Analysis on Spatial Distribution of Settlements in Mingalardon Township

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Abstract

This research aims to describe spatial distribution of settlements in Mingalardon Township. The study area occupies the northern part of Yangon City. It is located in North Yangon District. The areal extent is 106.97 square kilometres in which about 260,000 people are residing. Due to the construction of main road through the township and installation of new infrastructural facilities, settlements have been more spatial distribution with fairly accelerated momentum in the recent years. The analysis spatial distribution of settlements in Mingalardon Township are based the result derived from detecting and comparing the Aerial Photographs (1990), Google Images (2010) as well as information acquired from ground surveys with Geographic Information System (GIS). According to Nearest Neighbour Analysis, the spatial distribution of the settlements is clustered. Kernel Density Analysis reveals that settlement density is highest at Htaukkyant Junction and the wards near Mingalardon Market. Generally, population density coincides with the settlement density. Checked by Euclidean Analysis, most settlements are distributed over an elevation of about 10 metres about sea-level. The type of housing varies from place to place, but the wooden houses are the most dominant. The future more distribution of settlement within the study area depends largely on the government policy and if the adjacent agricultural land is allocated for use as residential land, the pace of settlement growth would be somewhat accelerated in the near future, although about half of the township area is not available for residential use.

Introduction

Urban population is usually distributed among settlements of differing sizes along a continuum from small towns to giant cities with population to tens of millions (Pacione, 2001). Rapid urbanization, the concentration of the urban population in large cities, the sprawl of cities into wider geographical areas and the rapid growth of mega-cities are among the most significant transformations of human settlements (United Nations 1994).

Yangon City is the former capital city in Myanmar. It is located in Yangon Region (Division) and is the largest urban area in Myanmar, having more than 59 million people in 2010 (CSO, 2010). According to population census, the population of Yangon City was 2.5 million in 1983. The estimated population was 2.8 million in 1988 and 3.9 million in 2001. It will increase to 5 million in 2010. The population of Mingalardon Township was 145,914 in 1988. The estimated population was 198,191 in 1998. The total population increased to 259,797 in 2010 (Township Basic Data, 2010). The impact of rapid growth of Yangon City's population resulted in the requirement of new settlement units.

Growth of Yangon City is somehow restricted by the natural barriers of Hlaing River in the west and Ngamore Yeik Creek in the east. Mingalardon Township is located continuously within Yangon City without barriers. It is a favourable place for settlements development due to its relief and high accessibility. Mingalardon is the largest township within the Yangon City. The area of Mingalardon Township is 106.97 square kilometers, shared by 33.16 square kilometres (30.99) percent of recreational area, 18.62 square kilometres (17.41) percent institutional area including cantonment area. Therefore, nearly half the township area forms as barrier for settlement development. The study period of this research work is two decades from 1990 to 2013.

Aim and Objectives

The main aim of this study area is to examine the distribution of settlements in Mingalardon Township.

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This analysis will conduct with the following objective;

- to examine the spatial distribution of various settlement patterns within Mingalardon Township
- to investigate the controlling factors of the settlements distribution in Mingalardon Township

Sources of Data and Methodology

As secondary data, population data are acquired from the Ministry of Immigration and Population Department, data and maps are obtained from General Administrative Office in Mingalardon Township. Settlement data are obtained from the Department of Human Settlement and Housing Development (DHSHD), and Yangon City Development Committee (YCDC). Aerial photographs of 1990 (1:20,000) are obtained from Survey Department, Yangon, and Google Earth Image 2010 (1:50,000) from SPOT 5 Satellite Images, and the Primary data such as migration pattern of the people lived in the area, growth of residential areas selected from field surveys, open-talks and interviews.

The spatial distribution of settlement units is checked by Nearest Neighbour Analysis, revealing as being clustered for the study area. For identifying the density of houses, Kernel Density Analysis is used and varying densities are presented by maps. Euclidean Distance Analysis is used to describe the relationship of each cell to a source or a set of sources based on the straight-line distance. The evaluation of road connectivity and accessibility of the different parts of the study area, Q Basic Method is used to calculate such networks connectivity in terms of Beta Index, Alpha Index and Cyclomatic Number.

Study Area

Location, Size, Shape and Boundaries

Mingalardon Township is one of the townships in Northern Yangon District of Yangon Region in Myanmar which occupies the northern part of Yangon City. It lies between North latitudes 16˚ 53´ and 17˚ 04´ between East longitudes 96˚ 05´ and 96˚ 11´ (Figure 1). It is bordered by Hmawbi and Hlegu townships on the north, Hlegu and North Okkalapa townships on the east, Mayangon Township on the south and Insein and Shwepyithar townships on the west. Mingalardon Township has an area of 41.30 sq. miles (106.97 sq.km). The township comprises of 32 wards (Figure 2). The shape of the township is somewhat elongated.

