include lakes, rivers, ponds, and marshlands.
Agricultural land	Include grazing areas, and cultivated lands, community open lands and areas along the lake shore that are used for agricultural proposes when the lake level retreats following the long dry-season (October–May). Information obtained from the local residents indicates that the units categorized in this category can generally be used in one way or the other for agricultural purposes.

occurred within the 1957 boundary of the city during the period 1957–1994. We refer to this type of change as intensification – increasing the density of dwellings and other infrastructures within existing built-up areas (Melia, Parkhurst, & Barton, 2011). To evaluate intensification of built-up areas and to better understand the conversion of Bahir Dar from 1957 to 1994, the 1957 LULC map was used as an AOI to clip and compare with the LULC maps of both 1984 and 1994.

The land consumption rate (LCR), which was used as an index to evaluate the progressive spatial expansion of the study area, was determined using the following relationship (Fanan et al., 2011):

$$LCR = \frac{UA}{P}, \quad (2)$$

where UA is area of the city (ha) and P is the population.

Projecting the future urban land area is important when analyzing the dynamics and impact of urban expansion. In this study, a currently acceptable approach to project the urban land area as a function of population growth (He et al., 2008; Lopez et al., 2001; Sutton, Roberts, Elvidge, & Baugh, 2001) was adopted. A regression model was established between the city's population and urban area for the years 1957, 1984, 1994, and 2009. Population statistics for the years 1984, 1994, and 2007 were obtained from the Ethiopian Population and Housing Census results. The 1957 and 2009 population data were projected using the following exponential growth rate relationship recommended by the Ethiopian Central Statistical Agency:

$$P_t = P_o e^{r \times t}, \quad (3)$$

where P_t is the population projected at a given time, P_o is the population size of a base year, e is the natural logarithm base, r is annual population growth rate (4.6% for urban areas as previously discussed), and t is the time interval between the base year and the projected year.

2.3. Socioeconomic survey

After delineating the 1957, 1984, 1994, and 2009 urban boundaries, a total of 20 residents, five for each period, were interviewed as key informants about the historical development of the area and other related socioeconomic consequences, as well as about the factors that contributed to urban expansion. The informants were selected considering into account the following criteria: age (elderly community members of 50 years older and above), willingness to provide information, continually resided in the area for the last 20–30 years and considered by the locals to be knowledgeable enough about the urban expansion and its impacts. Moreover, four officials from Bahir Dar City Service (a Land Provision and Administration Head), three officials that work in the Compensation Study Department were interviewed concerning the policy and strategies followed in the city's expansion, farmland expropriation, and compensation modalities adopted. Moreover, the study included four focus-group discussions, each having six members from both genders.

To address the impacts of the expansion on the small-scale farmers livelihoods living in urban fringe farmers expropriated from their farmland have been interviewed. A list of the names of farmer households who had been expropriated from their farmland as a result of urban expansion was obtained from the Bahir Dar City Land Provision and Administration Office. However, the data were available only for the period from 2004 to 2009, so the documentation was not sufficiently comprehensive. Finally, 2878 household heads were found listed for the purpose of land compensation because their agricultural lands, whether totally or partially, had been affected as a result of urban expansion between 2004 and 2009. A total of 271 of these farmer household heads were chosen randomly to complete a questionnaire. Moreover, we collected unpublished documents and reports on the types of compensation as well as the type and access to social and economic services that were promised and realized, such as roads, clean water, credit, healthcare, school, electricity and bank. Descriptive statistics has been employed to analyze and interpret the data using Statistical Package for the Social Sciences (SPSS version 16, 2007).

