Dar es Salaam city temporal growth and its influence on transportation

Charles Cosmas Mkalawa* and Pan Haixiao

Urban Planning and Design Department, Tongji University, Shanghai, China

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This study aims at using spatial data to investigate and analyze the temporal spatial growth of the city of Dar es Salaam in Tanzania and quantify its relationship to transportation growth. The study will focus on the period from 1945 to 2012 and will use population and economic growth as parameters. The findings of this study show that there is a mutual relationship between Dar es Salaam’s urban growth, population, economy, and transportation. It found that transportation demand and infrastructure growth coincided with population growth; however, Dar es Salaam’s urban spatial expansion and residential area growth have been affected by transportation demand and infrastructure growth. It also found that enormous spatial expansion has caused dramatic changes in the daily share of travel modes and that these disparities have occurred in relation to urban growth and transport. Development initiatives and policies over time have not successfully solved this problem.

Keywords: temporal city growth; transportation demands growth; population growth

1. Introduction

In Global South countries, urbanization is a key driver of national economic growth. Continued growth requires innovative and complementary ways of applying funds and infrastructure to bring positive effects on private investment and living standards (UN-Habitat, 2013a). Some literature states that cities in sub-Saharan Africa are urbanized with little or no economic growth (Hsieh, 2014). This results in an increase of slums and informal settlements, which are difficult to provide with services and access to facilities (Augustijn-Beckers, Flacke, & Retsios, 2011; Vermeiren, Van Rompaey, Loopmans, Serwajja, & Mukwaya, 2012; Un-Habitat, 2013b, 2014). Most of the population of the world living in informal settlements is found in the in Global South (Oosterveer, 2009; Un-Habitat, 2010). Under the present scenario, informal settlements will continue to increase if mitigating measures are not taken.

There has been an unprecedented pace of rapid city growth mostly in the Global South caused by rapid population growth (Hsieh, 2014; Watson, 2009). Some literature shows that these drastic changes mostly take place in small- and medium-size cities in the Global South (World Bank, 2012). However, the growth has contributed to a rise in demand for social services and transportation (Gulyani, Bassett, & Talukda, 2014; World Bank, 2013). However, city and transportation planners have been working hard to solve this problem, but its intensity has remained a controversial issue (UN-Habitat, 2013b).

*Corresponding author. Email: mkalawa18938@alumni.itc.nl

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The objectives of this study are: to use spatial data to observe, quantify, and analyze spatial and temporal city growth in relation to population and economic growth of Dar es Salaam from 1945 to 2012, and to observe and analyze spatial and temporal growth of transportation demands and infrastructure in relation to population and economic growth from 1945 to 2012. It also intends to show the relationship between city spatial growth and spatial transportation growth, and finally to recommend viable measures to tackle the overriding problems around transportation and city growth.

The main sections that will be covered include: Section 2, literature review and background to the study which concentrates on the historical background, started by a general and then a specific approach. Section 3 includes materials and methods which outline data, materials methods, and the procedures carried out in order to arrive at the findings. Section 4 sets out the results of the research findings. And, Section 5 will cover discussion and final conclusions.

1.1. Study area

Dar es Salaam means “Haven of Peace” (Dari root salama peace) in the Swahili language. The city was established by Sultan Majid of Muscat in 1857 and later German colonialism was established, following the shift of its capital from Bagamoyo to Mzizima (the current Dar es Salaam). The following section introduces the study area and its basic details:

Dar es Salaam is located on the eastern side of the continent of Africa bordered by the Indian Ocean and islands of Zanzibar and Pemba to its east and northeast and to its south, north, and west it is hugged by the Coast Region. (Map 1) Since independence, Dar es Salaam has been the major and dominant business and industrial center of Tanzania.

2. Context

2.1. Urban growth

The rate of urbanization has taken off at a remarkable rate around the world, and that speed has recently been widely witnessed in the developing world (Amer, 2007; Baffour Awuah, Hammonda, Lamond, & Booth 2014; Kombe & Kreibich, 2001; Vermeiren, Van Rompaey, et al., 2012; Mkurunzinza, 2013). There has been a high demographic growth in sub-Saharan Africa for several decades (Ogbazi, 2013; Diaz Olvera, Plat, & Pochet, 2008). Demographic growth has been on the rise in sub-Saharan Africa in recent decades with the trend appearing to continue. The continent’s population is projected to double to 2 billion over the next 40 years, and about 720 million people are expected to be living in urban areas in that time (Linard, Tatem, & Gilbert, 2013).