Relief and Drainage

The physiographic feature of Mingalardon Township is generally higher in the west and the land gradually slopes eastwards to the Balar Creek. The low hills and the ridges are the southern continuation of Bago Yoma. The north-south trending ridge, known as Yangon Ridge, has a general elevation of 30- 45 metres (100-150 feet) above sea level. The hilly region of more than 30 metres (100 feet) covers about half of the township area. Hlawga Lake, Reserved forest and Htaukkyant Junction are included in this part. The eastern part is flat plain having an elevation of about 10 metres (30 feet). Most settlements are located along the western part of the lowland adjacent to the western ridge. At this elevation, the settlers can easily get potable freshwater and are free from the impact of Balar Creek flooding. The tributaries of the Balar Creek which flow through the eastern and northern parts of the study area are Kalauk kadaing, Thein, Yewe, Onhnepin, Letpanbin, Ainema and Talabaung creeks (Figure 3).

Figure 1. Location map of Mingalardon in Yangon City
Source: Land Record Department (YCDC)

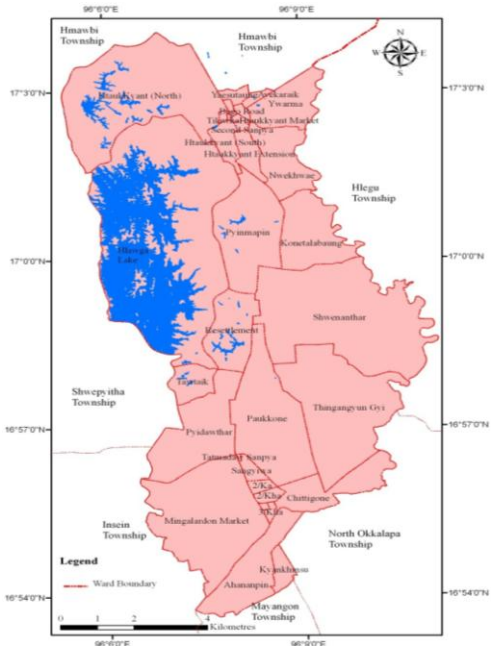

Figure 2. Wards of Mingalardon Township
Source: General Administrative Office of Mingalardon Township

The Evolution of Settlements in Mingalardon Township

The development of settlement in Mingalardon Township has been related to the growth and history of Yangon City. As lateritic culture belonged to the ancient Mon people, Tadagele which was not very far from Mingalardon had been inhabited since before the 11th century, based on a votive tablet with Pali inscription. In the middle of Hanthawady Era, Kyaikalot, Kyaikalae and Sadukan pagodas, located in Mingalardon Township were built by the Mon people, the study area has been inhabited since before the eleven century, though the number of population might has been small. According to authentic historical evidence, elephants that involved in the 40- year Mon-Bamar War were kept at Mingalardon, as it had some wetland favourable for elephants (Khin Swe Tun, 1977). The derivation of the name "Mingaladon" is rather vague and untraceable. It is impossible to have derived from the name of female deer "Minglar" as accepted by some. Anyhow, the area was already settled since 10 centuries ago. After independence, the army took hold of the state power in 1962 and under the regime of Revolutionary Council the study area encountered many changes in administration. In 1964, Insein Township was labeled as No. (1) Region in which Insein and Mingalardon were included as subregion.

In 1992, Yangon Region (Division) was reorganized into 4 districts as Eastern Yangon District, Western Yangon District, Southern Yangon District and Northern Yangon District. Mingalardon Township is included in the Northern Yangon District which comprises 8 townships (Township Basic Data, 2003).

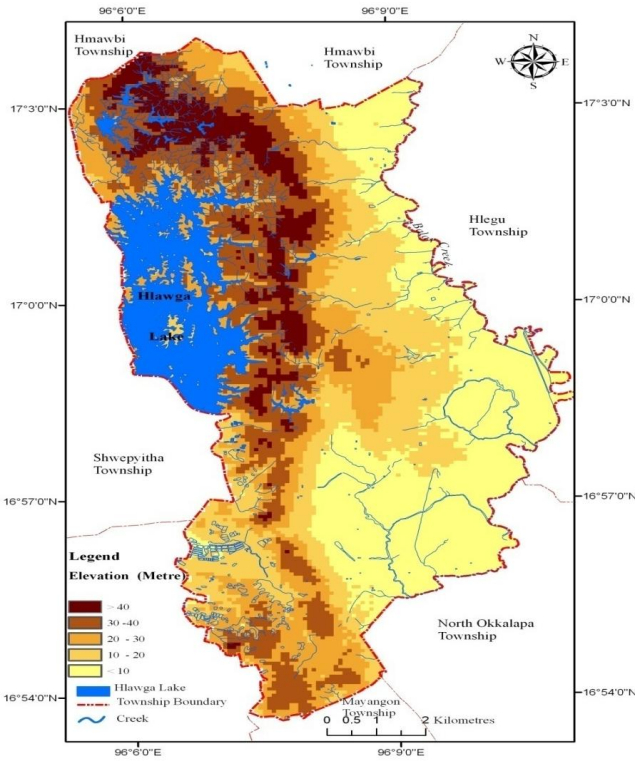

Figure 3. Physical features of Mingalardon Township
Source: Land Records Department (YCDC)