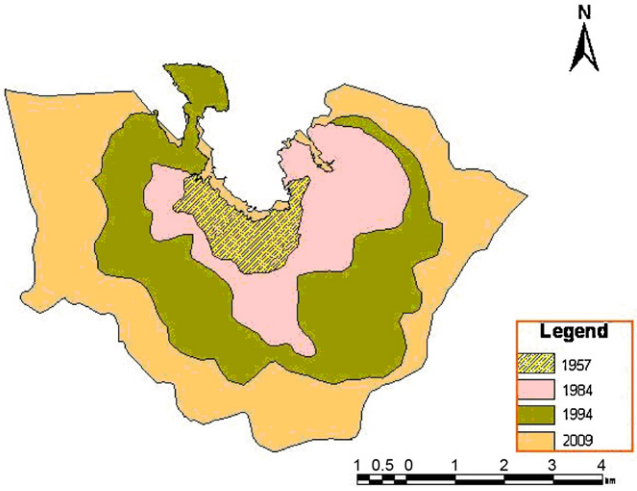

Fig. 2. Horizontal expansion of Bahir Dar from 1957 to 2009.

3. Results

3.1. The extent and direction of urban area expansion during 1957–2009

Fig. 2 shows an overlay of Bahir Dar administrative boundaries in 1957, 1984, 1994, and 2009. The total urban areas for the four respective periods were estimated at 279, 1159, 2777, and 4830 ha (Table 2). Analysis of the annual rate of change between the three survey periods (1957–1984, 1984–1994, and 1994–2009) showed that the area expanded by 12% (33 ha year^{-1}), 14% (162 ha year^{-1}), and 5% (137 ha year^{-1}), respectively, with an average rate of 31% (88 ha year^{-1}) for the whole study period, from 1957 to 2009 (Table 2).

The expansion occurred to the east (Gondar outlet), west (Airport and Hospital Street), and south (Merawi and Mota outlet) directions, whereas expansion to the north was limited by Lake Tana (Fig. 1). The eastward expansion was the greatest and is attributed to the presence of the Abay River, which offered easy access to water, and the availability of abundant flat land suitable for housing construction. A major road connecting the country's capital with Gondar city is also passing through Bahir Dar in this area.

3.2. LULC change for the period 1957–1994

3.2.1. Horizontal expansion

The four LULC classes (built-up areas, forest land, water bodies, and agricultural land) were identified for the years 1957, 1984, and 1994 (Fig. 3a–c), and the area for each LULC classes has been presented (Fig. 4). In 1957, the majority (62%) of the study area was categorized as agricultural land, whereas built-up areas, water bodies, and forest land accounted for 28%, 8%, and 2%, respectively. For the year 1984, built-up areas accounted for 54% of the study area, whereas agricultural land, water bodies, and forest land covered 35%, 10%, and 1%, respectively. In 1994 agricultural areas covered 55% of the study area, whereas built-up areas, water

Table 2
Bahir Dar urban area expansion between 1957 and 2009.

Year	Urban area (ha)	Change (% year^{-1})			
		1957–1984	1984–1994	1994–2009	1957–2009
1957	279	12			
1984	1160		14		
1994	2777			5	
2009	4830				31
Change (ha year^{-1})		33	162	137	88

bodies, and forest land accounted for 30%, 11%, and 4%, respectively. The observed general increasing trend for all LULC classes corresponds with the overall increase in the area of Bahir Dar as shown in Table 2. Although analysis of the horizontal expansion is important in understanding how rapidly the study area expanded horizontally as described in Section 3.1, its importance in helping us understand conversion from one LULC class to another is limited as the urban area has also varied simultaneously. Hence, analysis of LULC change resulting from intensification can offer a better picture of LULC conversion.

3.2.2. Intensification

Net-area changes of the four LULC classes due to intensification are shown for the periods 1957–1984, 1984–1994, and 1957–1994 (Table 3). The analysis for the period 1957–1984 revealed that the built-up area increased by 53.8%, whereas the agricultural land category decreased by 52.3%. Forest land and water bodies also showed a decrease by 0.8% and 0.7%, respectively. A similar analysis for the period 1984–1994 revealed little change in either direction for all classes. During the entire study period (1957–1994), built-up area increased by 55.6%, primarily at the expense of agricultural land, which decreased by 54.1%. Forest land and water bodies also showed little decreases (0.4% and 1.1%, respectively).