As opposed to Global North, urbanization in developing countries is primarily the outcome of demographic transitions, and economic factors and other considerations are secondary influences (Hsieh, 2014). What is clear in sub-Saharan Africa is the fact that cities are growing unmonitored and without due care for urban planning (Kombe, 2005; Lupala, 2002; Diaz Olvera, Plat, & Pochet, 2013). This trend outpaces infrastructure development leaving planners with the role of playing catch-up with past developments instead of planning for the future (Seto, 2011). This growth has brought positive impacts such as trade growth and negative impacts, including increased housing demand, shortage of services, a decline in living standards, land speculation, absence of urban waste management, and overcrowding (Kironde, 1997; Mbiba, 2014; Rizzo, 2014; Wubneh, 2013).

We will now focus on Dar es Salaam, the study area.
2.2. Urban growth in Dar es Salaam

The rate of urban growth in Dar es Salaam from 1990 to 2010 had an annual growth rate of 4.67% (Mkurunzinza, 2013) and was ranked the third fastest growing urban area in Africa (Hill & Lindner, 2010). Unlike in other cities in the developed world, where urbanization was the result of industrialization, urbanization in Dar es Salaam has been the outcome of population growth (Amer, 2007). Dar es Salaam city residents use public transport (Daladala) and walking as the major means of mobility (Transport Policy, 2008) – also see (Figures 1 and 2, Table 1). During the German colonial era, the headquarters of the German East Africa Company was transferred from Bagamoyo to Mzizima (the current Dar es Salaam) because of its natural harbor (Halla, 2007), and this was the period when the Germans prepared and implemented the general planning scheme of 1891–1916. German colonization was followed by the British who introduced the second general planning scheme from 1949 (Halla, 2007). It was the British who introduced the concept of a master plan for the city center followed by institutional arrangements for professional practices which included the Land Ordinance of 1923, Town and Country Ordinance of 1956, Dares Salaam Municipal Ordinance of 1947, and the establishment of the Town Planning Department to be responsible for relevant tasks including the creation of a new master plan and other relevant issues.

2.3. Transportation in Dar es Salaam

Transportation plays a very important part in urban developments (Aljoufie, Zuidgeest, Brussel, & Maarseveen, 2013; Chissano & Minnery, 2014). Transportation plays a major

![Figure 1](image-url)
role in urban development enabling movement of both people and goods between points. For Dar es Salaam, transportation is dominated by public transit and walking between its four primary roads and arterial roads (World Bank, 2011).

The history of public transport in Dar es Salaam can be traced back to 1967, when Tanzania adopted the Ujamaa socialist strategy for development and the country’s economic sectors were nationalized (Diaz Olvera, Plat, & Pochet, 2003b; Vermeiren, Van Rompaey, et al., 2012). In 1970, the Dar es Salaam Motor Transport System (DMT), the British monopoly company, was nationalized and split into Kampuniya Mabasiya Taifa (KAMATA), responsible for regional routes, and Usafriri Dar Es Salaam (UDA), operating and serving as Dar es Salaam public transport (Diaz Olvera, Plat, et al., 2003b; Vermeiren, Van Rompaey, et al., 2012, p. 136). UDA’s operation, however, declined with time from the very beginning (Table 2) due to the economic crisis in the 1970s (Sohail, Maunder, & Miles, 2004). And then, privatization contributed to the huge importation of private vehicles from 2003 to 2013 (Table 3). This was combined with an economic crisis so that government faced a difficult situation in providing services to major roads.

Figure 2. Mobility share mode in 1979: in 1979, the most popular means of mobility among residents of Dar es Salaam was walking; however, it changed with time to public transport. Source: Dar es Salaam Master Plan (1979, p. 50).