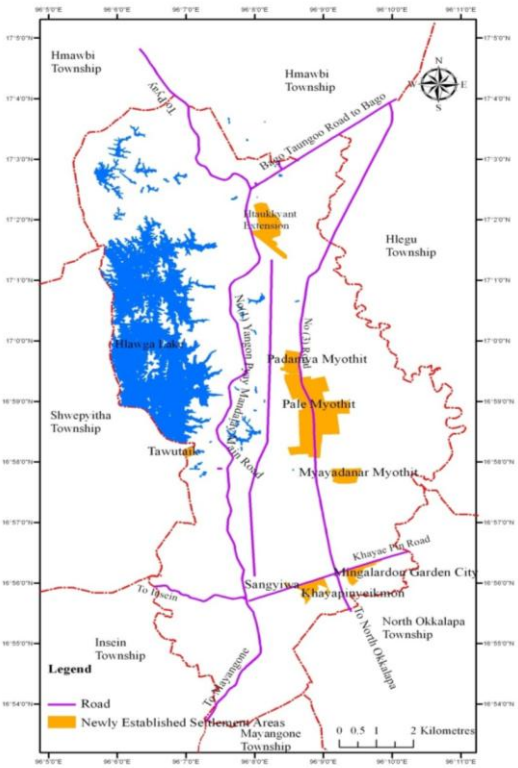

Figure 4. Establishment of new settlement areas as new towns and wards in Mingalardon Township in 2010.
Source: Defined by author based on field work and Google Earth Images (SPOT 5, 201)

In 1989, the economic system was changed from centralized state-control socialist system with closed door policy to market-oriented economic system with open door policy, relaxing the restrictions on the movement and sale of crops, domestic and foreign trade and encouraging foreign direct investment (FDI). As a result a number of medium to large-size factories sprung up one after another essentially in the outer rim of Yangon City and industrial zones located in the new town. During this period some agriculture and pasture lands were converted into settlement lands in Mingalardon Township such as Myayatana Myothit **,**Padamya Myothit, Htaukkyant Extensich on Project, Pale Myothit, Mingalardon Garden City, Sangyiwa Housing Estate, Khayaepin Yeikmon (Figure 4).

Such establishment of new towns, new housing projects, industrial zone and the extension of the township's area had resulted in the rapid development of settlements within the study area.

The Types of Settlements in Mingalardon Township

Based on the number of buildings and structural organization of the settlements, Mingalardon is included in the small town type as it has two communication main routes, marketing centre at Htaukkyant Junction, industrial zone and agricultural land. It can also be included in the city type because of "the presence of Military Hospital, Christian church, and Institute of Medicine until recent years" (Geography of Settlement, 2004).

Besides, ribbon development also manifests along the two main roads which may over time lead to the formation of a conurbation. Even a few isolated settlements are observed in areas adjacent to paddy fields, particularly in Swenanthar, Konetalarbaung and Nwekhwae wards which have become parts of the urban area in the very recent years. The nucleated or compact type of settlement is most prominent around the Htaukkyant Junction.

"A city is generally defined as a political unit, that is, a place organized and governed by an administrative body. A way of defining a town, city or urban area is by the number of residents or settlements. The United Nations defines areas having settlements over 20,000 as urban, and those with more than 100,000 as cities (United Nations, 1994). Therefore, 'town' may be defined as an area of having settlements between 20,000 and 100,000. The United States defines an urbanised area as a city and surrounding area, with a minimum population of 50,000. A metropolitan area includes both urban areas and rural areas that are socially and economically integrated with a particular city. Generally, cities with over 5 million inhabitants are known as megacities" (Bhatta, 2010). With a total population of more than 250,000, Mingalardon can be labeled as a city which is part of Megacity Yangon.

Spatial Distribution of Settlement

"Nearest Neighbour Analysis can be used to identify a tendency towards clustering or dispersion of settlements and it also identifies geographic patterns. Nearest Neighbour Analysis calculates a nearest neighbor index based on the average distance from each feature to its nearest neighbouring feature" (ESRI, Arc GIS, 9.3).

The settlement pattern of Mingalardon Township, is calculated with Nearest Neighbour Analysis for 1990 and 2010. In these years, the Expected Mean Distance ratios are 0.42 and 0.44 respectively. These indices value are less than 1 and thus, the settlement patterns in the study area exhibit clustering in both years.

Spatial Distribution of Settlement Density

Settlement pattern in Mingalardon vary from ward to ward. According to Kernel Density Index the settlement distribution of Mingalardon Township for 1990 presents about linear settlement pattern concentrated along eastern side of No.1 Main Road and both sides of No. 3 Main Road. Clustered settlement pattern is concentrating at Htaukkyant Junction.

Settlements with highest density are wards of Paukkone, Sangyiwa, 2 Ka 2 Kha and near at Htaukkyant Junction wards and Padamyar and Myayatana Myothit (new towns). Settlements with lowest density are Konetalabaung, Htaukkyant North and First Sanpya. In 2010, settlement expanded to nearby agricultural land. The expansion wards are Htaukkyant Extension, Resettlement, Pyidawthar, Paukkone, Chittigone, Shwenanthar and Thingangyungyi (Figure 5 and 6).

Settlements Pattern along Roads

The Euclidean Distance tools describe each cell's relationship to a source or a set of sources based on the straight-line distance. The source identifies the location of the roads. Euclidean distance is calculated from the center of the source cell to the center of each of the surrounding cells. True Euclidean distance is calculated in each of the distance tools.