3.3. Drivers of expansion

Fig. 5 shows that total population and total urban area have a strong power relationship with time. A similar analysis between total population and total urban area found the following linear relationship between the two:

$$UA = 0.024P + 150, \quad (r^2 = 0.98; \quad \alpha < 0.05), \tag{4}$$

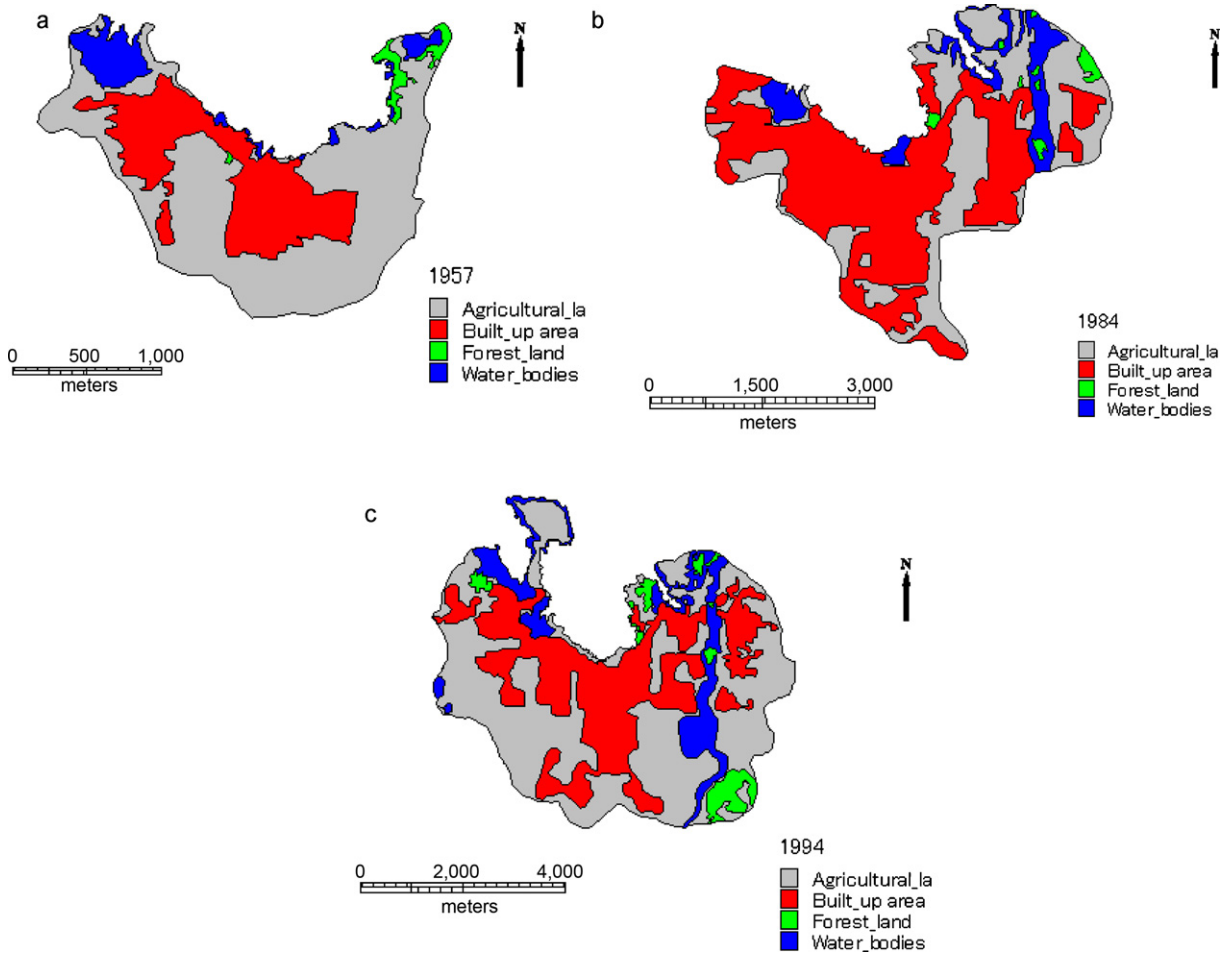

Fig. 3. The land use/land cover maps of Bahir Dar; (a) 1957, (b) 1984 and (c) 1994. The urban area during the three respective periods was 279 ha, 1160 ha and 2777 ha, respectively.

Table 3
Intensification of built-up areas within the 1957 boundary of Bahir Dar. Areas of the four LULC categories for 1957, 1984, and 1994 are shown; the net changes are shown for the periods 1957–1984, 1984–1994, and 1957–1994.

Land use class	1957		1984		1994		Change					
	(ha)	(%)	(ha)	(%)	(ha)	(%)	1957–1984		1984–1994		1957–1994	
							(ha)	(%)	(ha)	(%)	(ha)	(%)
Built_up area	79.5	28	229.7	83	234.6	84	150.0	53.81	5.0	1.75	155.0	55.57
Forestland	6.0	2	3.7	1	4.8	2	−2.3	−0.83	1.0	0.39	−1.0	−0.44
Water bodies	22.0	8	20.0	7	19.1	7	−2.1	−0.70	−1.0	−0.35	−3.0	−1.05
Agricultural land	171.5	62	25.6	9	20.6	7	−146.0	−52.28	−5.0	−1.79	−151.0	−54.07
Total	279.0	100	279.0	100	279.0	100	0.0	0.00	0.0	0.00	0.0	0.00

where *UA* is total urban area (ha) and *P* is the total population number. Using this linear relationship, we predicted that the current (2009) urban area size will double by 2024.