Table 1. Trend of changes in transportation demands and share mode from 1979–2014.

| Mode                  | Stage 1% | Stage 2% | Stage 3% (1999) | 2014 |
|-----------------------|----------|----------|-----------------|------|
| Walk                  | 52       | 49       | 45              | 36   | 17 |
| Public transit        | 13       | 16       | 20              | 24   | 68 |
| Employer transit      | 12       | 13       | 13              | 13   | 1  |
| Private vehicles      | 16       | 14       | 13              | 12   | 12 |
| Bicycle and Motorcycle| 6        | 8        | 9               | 15   | 2  |
| Total %               | 100%     | 100%     | 100%            | 100% | 100% |

Source: 1979 Master plan for 1979 to stage 3 and research data for 2014.
2.4. Current transportation situation

Traveling for Dar es Salaam residents is influenced by behavior, proximity, and a mix of land use, density, and design. The city’s residents travel short distances but with much difficulty (Mkurunziza, 2013; Diaz Olvera, Plat, & Pochet, 2003a), leading to low levels of mobility and therefore, difficulty in meeting transportation demands. Some literatures show that most of the urban poor cannot afford the fare of officially set for private services providers (Diaz Olvera, Plat, et al., 2003b; Sohail, Maunder, et al., 2004).

The poor level of mobility is caused by overpopulation, poverty, and uncontrolled urban growth, factors that directly affect the provision of transport services and transportation infrastructure construction. Dar es Salaam is generally clustered and uses zoning systems with high-density residential areas; most of its residents regardless of where they live rely on public transport. In spite of this, residents who live on the fringes of the city use informal means of transport due to the fact that access to bus stops varies from place to place. Normally, the waiting time at a bus stop is five minutes (this is not official since no public transport schedules exist); however, due to a shortage of buses, residents are forced to scramble when a bus pulls in, which means one would spend more time waiting for a decent opportunity to board a bus. It is because of this problem some middle-income earners tend to buy second-hand vehicles to meet their needs (Figure 3). As a consequence of heavy congestion during peak hours, some residents resort to using motorcycles, thus increasing their demand and bringing their number to about 600,000 (Table 4). Motorcycles account for about 50% of traffic on main roads during peak hours (Figures 1 and 2, 4–7).

The city lacks enough grid arterial roads (Map 3), preventing an introduction of an effective public transport system that extends far into the urban fringes that would convince residents to rely on public transport. Other problems plaguing the city include parking space shortage, lack of pedestrian zones, and a high mixture of traffic in the city center (Ministry of lands, 2002).

Table 2. Public buses under UDA.

| Year | Buses | Year | Buses |
|------|-------|------|-------|
| 1974 | 130   | 1986/87 | 101   |
| 1975 | 257   | 1987/88 | 109   |
| 1976 | 245   | 1988/89 | 70    |
| 1977/78 | 221 | 1989/90 | 59    |
| 1978/79 | 172 | 1990/91 | 32    |
| 1979/80 | 142 | 1991/92 | 25    |
| 1980/81 | 141 | 1992/93 | 36    |
| 1981/82 | 139 | 1993/94 | 54    |
| 1982/83 | 164 | 1994/95 | 40    |
| 1983/84 | 141 | 1995/96 | 32    |
| 1984/85 | 139 | 1996/97 | 24    |
| 1985/86 | 108 | 1997/98 | 12    |

Source: Rizzo *Shirika la Usafiri Dar es Salaam 1995: 6; Shirika la Usafiri Dar es Salaam (UDA), ‘Fleet performance files’ (1994/1995–1997/1998).
2.5. Income disparity

Income disparity is synonymous with the city’s geography and history. Today, most high-income earners live on plots close to the beach in suburbs like Mikocheni, Oyster Bay, and Mbezi Beach (Map 4). The income bar drops proportionally as you move away from the sea front (this does not apply to the new city area around Kigamboni, Mjimwema, and Kibada). Historically, during German and consequently British colonization, some areas designated for low-density residences such as Masaki and Oyster Bay were specifically for Europeans (Lupala, 2002). Upanga and Kinondoni, which were medium-density suburbs, were for Asians who were middle-income earners. Kariakoo and Tandika with high population densities were for Africans who earned low incomes. The current detailed distribution of income disparity apart from colonialism is shown below.