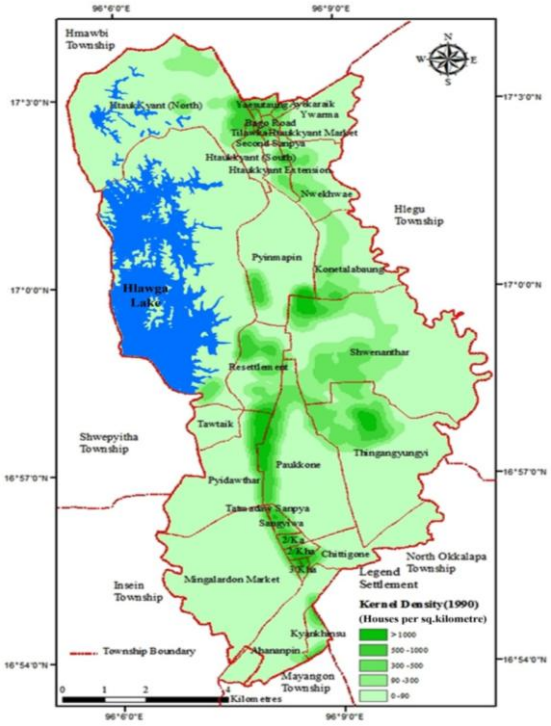

Figure 5. Distribution of settlements in Mingalardon Township 1990 (by using Kernel Method)
Source: Classified by author based on Aerial Photographs (1990), Survey Department

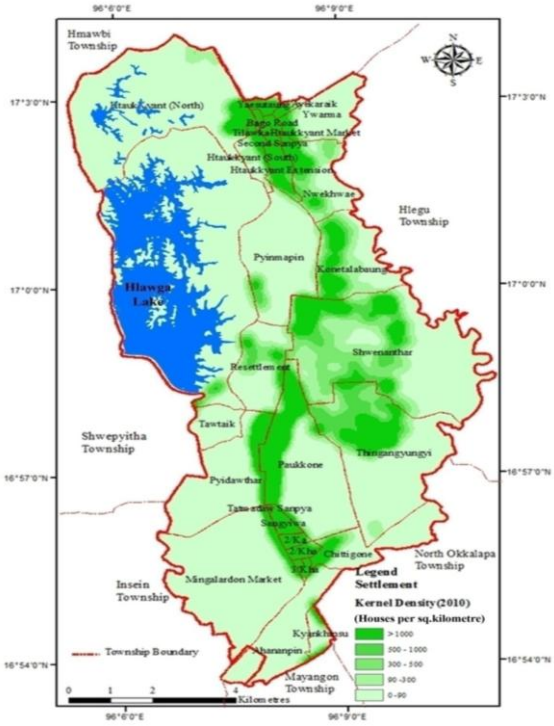

Figure 6. Distribution of settlements in Mingalardon Township 2010 (by using Kernel Method)
Source: Classified by author based on Google Earth Images (SPOT 5, 2010)

In 1990, most of the highest settlements are concentrated within the distance of 200 metres from roads. Moderate settlements are found between 200 and 400 metres and few settlements pattern between 400 and 600 metres. At the distance 400 and 600 and more than 800 metres from the road settlement is absent, Figure 7.

According to Figure 8, in 2010, Settlement area has expanded and roads are also extended. Settlements occupied within 0 and 200 metres from roads. Moderate scattered settlements occurred between 200 and 400 metres. Settlements are not found at distance more than 600 metres.

Distribution of Settlement According to Relief

Figure 9 and 10 show that settlement distribution according to relief. Most of the settlements were located at less than 10 metres relief elevation in 1990. Moderate settlement also occurred between 10 and 30 metres, but only a few settlements at elevation of 30 and 50 metres. In 2010, Settlement expanded into flat plain with more than 10 metres an elevation.

Generally, agricultural land use decreased and residential land use increased between 1990 and 2010. Settlement area has been extending into agricultural land area. Linear and cluster settlement pattern are the most dominant. Linear patterns occurred along No.1 and No.3 Main road. Cluster settlement is at Htaukkyant Junction area. Settlement density is uneven according to relief. Population density corresponds to settlement density area. Most people live in within 200 metres distance from road and at about 10 metres elevation.

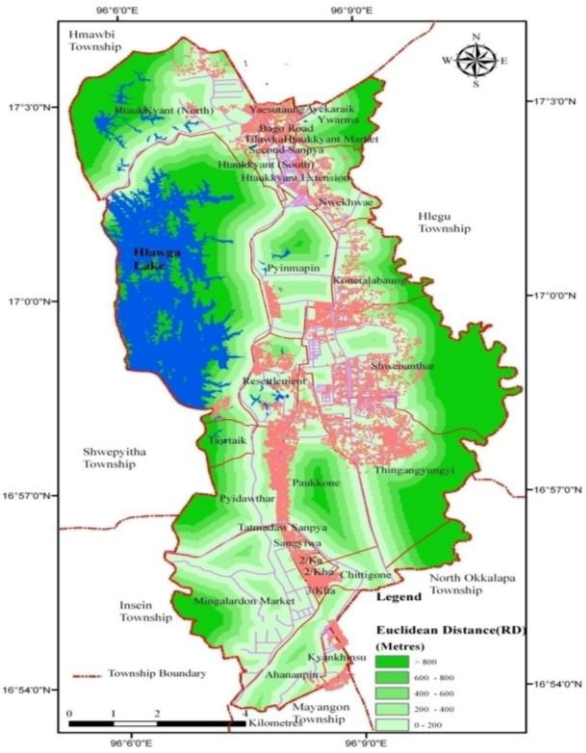

Figure 7. Settlements sistribution in relation to the distance from main roads in 1990 (by using Euclidean method)
Source: Classified by author based on Aerial Photographs (1990), Survey Department