Personal communications with the Land Registration Office in Bahir Dar revealed that the average plot allocated for residence building per household has decreased from 250 m^2 in the 1990s to about 100 m^2 currently. This was confirmed by analyzing the land consumption per capita for the years 1957, 1984, 1994, and 2009, which generally decreased from 0.1 in 1957 to 0.02 in 2009 (Fig. 6). This is because of the ever increasing demand of more urban land for various purposes. For instance, own compiled data showed that a total of 130.35 and 124.55 ha of urban land were distributed for housing, respectively, for 5930 private applicants and 5589 members of different cooperative unions from 1996 to 2008. A total of 269.43 km of various classes of roads was built during the same period. The city also has several various social services such as kindergartens (31), elementary schools (50), secondary schools (16), and colleges (10). The per capita land consumption estimates obtained in this study are within the range (0.004–0.125 ha) reported by Demographia World Urban Areas (2010) based on population data from 1400 towns and cities from different parts of world.

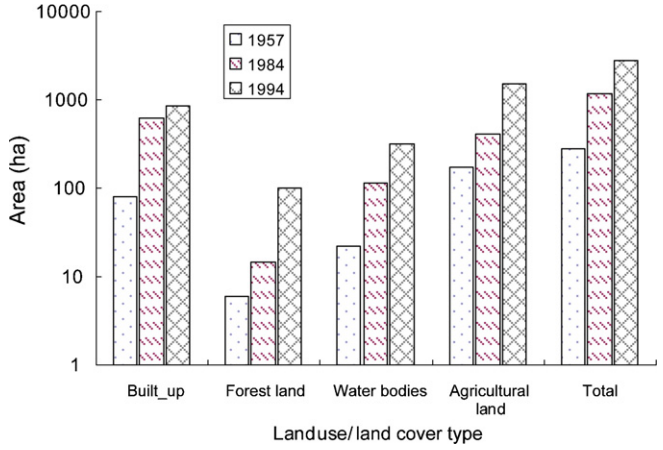

Fig. 4. Temporal changes of the different LULC classes of Bahir Dar from 1957 to 1994 as influenced by horizontal urban area expansion.