Table 3. Imported buses from 2003 for government and private use (at Dar es Salaam Port).

| Year | Imported buses for both government and private sectors |
|------|------------------------------------------------------|
| 2003 | 12,834                                               |
| 2004 | 54,321                                               |
| 2005 | 51,563                                               |
| 2006 | 33,695                                               |
| 2007 | 25,699                                               |
| 2008 | 32,506                                               |
| 2009 | 41,924                                               |
| 2010 | 44,552                                               |
| 2011 | 37,427                                               |
| 2012 | 41,162                                               |
| 2013 | 48,066                                               |

Source: Tanzania Revenue Authority Excel file CMRS VEH STAT2003–2013 (Tanzania Revenue Authority, 2013).
3. Methods

3.1. Data

To conduct this research, different methods of collecting primary and secondary data were used. Secondary data collected include policies, master plans, shape files, satellites images, topographic sheets, aerial photographs, and relevant reports.

Primary data were gathered by way of a questionnaire sent or distributed to 654 respondents. Information gathered from the questionnaire aimed at providing information on mobility share mode, traveling time from home to a destination, waiting times...

Figure 4. Trend of population growth Dar es Salaam from 1948 to 2012.

Figure 5. Dar es Salaam’s population growth in relation to other regions of Tanzania has been rising with considerable variation from 1988, and over – escalation increased in 1990s.
at the bus stop, and attitudes of residents toward the use of public transport. Spatial data collected aimed at indicating the temporal changes that have been taking place in the study area, population distribution, services distribution, and transportation infrastructure. The data were then processed into an excel sheets for the purpose of analysis and findings. Other primary data were collected through interviews and direct observations. Most of the data collected were in spatial data format, so there was a need to process the information by georeferencing to get them in the proper order. The researcher used projection called UTM WGS 84 Southern Hemisphere Zone 37 South, as it is suitable for Dar es Salaam.

Spatial data were also processed by creating two geodatabases of personal and file geodatabase created through Arch Catalog and all of the feature classes and raster datasets were imported. A digitization process was conducted to create shape files and the required layers for study. The shape files created include urban growth 1945, 1947, 1963, 1967, 1978, 1992, and 2012.

Figure 6. Population growth between the two major cities in east Africa, Dar es Salaam has the highest population growth with Kampala having the highest density.

Figure 7. Dar es Salaam’s GDP growth in relation to other regions in Tanzanian Shillings from 1980, 1992–1995 data not available. Source: Research data.
Other layers made include primary road network layers from 1945 to 2012, different layers, rivers, Indian Ocean, population density, income distribution, average distance to the city center, and some other layers of different uses.

3.2. Application of methods

Data collected from the questionnaire were loaded into excel sheets and then simple calculations were made to get graphical results and tables. Some of the graphs were also made using ArcGIS software. Also, modeling and some prediction were done using ArcGIS. Mapping clusters were achieved using cluster outlier analysis (Anselin Local Moran’s I) (Map 6). This was done to display the intensity of clustering in the city. Spatial relationships were indicated using ordinal least square (OLS).

Analysis of this study was mainly made using ArcGIS, and for data processing and editing, Arc Catalog was used. ArcMap was used for processing (georeferencing, editing,) analysis (charts, graphs, and calculations), and mapping. There are a lot of works and analyses made using Microsoft Excel due to the fact that it is easy to learn including data entry, simple computations like sum, subtraction, and mean calculation.

Some calculations were computed for population density, city area in spatial size, and road distances in square kilometers. All of them were calculated with an ArcMap attribute table and then the option of calculation geometry for distance and area was used.

4. Results

4.1. Temporal City growth of Dar es Salaam from 1945 to 2012

Urban spatial expansion and residential area growth are catalyzed by transport infrastructure expansion along the four main primary roads of Dar es Salaam, i.e. Morogoro, Ally Hassan Mninyi, Kilwa, and Mandela roads (see Map 5). The increase in vehicle importation (Table 5) indicates a rise in the number of trips generally, which also increases travel demand resulting in an imbalance between travel demand and transport infrastructure supply. This consequently is the cause of the substantial increase in congestion.