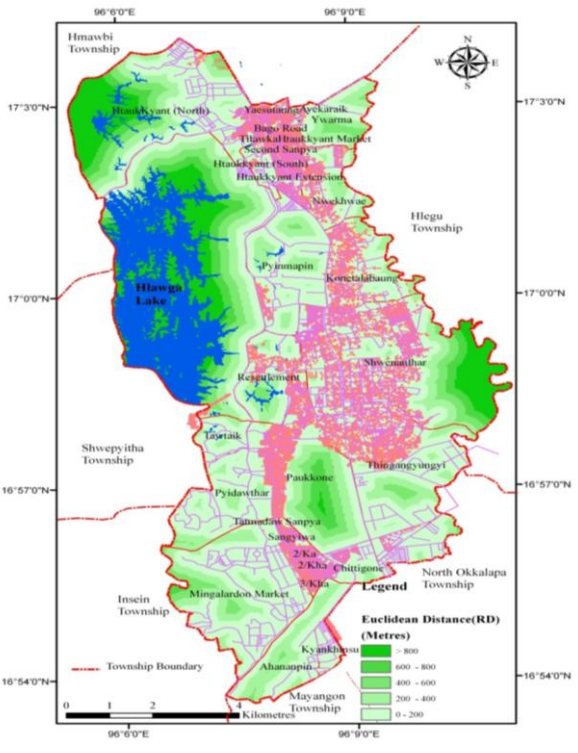

Figure 8. Settlements distribution in relation to the distance from roads in 2010, by using Euclidean Method
Source: Classified by author based on Google Earth Images (SPOT 5, 2010)

Changes in the Total Number of Population and Houses of Mingalardon Township in 1990- 2010

According to Table 1, in 1990, Mingalardon Township had 155,401 people and 14,532 houses and the number of population increased to 259,797 and total number of houses was 28,955 in 2010. The increase in the 20 years period from 1990 to 2010 was 104,396 people and 14,423 houses. The factors responsible for the increase in the number of population and houses are natural population growth, circulation migration, rural-urban migration, industrialization and improvement in transportation. Mingalardon Township constitutes 32 wards and the increase in the number of population and houses varies from wards to wards.

House Type

Whatever the mode of construction, residents soon influence their urban environment, changing and modifying it to suit their way of life (Lozano, 1990). Mingalardon Township is composed of 32 wards in which different house types occupy, totaling 19057. The houses within the township can be differentiated into four types and these are: (1) reinforced cement concrete, (2) brick noggin, (3) wooden and (4) hut. The numbers of different types of house in all wards are presented in Table 2 and Figure 11.

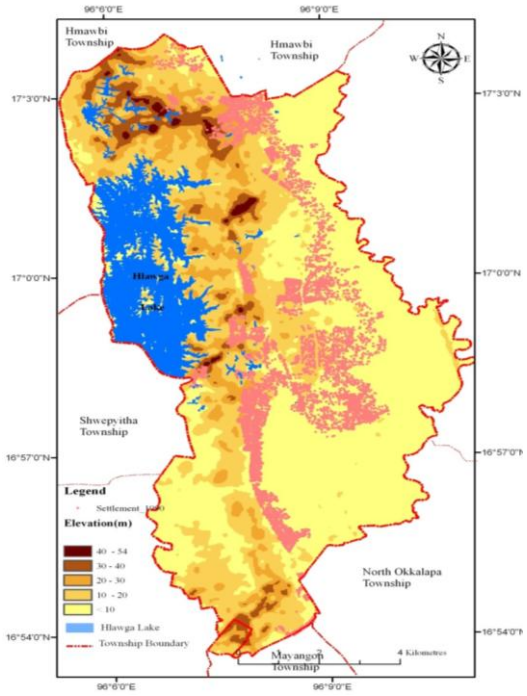

Figure 9. Settlements distribution according to Relief in 1990

Source: Classified by author based on Aerial Photographs (1990), Survey Department

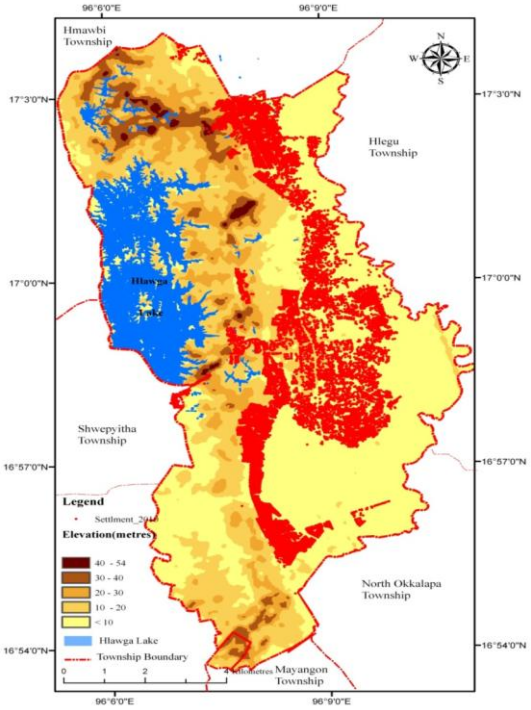

Figure 10 Settlements distribution according to Relief in 2010

Source: Classified by author based on Google Earth Images (SPOT 5, 2010)

