Assessing Resilience of Agricultural System of Dhaka, Bangladesh.

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Degree Project in Environmental Strategies, Second Cycle
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<tr>
<td>APB</td>
<td>Action Policy Brief</td>
</tr>
<tr>
<td>BMD</td>
<td>Bangladesh meteorological Department</td>
</tr>
<tr>
<td>CCC</td>
<td>Climate Change Cell</td>
</tr>
<tr>
<td>DPHE</td>
<td>Department of Public Health Engineering</td>
</tr>
<tr>
<td>DMDP</td>
<td>Dhaka Metropolitan Development Plan</td>
</tr>
<tr>
<td>FOMU</td>
<td>Food Planning and Monitoring Unit</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>MDG</td>
<td>Millennium Development Goal</td>
</tr>
<tr>
<td>MoA</td>
<td>Ministry of Agriculture</td>
</tr>
<tr>
<td>MoEF</td>
<td>Ministry of Environment and Forest</td>
</tr>
<tr>
<td>MoL</td>
<td>Ministry of Land</td>
</tr>
<tr>
<td>NAP</td>
<td>National Action Plan</td>
</tr>
<tr>
<td>NLUP</td>
<td>National Land Use Policy</td>
</tr>
<tr>
<td>NSDS</td>
<td>National Sustainable Development Strategy</td>
</tr>
<tr>
<td>PoA</td>
<td>Plan of Action</td>
</tr>
<tr>
<td>RAJUK</td>
<td>Rajdhani Unnoyon Kotripokho</td>
</tr>
<tr>
<td>RAW</td>
<td>Resilience Alliance Workbook</td>
</tr>
<tr>
<td>SDG</td>
<td>Sustainable Development Goal</td>
</tr>
<tr>
<td>SES</td>
<td>Social and Ecological System</td>
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<td>USGS</td>
<td>US Geological Survey</td>
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Abstract

Due to rapid urbanization agricultural lands in metropolitan areas are shrinking. As a result our cities are getting more dependent on distant places for food, which is making the food system vulnerable. In the context of rapid urbanization and climate change a resilient agricultural system of Dhaka could be one of the key to ensure a sustainable future. To investigate the impact of urbanization and climate change on the resilience of the agricultural system of Dhaka a resilience assessment of agricultural system of Dhaka has been done. The study followed the resilience assessment wordbook for practitioner as method of assessment. As methods to collect and analyze data field studies, interview, GIS analysis, policy analysis were conducted. This study shows that, urbanization is directly responsible for changes in both quality and quantity of the agricultural land of Dhaka whereas climate change does not affect directly. Even with this rapid urbanization there is still scope to take measures to make agricultural system resilient by preserving land within Dhaka metropolitan area. Therefore two Strategies have been proposed. First one is; increasing local food production without administrative reformation and the second; reducing the future demand by administrative and economic decentralization of Dhaka. Both of the strategies will require strong political will along with recognition of importance of agricultural land within the city boundary.

Key words: urbanization; resilience; agricultural land; sustainability; Dhaka; Bangladesh

Sammanfattning


Nyckelord: urbanisering; resiliens; jordbruksmark; Dhaka; Bangladesh
Chapter 01: Introduction

Following the trend of Europe and America, Asia is also following the massive transformation from rural-agrarian to urban industrial society (Taniguchi et al., 2008). According to the UN, over 70% of the global population will live in urban areas by the year 2040, (UN, 2014). But meeting the demand of this growing population in urban areas creates pressure on agricultural land and natural environment, which eventually will increase the vulnerability of the system. Most of the Asian cities are facing this challenge and Bangladesh is not an exception in this case.