| Year | Motorcycle (TRA) | Rickshaw Bajaj (TRA) | Ministry of works (Rickshaws and motorcycle) | Sum for the year |
|------|------------------|----------------------|---------------------------------------------|------------------|
| 2013 | 117,544          | 8,794                | 0                                           | 126,338          |
| 2012 | 108725           | 7672                 | 1207                                        | 117604           |
| 2011 | 114,743          | 4,907                | 940                                         | 120,590          |
| 2010 | 115,732          | 2,025                | 1400                                        | 119,157          |
| 2009 | 85702            | 2,124                | 1620                                        | 89,446           |
| 2008 | 45474            | 1306                 | 910                                         | 47,690           |
| 2007 | 28529            | 460                  | 750                                         | 29,739           |
| 2006 | 20117            | 290                  | 320                                         | 20,727           |
| 2005 | 14677            | 147                  | 686                                         | 15,510           |
| 2004 | 7371             | 104                  | 843                                         | 8,318            |
| 2003 | 1883             | 59                   | 217                                         | 2,159            |
| Total|                  |                      |                                             | **697,278**      |
Historically, the growth and expansion of Dar es Salaam as a city has gone through different stages. In the years before 1948, it grew at an annual rate of 2.6% and then rose to more than 7.7% after 1948 (Kironde, 2000) (Figure 4). From the analysis of research findings, there is a substantial temporal relationship between urban growth and economic growth in relation to population growth (see Figures 8–10 and details in next paragraph).

The figures above provide analysis for the existing situation, for example, Figure 9 indicates the trend of urban growth in different periods measured in km². Population growth started with a slow pace in 1945 and the intensity increased with time leading to the increase in demand for more land for settlements and urban use (Figure 4). Figure indicates that transportation infrastructure grew collinearly with urban growth (this study has taken only road, meaning expansion from 1945 varied with time and it began with latent growth, but the frequency increased after 1995. Figure 8 shows the collinear relationship between road construction and urban growth during the same period.

4.2. Analysis

Growth in population in Dar es Salaam is linked to GDP growth in the city (Figure 7). It is also contributed to by the geographical location of the city, the availability of social

![Figure 9. Relationship Between urban growth and road network expansion.](image)
amenities and serenity, and local and foreign investments in both industry and business. Currently, the Government of Tanzania has focused priority on paving secondary roads, thus increasing their number and matching them with the rate of urban growth (Figure 9). Likewise, for economic growth, the number of people employed with a middle income keeps on increasing, as a result of both the formal and informal sectors.

Table 5. The rate of vehicle importation at Dar es Salaam Port.

| Year | Foreign affairs | Tanzania revenue authority | Ministry of works |
|------|----------------|----------------------------|------------------|
| 2013 | 269            | 192,242                    | 2439             | 194,950          |
| 2012 | 260            | 176,296                    | 2056             | 178,612          |
| 2011 | 211            | 173,700                    | 3037             | 176,948          |
| 2010 | 163            | 177,749                    | 3060             | 180,809          |
| 2009 | 129            | 147,499                    | 2106             | 149,605          |
| 2008 | 91             | 95,364                     | 1754             | 97,118           |
| 2007 | 85             | 70,587                     | 1501             | 72,173           |
| 2006 | 89             | 73,523                     | 2148             | 75,760           |
| 2005 | 68             | 95,336                     | 2266             | 97,670           |
| 2004 | 49             | 89,929                     | *                | 89,978           |
| 2003 | 59             | 19,752                     | *                | 19,811           |
| 2002 | 52             | –                          | *                | 52              |
| 2001 | 41             | –                          | *                | 41              |
| 2000 | 93             | –                          | *                | 93              |
| SUM  | 1659           | 1,311,977                  | 20367            | 1,333,620        |

Source: Tanzania Revenue Authority, Ministry of Works, and Ministry of Foreign Affairs.

*No data.

Figure 10. Simultaneous relationship between economic, spatial, and population growth from 1952 to 2012.

Table 6. Dar es Salaam Urban Growth from 1945 to 2012 shows latent growth, but an escalation from 1996 onward.

| Years | 1945 | 1947 | 1992 | 1996 | 2012 |
|-------|------|------|------|------|------|
| Urban growth (km²) | 9    | 13   | 212  | 572  | 927  |

Computed from digitized shape files.
providing a significant number of job opportunities. The rates of employment dropped between 2005 and 2007, when the government action affected recruitment in the public sector.

Overall, the population of Dar es Salaam has been swiftly growing for the past 20 years, due in large part to its primacy as the main city in Tanzania, dominating other cities in business and industrial sectors.

The maps below (Map 5) show sequential growth of the city from 1945 to 2012, which is the result of population growth and economic improvements.