Construction of Different House Types between 2001 and 2010

The numbers of different house types constructed during the period from 2001 to 2010 are shown in Table 3. The Table shows that no hut was built during the period and only 4 wooden houses emerged. Even brick nogging house type was much smaller in number (49) if compared with reinforced cement concrete (397) which account for (10.88%) of all houses built during the 10 years period. In 2006, 20 brick nogging houses were built, all in Khayaypin Yeik Mon and Mingalardon Garden City. As brick nogging building partially needs wood which is more expensive, the private and construction companies prefer to build reinforced cement concrete residential units which are more durable. These 397 out of 450 newly built houses in the 2001-2010 periods were of reinforced cement concrete type.

Factors Controlling the Settlements Distribution In Mingalardon Township

Housing Policy

The existing law related to housing is 1951 State Housing Rehabilitation and Settlement Development Act, promulgated in 1951 which includes 16 responsibilities to undertake for the development of housing. Based on the 1951 Act, the following new housing strategies have been laid out since the emergence of DHSHD.

(a) Emergence of DHSHD.
(b) Site and services schemes
(c) From hut to apartment schemes
(d) Low cost housing schemes
(e) Development of new residential areas
(f) DHSHD's high value and high-rise building project
(g) Development of industrial zones and city of industry
(h) Site selection for residential land plots.

According to the department concerned, it could have materialized only partially the above-mentioned housing strategies.

Table 1. Total Number of Population and Houses According to Wards of Mingalardon Township in 1990-2010

Wards	1990		2010	
	Number of Houses	Total Population	Number of Houses	Total population
Htaukkyant (South)	143	2757	371	8421
Htaukkyant (North)	676	5530	863	3590
First Sanpya	68	614	106	925
Second Sanpya	213	1825	316	2696
Yesutaung	279	2406	632	5437
Bawlonekwin	244	1641	305	2048
Ayekayeik	75	752	235	2417
Bago Road	61	1079	240	2216
Tilawkayone	58	1992	246	2355
Junction	90	1206	98	1241
Market	145	1118	158	1182
Ywama	113	1601	316	3971
Extention	781	5818	1227	8839
Kyankhinsu	1154	6779	1314	6922
Ananpin	235	3519	416	6599
Chittigone	206	2837	651	6769
2 Ka	451	4919	735	7917
2 Kha	346	2601	480	3605
3 Ka	166	1805	208	2257
3 Kha	589	4526	626	4560
Sangyiwa	273	6490	955	7804
Tatmadaw Sanpya	65	876	123	1652
Paukkone	1328	13572	4045	25301
Mingalardon Market	129	2951	533	19851
Resettlement	880	7600	2484	17164
Pyidawthar	327	3399	490	5092
Tawtaik	347	3452	636	5642
Nwekhawae	366	2641	1235	20480
Konetalabaung	944	8462	1383	12242
Shwenanthar	1789	7420	4074	28186
Pyinmapin	501	8823	815	11273
Thingangyungyi	1480	10627	2639	21293
Total	14532	155401	28955	259797

Housing Delivery System in Public and Private Sectors in Mingalardon Township

In Yangon City, Housing Delivery Systems are managed by the Department of Human Settlement and Housing Development.. Khayaepin Yeik Mon Housing Project in Mingalardon Township is a Government's Joint Housing project. The idea is to help people in saving to get an own house. The beneficiary or the person who want to own a house has to pay half the total cost as cash down payment and the remaining half is to be paid on installment basis within fifteen years with 5 percent interest rate. Due to the rising cost of construction materials and high rate of inflation, the government stopped practicing the system in the subsequent years.

After 1988, Pale Industrial Housing Project was implemented on No.3 Main Road in Shwenanthar Ward of Mingalardon Township. As the project was less attractive due to distance from the developed parts of Yangon City and quite costly even for the upper middle

class, the construction ceased for a long time. It has now been revitalized as the demand for individual house unit has been rising.

Table 2. Total Number of Population and Houses According to Wards of Mingalardon Township in 1990-2010