1.1. Urban growth and its impact

Due to rapid urbanization cities are experiencing social and spatial vulnerabilities. The overuse of natural resources due to urbanization leads toward various environmental degradations. Loss of agricultural land has been one of the consequences of urbanization (Pandey and Seto, 2015). It is also responsible for loss of productivity of land (Xu et al., 2007). Land cover changes alter the ecology of landscape and fragmentation in natural habitat causes loss in biodiversity (Pauleit and Breuste, 2011; Tratalos et al., 2007). Urban growth also has significant impact on air quality and energy consumption (ibid) along with degradation of water quality (Xian et al., 2007). Increasing the land surface temperature urbanization is also responsible for heat island effect (Ahmed et al., 2013).

1.2 Resilience and urbanization

New demands for land and ecological services are creating extra pressures on urban ecosystems. The fragmented character of urban development has increased all around the world (Taşan-Kok, 2004). In such context, the necessity for new theoretical perspective has emerged to deal with uncertainty and complexity. As a result the necessity of resilience thinking in planning has been amplified (Eraydin and Tasan-Kok, 2012, p. 4). To ensure sustainability of cities, resilience thinking is very much needed. In recent policy discourse resilience has been emphasized (Evans, 2011, p.223). Significance of spatial planning to ensure urban resilience has been recognized and discussed by (Davoudi, 2012; Fleischhauer, 2008; Gleeson, 2008).

Pickert et al. (1997, p.193) has identified the twofold relation of urbanization and resilience. First one is the stress, change and disturbances to ecological systems created by urbanization, and the second one is the forced land-use conversion due to spread of urbanization. This twofold relation is also obvious for preserving agricultural land of Bangladeshi cities.

1.3 Agriculture and city

Where the foods are grown, is one of the main concerns for sustainable city (Peters et al., 2009, p.72; Beatley and Newman, 2013). In other words, it can be said that agricultural land within and adjacent to the city to grow food has been given importance. Study by Cofie et al. (2003) and Mallick et al. (2012) argue that urban and peri-urban agriculture (UPA) is significantly
contributing to a higher variety of foods of the city markets, contributes to employment, livelihoods and poverty alleviation.

In North America, Europe and Australia alternative food networks (AFNs) represent efforts to re-spatialize and re-socialize food production, distribution and consumption. Shorter distances between producers and consumers is one of the defining factors which helps minimize transport distances, oil consumption and bypass middlemen in the distribution chain (Jarosz, 2008, p.222). This form of production and consumption in one hand conserves fossil fuel both in production and transport, on the other hand city dwellers get food at affordable price (Mallick et al., 2012).

1.4. Agriculture in Bangladesh

Bangladesh is mainly an agricultural country. Fertile land is one of the important resources of the country. 18% of GDP is generated by agricultural sector (BBS, 2011) (see figure 1). Increasing urban population caused by large rural to urban migration has lead to serious land transformation in cities of Bangladesh. These transformations are taking place without much concern about sustainability. Accordingly, urban growth has caused notable reduction of arable land. Moreover, due to the impact of flooding and erosion, people are losing their land (Hessel, 2013). According to projection of the Climate Change Cell (CCC, 2008) due to a projected sea level rise of 23 cm, 10-15% of the land in the country will be under water by 2050 which will decrease the per capita land and will have impact on agricultural system as well.. According to Hossain et al. (2011), impact of urbanization and impact of climate change both are responsible for the loss of availability and quality of agricultural land. The associated challenges to meet the demand with domestic production for this large population (see table .1) have also been discussed in their study (ibid).

Figure 1: Agriculture is the third largest contributing sector of GDP of Bangladesh; Source: BBS (2011)

Though domestic food production has an important role to play to ensure food security in Bangladesh (Begum and D’Haese, 2010). Although Bangladesh has almost reached self-sufficiency in food, in recent years preserving agricultural land has been considered a necessity to ensure sustainability and food security for increasing demand (Rahman, 2012; Siddique, 2016,
Seraj, 2016). Conserving agricultural land has been also given importance in policy discourse of Bangladesh, which has been discussed later in this paper under the section “historical timeline and governance system” (see chapter 5). However, the current development trend shows strong evidence of unstoppable transformation of agricultural land into urban area throughout the country. As a consequence, food production, food availability and food affordability will be affected. If this trend continues, it would be a great hurdle for Bangladesh to meet up the growing food demand for its increasing population (Dewan et al., 2012, p. 316).