The city’s spatial growth varies with time. The series of maps above indicates temporal city growth from 1945, when its size was not more than 10 km². Today, the situation is different with the city overwhelmed by population growth. Table 6 shows the rate of the city’s temporal spatial growth from only 9 km² by coverage in 1945 to 927 km² in 2012. The results indicate that for the past 20 years, the city grew to 715 Km² from 1996 to 2012, a situation sharply different from 40 years ago when the city grew to 203 km² from 1945 to 1992. The impact of this swift growth has mostly been a rise in demand for housing creating intense pressure on land. Urban growth, however, does not conform to city planning, resulting in a significant percentage of informal settlements.

The city’s growth whose rate was gradual after independence suggesting that economic growth had a direct connection to employment as Table 7 indicates. Data for the period of the economic crisis between 1970 and 1990s are not available. Generally, for the years with available data, economic and population growth both grew. Historically, Dar es Salaam population compared to other main regions is keeping higher (Figure 5).

Dar es Salaam’s growth comes in large part from the opportunities for employment available from many institutions found in the city, including universities,

| Year  | Number of employees | Year  | Number of employees |
|-------|---------------------|-------|---------------------|
| 1961  | 37,107.00           | 2003  | –                   |
| 1962  | 41,900.00           | 2004  | –                   |
| 1963  | 43,958.00           | 2005  | 265,728.00          |
| 1964  | 46,640.00           | 2006  | 243,619.00          |
| 1965  | 54,604.00           | 2007  | 323,565.00          |
| 1966  | 59,124.00           | 2008  | 419,583.00          |
| 1967  | 65,246.00           | 2009  | –                   |
| 1968  | 70,655.00           | 2010  | 419,583.00          |
| 2001  | 338,568.00          | 2011  | 456,815.00          |
| 2002  | 934,633.00          | 2012  | 511,596.00          |

Source: Employment and Earnings 1961–1968 and 2001–2012.

*– Data not available.

| Year | Number of employees |
|------|---------------------|

| Urban Growth (km2) | 1945 | 1947 | 1967 | 1992 | 2012 |
|-------------------|------|------|------|------|------|
| Road Growth (km)  | 74   | 107  | 190  | 230  | 941  |

Source: Spatial calculated data.
hospitals, numerous businesses, international organizations, and diplomatic missions. Its port services most of east and central African landlocked countries like Rwanda, Burundi, Uganda, Zambia, Zimbabwe, and Malawi (UN-Habitat, 2013a;
Zhong, Li, Xiang & Zhu, 2013) (Figure 5). In comparison with other big cities in East Africa for example Kampala city, of Uganda the population in Dar es Salaam is found to be higher (Figure 6). Dar es Salaam is a venue for tourism due to its convenient connection to Zanzibar, Morogoro, and southern Tanzania, in addition to its international airport connecting Tanzania to the rest of the world, while its railway station links the city to other regions and neighboring countries. These connections also contribute to population growth through business, industry, and tourism as well as immigrants for DR Congo, Rwanda, Burundi, Zambia, Malawi, Mozambique, Uganda, and Kenya (World Bank, 2012).

4.3. Spatial and temporal growth of transportation from 1945 to 2012
This section will provide answers to how transportation in Dar es Salaam is growing spatially with time. The analysis shows that transportation services and physical infrastructure have been growing at a substantial pace (Table 7).

Map 2. Population Density in Dar es Salaam with high density around the city center, decreasing outwardly toward fringes.
In Dar es Salaam generally, transportation infrastructure expansion coincides significantly with population growth. In contrast, urban spatial expansion and residential area growth have been affected by transportation infrastructure expansion (Map 5). Moreover, population growth seems to have caused an increase in daily trips, trips, and travel demand and consequently congestion. In Dar es Salaam, there has been enormous expansion caused by dramatic changes in daily share modes. There are great disparities between urban growth and transport.

The government has taken initiatives to improve the situation in the city (Transport Policy, 2008) through transportation policy interventions and various development processes, though these have not proven successful.

4.4. Analysis by modeling

To arrive at the findings of ArcGIS (mapping clusters), the cluster and outlier analysis model (Anselin Local Moran’s) was used during this analysis, to quantify the level of significance based on population density (Map 6). The level of significance in this study determined by population density indicates that areas around the city center with high population density (Map 2) have the highest level of significance compared to fringe areas.