Wards	Types of House								
	Hut	%	Wooden	%	BN	%	RC	%	total
Htaukkyant (South)	9	0.97	274	1.2	79	1.85	9	1.6	371
Htaukkyant (North)	12	1.29	597	2.8	193	4.53	59	10.51	863
First Sanpya	5	0.54	58	0.3	42	0.98	1	0.17	106
Second Sanpya	21	2.26	206	0.9	85	1.99	2	0.35	316
Yesutaung	0	0	584	2.4	30	0.7	0	0	632
Bawlonekwin	22	2.37	190	0.8	55	1.29	38	6.77	305
Ayekayeik	4	0.43	138	0.6	119	2.79	2	0.35	235
Bago Road	0	0	131	0.6	99	2.32	5	0.89	240
Tilawkayone	10	1.08	85	0.4	80	1.88	71	12.65	246
Junction	0	0	73	0.3	20	0.47	5	0.89	98
Market	0	0	80	0.3	45	1.05	33	5.88	158
Ywama	4	0.43	235	1	75	1.76	2	0.35	316
Extention	38	4.1	761	3.2	363	8.53	65	11.58	1227
Kyankhinsu	0	0	1095	4.7	221	5.19	1	0.17	1317
Ananpin	58	6.26	234	1	124	2.91	0	0	416
Chittigone	0	0	472	2	224	5.26	0	0	651
2 Ka	12	1.29	509	2.1	214	5.02	0	0	735
2 Kha	0	0	327	1.4	143	3.36	10	1.78	480
3 Ka	11	1.18	186	0.8	11	0.25	0	0	208
3 Kha	52	5.61	573	2.4	47	1.1	0	0	626
Sangyiwa	0	0	917	3.9	38	0.89	0	0	955
Tatmadaw Sanpya	26	2.8	71	0.3	18	0.42	2	0.35	123
Paukkone	13	1.4	3061	13.2	418	9.82	13	2.31	4045
Mingalardon Market	15	1.61	473	2	37	0.86	8	1.42	533
Resettlement	59	6.37	2168	9.3	184	4.32	11	1.96	2484
Pyidawthar	0	0	364	15	110	2.58	16	2.85	490
Tawtaik	57	6.15	465	2	113	2.65	1	0.17	636
Nwekhwae	35	3.5	1173	5	27	1.8	0	0	1235
Konetalabaung	43	4.64	1290	5.5	46	1.08	4	0.71	1383
Shwenanthar	448	48.38	2717	11.7	788	18.51	121	21.56	4074
Pyinmapin	45	0	654	2.8	54	1.26	62	11.05	815
Thingangyungyi	70	0.75	2396	10.3	153	3.59	20	3.56	2639
Total	1069	100	23137	100	4255	100	492	100	28955

Source: Field Survey and Township Development Committee

In 1996, the Department of Human Settlement and Housing Development in cooperation with Zaykabar Company established Mingalardon Garden City and Yangon Industrial Zone.. To attract more buyers of the house units the DHSHD, in cooperation with Zaykabar Company, established Yangon Industrial Zone within the Garden City. As a result, all the house units are now being occupied by those who can afford.

Spatial Variations in Land Values

Land value varies depending on the distance from the commercial hub, downtown area of Yangon City, development stage of the area characterized by urban function and accessibility. Within Mingalardon Township, the variation in the value of land is largely influenced by the location. Generally the land plots close to the main roads are relatively

expensive and the value decreases with the increasing distance from the main roads. The land value on both sides of the road is much more expensive than that of the interior parts of the wards. The study area still has vacant land in the middle part control as cantonment area and agricultural land in the eastern part.

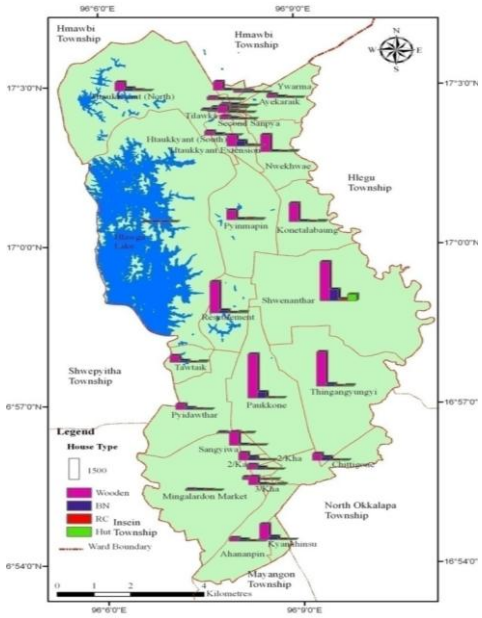

Figure 11. House Types in Mingalardon Township
Source: Based on Table 3.2

Table 3. Construction of House Types between 2001 and 2010

Years	Wooden house	Brick noggin building	Reinforced cement concrete	Total	%
2001	1	-	7	8	1.7
2002	1	3	86	90	20
2003	-	-	31	31	6.8
2004	-	1	33	34	7.5
2005	-	3	40	43	9.5
2006	1	20	48	69	15.3
2007	-	5	32	37	8.2
2008	-	4	35	39	8.6
2009	1	11	27	39	8.6
2010	-	2	58	60	13.3
Total	4	49	397	450	100

Source: City Planning and Land Administration Department,

Comparatively, the land value of new wards is higher than that of the old wards. The current price of a land plot measuring 20×50 feet or 40×50 feet ranges between 100,000 and 1,000,000 kyats, whereas a land plot of 40×50 in the new wards demands between 2,000,000 and 5,000,000 kyats in 2010 (Interview, 2010).

With the increasing population and diversification of commercial activities and establishment of trading companies as a result of the adoption of open market oriented economy, the land value is extremely high in the downtown area. Those who want to live in an individual house cannot afford to buy a land plot in the downtown or even in the Inner Urban Townships Zone. Such families are attracted towards the peripheral area of Yangon City, including Mingalardon Township.