Table 1: projected population of Bangladesh shows in next 40 years the population will grow 1.3 times in 2051.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2011</th>
<th>2016</th>
<th>2021</th>
<th>2025</th>
<th>2031</th>
<th>2036</th>
<th>2041</th>
<th>2046</th>
<th>2051</th>
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<tr>
<td>High</td>
<td>149.8</td>
<td>161.3</td>
<td>173.6</td>
<td>186.6</td>
<td>199.6</td>
<td>212.0</td>
<td>223.5</td>
<td>234.5</td>
<td>245.6</td>
</tr>
<tr>
<td>Medium</td>
<td>149.8</td>
<td>160.3</td>
<td>170.2</td>
<td>180.2</td>
<td>190.0</td>
<td>198.9</td>
<td>206.5</td>
<td>212.9</td>
<td>218.4</td>
</tr>
<tr>
<td>Low</td>
<td>149.8</td>
<td>160.2</td>
<td>168.7</td>
<td>176.3</td>
<td>183.8</td>
<td>190.4</td>
<td>195.6</td>
<td>199.1</td>
<td>201.3</td>
</tr>
</tbody>
</table>

Source: The table is taken from The Impact of the Demographic Transition on Socioeconomic Development in Bangladesh (Hayes and Jones, 2015)

According to the future projection on food supply and demand, it has been found that demand for food grain are greater than supply (Hossain et al., 2011). Their study showed that there is a decreasing trend for fruit and vegetables availability over the periods. Household Income and Expenditures Survey (HIES) data by Bangladesh Bureau of Statistics (BBS, 2010) shows a new pattern of food consumption in recent years. The consumption of rice is decreasing, but the demand for other kind of food is increasing (see Figure 2), which means there is changing pattern including more consumption of vegetable and fruit.

![Figure 2: decreased consumption of rice with increased consumption of total food in Bangladesh; source: HEIS (2010)](image)

1.4.1. Agriculture in Dhaka
Due to unplanned growth, Dhaka, the capital of Bangladesh, has positioned itself as second least livable cities in the world (The economist, 2015). One third of the urban population of Bangladesh lives in Dhaka (The World Bank, 2007). There is no city or town in Bangladesh without vast agricultural land in the city boundary. Dhaka was not also an exception in this case (Mahmud and Jahangir, 2015). Because of rapid urbanization the land cover of Dhaka has change significantly. A study by Dewan et al. (2012) has shown a large reduction of agricultural land from 12,040 to 6,236 ha 1975 to 2005 and an increase of urban built-up area from 5,500 ha in 1975 to 20,549 ha in 2005 (see figure 3). Along with other environmental consequences associated with rapid and unplanned urbanization, land quality in Dhaka has degraded considerably (Amin et al., 2008; Dewan and Yamaguchi, 2009, p.317). But Still 11% of populations of Dhaka district are farmers (BBS, 2011).

Figure 3: Land use changes of Dhaka showing almost 50% of agricultural land decreased over last 30 years from 1975 to 2005; source: Dynamics of land cover changes in Dhaka, Dewan et al (2012)