It also shows the population is growing temporally from high level to high (H–H) in areas within 10 km from the city center, i.e. Sinza, Oyster Bay, Manzese, Temekte, Tandika, and Buguruni. It also indicates that areas around the city center and the port area are not significant, which may be true because these areas have changed into commercial areas and, therefore, not populated. Moreover, living in the vicinity of the CBD is very expensive and few can afford it.

Map 3. Public transport accessibility from the main roads indicating arterial roads when buffered with 1 km from the center to measure the convenience of public transport proximity and accessibility.
Areas around the southeast of the city 10–20 km from its center have a significance level of L–L (low–low) despite being areas earmarked for the future new city. The reason may be that residents are moving to new locations to give way to development. Generally, the city is clustered around the center and dispersed toward the fringes. Map 6 shows many closed clusters around the city center, but more dispersed with distance toward the fringes. Its H–L (High to Low) density nature is not available in the results, but shown on the key legend.

4.5. **Analyzing spatial relation with ordinal least square**

The other GIS model used was ordinal least square, which provides basic correction of the spatial data and shows prediction of patterns. By taking values from the results of spatial autocorrelation, the ordinary least square was calculated, and the results show that the degree of closeness to the city center is more compact and it decreases with...
distance toward the fringes. The computations were made using population density as a parameter; therefore, with a correlation map (Map 7), we can vindicate the results indicating the relation is gradually transforming from yellow to orange, then to red, as it keeps on transforming as one moves from the city center to the fringes. The pattern does not apply so much in the south and east sides because these areas are not well developed. The concept used the threshold number to determine high and low density. This concept as well applies with the increase in land value and, therefore, house prices as we move away from the city center.

Map 5. Dar es Salaam Temporal spatial Growth.
Source: Master Plan (1979), Master Plan (2012).
4.6. City spatial growth and spatial transportation growth

Table 8 shows the trend of urban and road network growth and expansions from 1945 to 2012. It indicates transport infrastructure expansion is strongly correlated with population growth, spatial expansion, and land use changes. Map 8 shows an enormous continuance of growth from 1945 to 2012 caused by population growth which increased daily trips and transportation demands leading to an increase in congestion. The number of roads with a four-finger pattern in 1945 is very clearly elaborated, but the web of roads has grown into a complex network web by 2012. Temporal analysis made in Map 8 shows the city’s temporal growth that has been contributed by population and economic growth as analyzed above. This growth is making it more complex with the pace of urban challenges growing as well. This paper provides more analysis in the subsequent sections (Table 1).

The mobility modal share in Dar es Salaam is dominated mainly by public transport followed by walking (Figure 2). Residents apply different mobility modes and they change with time (Table 1). This study focuses on 1979 onwards (because of data availability). Dar es Salaam had a population of 843,000 people, most whose main means of mobility used to be walking. At the moment, the city fringe was not more

Map 6. Population and city growth with the cluster and outlier analysis spatial correlation model (Anselin Local Moran’s) shows a high level of clusters around the city center in black color, which is reduced sequentially outwards towards the city fringes.
than 10 km from city center. Probably, some would tolerate 10-km walk to reach their destination. Modal share started to shift gradually and public transport deployed by government changed to private people. Until recently, public transport was this paramount means of mobility. However, service is not decent and convenient. Over time, the attitude of residents toward car ownership improved, and then the spike in private car ownership is now attributed to problems in public transport.

The results of the analysis of the data indicate that there is a relationship between the economy, population, spatial growth, and road growth. In 1945, the city had only four major primary roads connecting its center with fringes covering only 9 km.

4.7. Economic growth and transportation

For more than a decade now, economic growth in Dar es Salaam has been linked to population and transportation growth Figure 11. Dar es Salaam GDP growth is coincided with population, transportation, and urban growth.

Map 7. The spatial relationship by ordinal least square (OLS) indicates the population is more concentrated (high density – yellow color) around the city center, but decreases (brown orange to red) with positive value toward the northern and western areas and then decreases with negative values (grey – light grey to blue) indicating that land is sequentially reduced to empty as you reach the south and southeastern areas.
The scattered graph below (Figure 11) indicates the connection between transportation and the city’s economic growth. Economic growth of the city depends on more investment in the city and GDP growth. The latter is said to be caused by an increase in outputs from industrial production induced by population growth which provides cheap labor.