Settlement distribution with transport connectivity and accessibility in Mingalardon Township

Transportation Network Analysis classifies two types of network analytical tools. The first type is connectivity accesses to the overall characteristics of the entire network. The second type is accessibility that describes how one network segment is related to other segment or the entire network system. It can be assumed that the higher the degree of connectivity, the greater concentration of settlement units. In order to differentiate the level of connectivity of the study and its different segments, the calculated value of the Beta Index, Alpha Index and Gamma Index and Cyclomatic Number of the two periods (1990 and 2010) are compared.

As shown in Table 4, Figure 12, Mingalardon Township had 7 edges (e) in 1990 and 28 in 2010. The number of vertices (v) was 8 in 1990 and it increased to 23 in 2010. Likewise Cyclomatic number (μ=e-v+p) increased from 0.00 and 6.00 in the same period. The number of subgraph (p) for both years is 1. The resultant values are 0.88 and 1.22 by Beta Index, 0.00

and 14.63 by Alpha Index, and 38.89 and 44.44 by Gamma Index for 1990 and 2010 respectively. These measurements show that the transportation network connectivity has notably developed during the last 20 year period. The development of transportation network is basically depending on the development of settlement units.

Each individual vertices or edges have its own accessible characteristics and relationships with other vertices and edges throughout the network. Accessibility analysis is to identify how many edges is directly connected to a given vertices. If a vertice is connected with a number of edges, it is highly accessible. The higher the number of edges, the greater the accessibility of a given vertices.

Link V1, V2, V7 and V8 have 19 direct links in 1990. As shown in 2010, link V8 has the largest number of direct links (141) to other edges, followed by V9 with (113) links, and V11 with 111 links. Settlements development occurred at better connectivity and accessibility place of the study area such as Chittigone, Thingangyungyi, Shwenanthar, |Paukkone, near Htaukkyant junction wards. Good accessibility in the study area grows residential development are more dispersed (Figure 13).

Table 4. Transportation Network Connectivity

Indices	1990	2010
Number of edges (e)	7	28
Number of vertices (v)	8	22
Number of sub graphs (p)	1	1
Cyclomatic number (μ=e-v+p)	0.00	6.00
β= e/v	0.88	1.22
α=μ/2v-5	0.00	14.63
Ƴ=e/3(v-2)	38.89	44.44

Source: Calculation based on Q basis Analysis

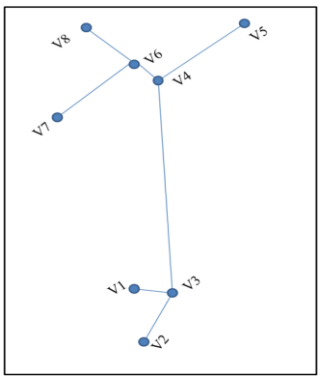

Figure 12 Transportaion Network of Mingalardon Township in 1990
Source: Based on Aerial Photographs (1990), Survey Department

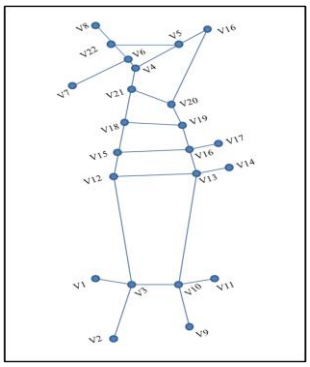

Figure 13 Transportation Network of Mingalardon Township in 2010
Source: 2010 Field Survey

Conclusion

Government policy, particularly in allocation of land for different purposes plays the most critical role in settlement development, as the use of land for recreation, industrial zone, and cantonment area as well as all urban extension is depended on the decisions of the Government. Although the establishment of industrial zone can attract employees to settle in and around the zone, the use of a considerable large part of land for recreation (Golf club) and military purpose hinders the growth of settlement within the study area. Hence the slow pace of growth would remain unchanged in the near future.

The current situation of settlement development is changing due to privatization according to transformation processes. For the comprehensive urban development of Greater Yangon, strategic plans for vision 2040 are being drawn by the Yangon City Development Committee in cooperation with JACA as well as NGOs and departments under the Ministry of Construction.

DHSHD, currently in corporation with Royal Family Construction Group, starts building low-cost housing in spacious vacant lands of inner urban townships and has plan to build in the outer urban townships including Mingalardon Township. According to the

Commander-in-Chief of Defence Services, some military lands unused for any purpose are to be returned soon to the former owners and these land plots can be utilized for settlement. Moreover, the government has received a large amount of loans from foreign countries of which some are intended to be used in urban housing. In response to democratization process of the country, a number of foreign firms are taking interest to invest in various economic sectors including housing. These ongoing situation may somewhat affect the systematic settlement development of the study area is not so distant a future.

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Plate 1. Mingalardon Garden City: Khayay Yeiktha of Mingalardon of Mingalardon Garden City revealing modern- style high –value two-storey single houses, locating at the Junction of No.3 Main Road and Khayaypin Road.
Source: Tin Tin Htwe (2010)

Plate 2. Khayaypin Yeikmon: Khayaypin Yeikmon 1 and Khayaypin Yeikmon 2 with modern-style two storey single houses, locating on Khayaypin Road in Chittigone Ward.
Source: Tin Tin Htwe (2010)

Plate 3. Individual house in Khayaypin Yeikmon 3: modern-style two-storey row individual houses built systematically with separate spacious compound in Khayaypin Yeikmon 3.
Source: Tin Tin Htwe (2010)