1.4.2. Food demand and supply in Dhaka

Dhaka mainly meets its demand for food through agricultural products that are produced outside the city. People of Dhaka consume 2 million ton of rice per year (BBS, 2007). Whereas, Dhaka produce 4680 metric ton rice for year 2010-11 (BBS, 2011). Rest of the amount are supplied mostly from northern districts of Bangladesh. Northern districts such as Rajshahi, Dinajpur, Rangpur, Mymensing, Bogra, etc. are the main source for rice (Kraas et al., 2013)( see figure 4). Even twenty to thirty years back Dhaka was able to produce and meet the demand of various crops, vegetable and fruits inside the city ( Siddque, 2016; Seraj, 2016; Rahman, 2016; Ashraf, 2016; expert interview).But now for winter vegetable, 70% of demand are grown in the greater Dhaka district including the adjacent thanas of Savar, Dhamrai, Keraniganj and Dohar, (Saha, 2014). The rest of the food are supplied from the distant place of Bangladesh; even from India and Mayanmar (Amin and Rahman, 2014)
1.4.3. Food affordability in Dhaka

Along with availability of sufficient food, affordability to buy food is also important. Considering these aspects, food securities are under threat in many developing cities where 80 percent of the income is spent on food in poor urban households. So, high food price or decrease in income made urban poor vulnerable (FAO, 2010). This has been found true in Dhaka as well. The study on food system of Dhaka by Bohle et al. (2010) has pointed out that in the future, food might be available but it might not be affordable to all income groups of Dhaka city. Due to transport and storage cost the food that is produced outside Dhaka is purchased at higher price (Bohle et al., 2010). Fruits and vegetables grown around the cities increase the supply of fresh, nutritious food and enable the urban poor's economic access to food (FAO, 2010). According to World Bank (2007), 300,000-400,000 poor migrant move to Dhaka each year. Jahan et al. (2015), found that due to affordability, people with low income of Dhaka, often buy low quality and rooten food, instead of fresh one.

Figure 4: Map showing the supply of rice to Dhaka from other parts of the country; map source: Krass et al. (2013)
1.4.4. Other ecological concerns in Dhaka

Other than food, agricultural land of Dhaka has other ecological values (see figure 5). Specially agricultural land in Dhaka has great impact on flood control. Study by Dewan et al. (2012) found that to offset the flood vulnerability land filling by sand and earth is a common practice in Dhaka. As, most of the agricultural lands are basically flood plains and it can retain water during monsoon (Rahman, 2016; Dewan and Corner, 2014). As a result, conversion of agricultural land into urban area enhances the flood risk to the city (ibid). Due to lack of open space in Dhaka, agricultural land can have recreational value for the city dweller as well. It also helps to create connection with nature and people (Ashraf, K.K, 2016; Ashraf, D., 2016; expert interview). With the reduction of wetlands and agricultural lands Dhaka is also experiencing increased temperature due to urban heat island effect (Ahmed et al., 2013). Agricultural land can also reduce the heat island effect by allowing more soft surfaces and vegetation.

Figure 5: The social and ecological benefits provided by agricultural land of Dhaka

1.5. Research problem

In the heart of the deltaic plane of Bangladesh, the capital Dhaka is often regarded as a rapid growing, busy and polluted city with many people living in poverty. Among 170 million people of Bangladesh, 15 million live in Dhaka. In a rapid urbanization context of Dhaka the increasing urban population will create pressure on agricultural land and natural environment in future. In
recent years Bangladesh has almost reached self-sufficiency in food, but still the geographical location makes her vulnerable to natural disasters. While climate change brings challenges of flooding and droughts, unplanned urbanization has made the scenario even worse. Having impact on agricultural land, socio-ecological system of agriculture is affected. For example availability of fresh food, food affordability, flood vulnerability etc. are becoming major issue of concern for Dhaka. In such context, for sustainable future of cities, resilience thinking has raised as dominant field of enquiry and thoughts. In the process of urban planning resilience in agricultural system will be helpful to reduce negative impacts and ability to provide necessary effective strategies for the city.

With the discussion above, it is very clear that the changes in agricultural land due to urbanization and climate change affects the system both socially and ecologically (see figure 5). Only integrated solutions can offer a way forward in this complexity of problems. By understanding and assessing resilience of the agriculture system of Dhaka with rapid urbanization and climate change impact could offer a way to solve the multiplicity of existing problems in Dhaka.