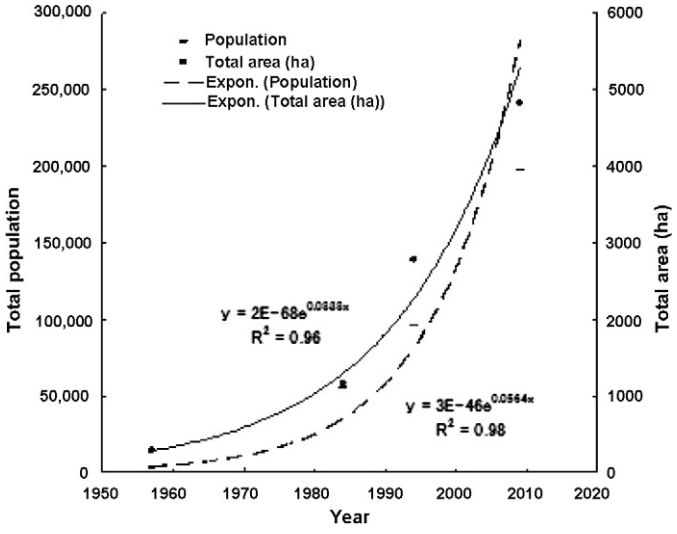

Fig. 5. The relationship between total size of Bahir Dar's population and urban area from 1957 to 2024. Population sizes for the years 1984, 1994, 2007, and 2009 were obtained from the Ethiopian Central Statistics Agency branch office in Bahir Dar. The population sizes for years 1957, 2014, 2019, and 2024 were estimated using Eq. (3). Total urban areas for 1957, 1984, 1994, and 2009 were determined in this study, and total areas for 2014, 2019, and 2024 were estimated using Eq. (4).

3.4. Impacts of urban expansion on small-scale farmers and compensation modalities for expropriated land

A list of 2878 households who received compensation during the period from 2004 to 2009 alone was compiled. Land holding size decreased considerably during the period of expansion. The 271 households interviewed lost about 242.2 ha of agricultural land as a result of expansion, which means that, on average, every household lost 0.89 ha of agricultural land. About 12% of interviewed households were totally expropriated from their agricultural land as a result of expansion. Similarly, the sample households lost about 48% of their permanent trees, which are important sources of cash, firewood and construction material.

Total livestock population size decreased by 24.2%, with a decrease of 31.9% for oxen, 27.9% for cows, 32.6% for goats, and 26.4% for donkeys obtained from the survey conducted on 271 sample households over the period between 2004 and 2009. The overall decrease in livestock population size is attributed to the feed shortage resulting from shrinkage of the land holding size

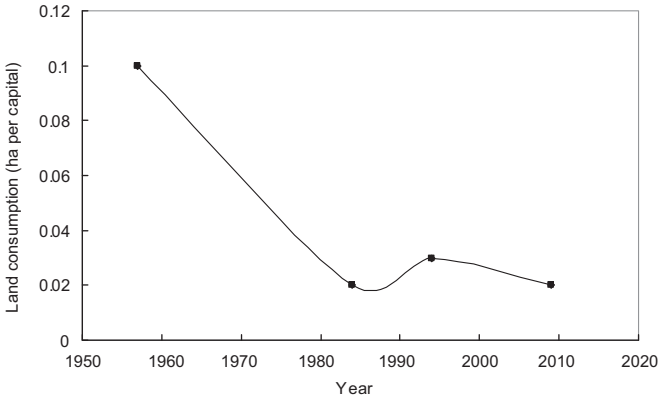

Fig. 6. Trend of land consumption per capita from 1957 to 2009 for Bahir Dar City, NW Ethiopia.

following urban expansion. Moreover, the decrease in the oxen population is related to the loss of agricultural land, either partial or total, to urban expansion because oxen in Ethiopia in general and in the study area in particular are the main source of draught power (Mouazen et al., 2007).