The graphs indicate that there is, but not very direct or simultaneous, connection between economic and transportation growth, for example, from years between 1980 and 1995 (they intersect in the middle). Generally, we can state that there has been simultaneous growth in the economy and transportation which reached a turning point in 1995, when investment in infrastructure rose above GDP as indicated in the graph as

Map 8. Road expansion from 1945 to 2012 (Source: Master Plan 1979 and Tan roads) the city is shaped by four major roads which provide important links to other roads. The resulting complexity has been growing parallel with the pace of population and economic growth.
a result of enjoying the benefits of political will, especially in Dar es Salaam, where the
central government and diplomatic missions are located. Generally, the economy of
Tanzania has been steady for almost 20 years as indicated in the graph.

4.8. Recommendations
Taking into account the research, further studies on the mutual relationship between
transportation and urban growth using the presented approach for other mono-centric
urban, structured cities is desirable.
Inclusion of socioeconomic aspects such as income must be considered in analyzing
the interaction between urban growth and transport. It also should involve the impact of
spatial and temporal distribution of different population groups in terms of their income
or social status on patterns of household trips or traffic movement in the city.
It is recommended that more studies be carried out to analyze a variety of policy
interventions and examine the capability of any new proactive approaches of how to
make the most use out of land for planning transport infrastructure. These solutions can
be applied to other growing cities in the Global South which have mixed land use and
multi-transport systems.
Planners and policy-makers in Dar es Salaam must be appreciated that more and
more people continue to migrate to the city thus expanding its population, and spatial
planning must prioritize adequacy to accommodate this growth.
Arterial grid roads in Dar es Salaam may contribute to the introduction of an effec-
tive public transport system that extends far into the urban fringes; however, putting in
place an arterial road is not a guarantee in or of itself that the grid will be used effec-
tively to carry public transport unless deliberate and lasting measures are taken.
As Dar es Salaam keeps expanding, the necessary land for public streets, public
infrastructure networks, and public open spaces must be secured in advance of develop-
ments. This should include right of way for arterial grid roads, preferably spaced 1 km
apart and within walking distance from the interior of the area they enclose. The grid
can carry public transport and trunk infrastructure as well as facilitate drainage.
Most of the studies indicate that the threshold for the establishment of a metro (sub-
way) is the population of 5 million people; therefore, for a city like Dar es Salaam,
which will be a megacity for the next 20 years (UN-Habitat, 2014), it is better to
foresee in advance a subway or light rail system for public mobility which other major
cities such as Lagos and Nigeria have already started.

5. Discussion and conclusions
The simultaneous relationship between spatial city temporal expansion in relation to
spatial transportation expansion due to population and economic growth is significant as
it has showed the link between the four entities. The trend of growth has a negative
impact on the continuation of future growth; consequently, policy-makers and urban
planners should take precautions to mitigate negative impacts that may result from it.
The findings of this research have implications for developing countries, which for the past
20 years have seen their populations grow faster and simultaneously with their economies
leading to high population increases in big cities linked to immigrants from other regions.
Overall, the findings of this study show that there is mutual relationship between
Dar es Salaam urban growth, population, economy, and transportation. It found that
transportation demand and infrastructure growth coincide with population growth.
However, Dar es Salaam’s urban spatial expansion and residential area growth have been affected by transportation demand and infrastructure growth. The enormous spatial expansion has caused dramatic changes in the daily share of travel modes. These disparities have occurred in relation between urban growth and transport. The pattern of development process and policies intervention which has taken place has not been successful in solving these problems.

Transport infrastructure expansion in Dar es Salaam is mutually related to population growth, spatial expansion, and land use change. Additionally, urban spatial expansion and residential area growth are catalyzed by transport infrastructure expansion. The imbalance between travel demand and transport infrastructure has rendered an increase in congestion. Also in Dar es Salaam, there is huge influence of transport infrastructure on spatial temporal expansion and land use change. The main roads and highways (Morogoro, Kilwa, Ally HassanMwinyi, and Mandela) have a stronger influence on spatial expansion and land use change compared to secondary roads.

Notes
1. Daladala is a small minibus and medium-sized privately owned city buses. The name is old slang for 5 Shillings, the standard fare when the service was first introduced.
2. KAMATA is the Swahili abbreviation for National Bus Company.
3. UDA-Usafiri Dar es Salaam –Swahili for transportation in Dar es Salaam.
4. Informal sector is employing a big number of residents in Dar es Salaam than formal Sector.

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