Our survey shows that the shortage of farmland as a result of the urban expansion has brought social problems such as increasing territorial conflicts among farmers and migration of people from their rural homesteads to communities living in the urban fringe. Moreover, the youth has become increasingly jobless and addicted to smoking cigarettes, chewing khat (*Catha edulis*), and alcohol. As a result they have become increasingly engaged in illegal activities that have affected the peace and security of the surrounding rural communities as well as of more urban areas. Moreover, the following environmental problems were identified, though described as less important, by the respondents: sound pollution from increasing number of heavy-duty trucks traffic, dust from construction sites and gravel feeder roads and solid waste disposal problems associated with the use of inappropriately located open-air dumping sites.

Not surprisingly, some of the same households who were negatively affected also have benefited from the expansion of Bahir Dar. According to the results of the survey of sample households, many households have benefited from access to education (74.9%), health services (56.1%), road infrastructure (21.8%), electricity (26.6%), and access to clean water (11.4%). However, all the respondents replied that owning their land is a matter of survival and describe the improved access to social services owing to urban expansion as a luxury in disguise.

Of the 271 households surveyed, 99% were offered monetary compensation and 97% of those had received it. In contrast, about 37% of the expropriated farmers were promised access to credit and 24% access to training and advisory services, but only 24% and 53% of those respective promises were actually kept. Our assessment of the allocation of the compensation money showed that 59% of the recipients deposited the money in the bank because they had no idea what to do with it, 13% used it for home consumption, 10% for renting land or draught animals, and 17% bought a house in city. One of the respondents said "I personally deposited some part of the compensation money in the bank, but whenever I face a shortage of money I may be tempted to spend it." He insisted further, "It would have been better to change the money into other assets. But to do this, I do not have experience and knowledge since I am illiterate."

4. Discussion and conclusions

Bahir Dar is in a state of rapid horizontal expansion; it increased from 279 ha in 1957 to 4830 ha in 2009, at an average growth rate of about 31% (88 ha year^{-1}). Literature on urban expansion rate especially at the scale of this study is scanty as most of the previous studies were focusing on larger and megacities (Cohen, 2004). For instance, Xiao et al. (2006) reported an average annual expansion rate ranging between 1.32% and 7.81% in Shijiazhuang, China, for the period 1934–2001, at an average rate of 240 ha year^{-1}. Similar study conducted in Shenzhen, South China, by Lv et al. (2011) reported an average annual expansion rate of 33 km^2 year^{-1} during the period 1975–2005. Farooq and Ahmad (2008) studied urban sprawl around Aligarh City in India and found that the urban area has almost tripled since 1971.

Bahir Dar has experienced spatial increase of different LULC classes due to corresponding horizontal expansion of urban area as well as conversion of LULC classes due to intensification of built-up areas within the 1957 urban boundary. In both cases, built-up areas and agricultural lands were the most dynamic classes. In terms of horizontal expansion, built-up areas have increased almost 10-fold, from 80 ha in 1957 to 848 ha in 1994. In terms of intensification, built-up areas increased from 80 ha in 1957 to 155 ha in 1994. The marked increase in built-up areas within the 1957 boundary is a result of a conversion of the other three LULC classes, primarily the agricultural lands category. A rapid loss of agricultural lands caused by urbanization is prevalent throughout the world. A very recent case study on Megacity Delhi by Mohan et al. (2011) reported that built-up area showed an overall increment of 17% in the period between 1997 and 2008, which mainly came from agricultural and waste lands. Another study on the dynamics of LULC change in Freetown, Sierra Leone, by Forkuor and Cofie (2011) reported that about 882 ha (27%) of agricultural lands in 1986 were converted to residential purposes in 2000. Much of the change occurred on the urban fringe, which suggests a strong linkage between urbanization and agriculture. Analysis of LULC changes and urban expansion in Nairobi for the period 1976–2000 found that built-up areas expanded by about 4700 ha (Mundia & Aniya, 2005). Similar studies on Canadian cities and towns by Hofmann (2001) reported that urban areas increased steadily from 1971 to 1996, consuming more than 1,200,000 ha in this 25-year period. Another study in Puerto Rico city by Lopez et al. (2001) reported that rapid losses of agricultural lands occurred as a result of urban expansion since 1950.

The small decrease observed in water bodies between 1957 and 1994 is associated with a retreat of the lake caused by siltation and the subsequent use of this land for built-up areas. Our field assessment verifies this conclusion because there are clear indicators of the retreat of Lake Tana. Similar studies conducted in different parts of Ethiopia reported that the life of both artificial and natural reservoirs is being threatened by a high sedimentation rate, with the sediment primarily being delivered from agricultural watersheds (Haregeweyn et al., 2006; Muleta, Yohannes, & Rashid, 2006; Tamene, Park, Dikau, & Vlek, 2006). The small increase in forest land from 1984 to 1994 is attributed to an increase in plantations (mainly eucalyptus trees) for use as fuel wood and construction. This is in agreement with the study by Newcombe (1987), who reported that a large afforestation effort took place in Ethiopia to reduce the gap between supply and demand of firewood for all rural and most urban households following the UNDP/World Bank Ethiopian energy assessment mission in 1983.

At least 2878 farm households had farmland expropriated for urban expansion purposes from 2004 to 2009 alone, and about 96% of those interviewed indicated that the amount of monetary compensation they received was not sufficient to replace the benefits they obtained from the land before the expropriation. Members of the focus-group discussants made statements such as, "There was no direct participation of the affected farmers in decision making about compensation amount rather only the chairman of the *kebele* [the smallest administrative unit of Ethiopia similar to ward] was represented." One of the discussants strongly expressed the sense of the unfairness of the compensation payment by stating, "I had 300 eucalyptus trees, 45 coffee trees, ten mangos and avocados, and ten papayas on my land, but finally I received compensation only for the farmland."

The new constitution of 1995 that approved state ownership of land in Ethiopia states, "the right to ownership of rural land and urban land, as well as of all natural resources is exclusively vested in the state and the peoples of Ethiopia" (Federal Democratic Republic of Ethiopia 1995, Article 40). In line with this, the Amhara National Regional State Rural Land Administration Proclamation No. 133/2006 Art. 2(18) states the land expropriation approach as follows: "Rural land can be taken from the holder for the sake of public interest by paying compensation in advance to undertake development activities by the decision of the government body vested with power." Ambaye (2009), however, argued that the compensation being paid is not adequate. In this connection, compensation modalities which were proved to be successful elsewhere should be tested and adopted to the Ethiopian situation. For

instance, experience from South Africa shows that compensation takes the following factors into consideration: the current use of the property, the history of the acquisition and use of property the market value of the property, the extent of state direct investment and subsidy in the acquisition and beneficial capital improvement of the property and the purpose of expropriation. Moreover, further study is necessary to provide options of what could be done to better prepare households for better livelihoods after the compensation.

In conclusion, we predict, based on the trends observed from 1957 to 2009 that the current (2009) urban area will double by 2024. This will have far-reaching ecological, socio-economic and environmental consequences especially to the urban fringe areas. This trend will exacerbate further expropriation of farmer households and may lead to food insecurity and social unrest in the surrounding areas. Policies that ensure a just and equitable compensation for such expropriated farmers still remain necessary. Hence, a better understanding of the spatial and temporal dynamics of urban growth and its impacts to the small-scale farmers living in the urban fringe, such as that provided by this study, forms a basis for achieving a sustainable urban growth and development.

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