If we consider agricultural activity as a system in city planning, agricultural land plays an important role. It has both social and ecological importance. It is both directly and indirectly related with food security, food affordability, food availability, economy, livelihood etc. In this study, agricultural system will be understood as a system where agricultural land will be focused. The change in agricultural land is the main issue of this study and issue of food (security, affordability, availability) will be considered as a related issue to understand the main system.
Chapter 02: Aim and scope of research

2.1. Aim

The main aim of this research is to understand the socio-ecological system of agricultural land of Dhaka and how urbanization and climate change affect this system. With this comprehensive understanding, it has been focused to assess the resilience of agricultural system of Dhaka and recommend few possible strategies to cope with future uncertainty.

2.2. Research Question

With this aforementioned scenario, the main objective of this research is to assess resilience of agricultural system of Dhaka. The overarching question this research aims to answer is:

“How do urbanization and climate change impact the resilience of the agricultural system in relation with quantity and quality of agricultural land of Dhaka?”

2.2.1. Sub questions

To understand changes in land quantity:

- What are the impacts of urbanization and climate change on availability of agricultural land?
- What are the impacts of urbanization and climate change on occupational change?

To understand changes in land quality:

- What are the impacts of urbanization and climate change on type of crops?
- What are the impacts of urbanization and climate change on irrigation?

In the process of resilience assessment, agricultural system has been chosen as the focal system. With the external pressure of rapid urbanization and climate change, agricultural land has been identified as the main issue that will be dealt within this focal system. Considering this main issue, quality and quantity of the agricultural land would be the attribute that can be valued or known by the stakeholder. To understand how this focal system has changed over time, few key variables have been decided that can serve as indicators. To understand quantity of land, land availability and occupational changes have been identified as variable. To understand quality of land, types of crops and irrigation will be investigated. How different changes in politics, economy and other institution have affected the overall system, can be interpreted with investigation of these variables.

2.3. Intended contribution

Based on the aim of the research, this study will inform planning, and policy for urban development of future Dhaka. Within rapid urbanization and climate change context, it will
work as a guideline for future urban development with a resilient agricultural system. The gained knowledge with this study could be helpful to other cities in Bangladesh and other fast growing cities with similar context. This thesis will work as background study for planner, researcher, urban designer to find out the innovative solutions for a resilient agricultural system.

2.4. Delimitations

The scope of this research remains focused around understanding the quality and quantity of agricultural land of agricultural land. Economic activity and socio-cultural relation with agriculture has not been explored in elaborative way, rather they have been studied a part of understanding of this system.

Due to the limitation in time and resources this research only accounts for crops as product of agricultural system. Livestock, fisheries etc. have not been included in the system. The production and consumption pattern of food has not been focused much. With the advancement of innovation and technology, the production of food will change in future which has not been studied within the scope of this research.
Chapter 03: Theoretical framework

Today’s world is full of uncertainty. Various direct and indirect human led activities have made our socio ecological system vulnerable. To deal with various uncertainties, resilience thinking in urban planning has emerged and taken very seriously both in academia and practice.

Resilience theory has been originated mainly in the field of ecology, which has manifold meaning, and different fields have used it in various ways (Folke, 2006; Walker et al., 2004). In ecological resilience, human actions have been considered as an integral part of the ecosystem dynamics, which was not included in the mainstream ecology. As the social and ecological systems are very much interlinked, yet interdependent, the cross scale interplay between the social and ecological systems can make the system either vulnerable or strong. (ibid). Resilience theory can be applicable in planning practice, as this concept offers the understanding of how social and ecological sub-system work with external and internal vulnerability (Eraydin and Tasan-Kok, 2012; Shaw, 2012; Sellberg et al., 2015). The resilience perspective could also be useful to integrate various actors through adaptive management (ibid).

In planning resilience thinking can be used to evaluate the interaction among social, economic and ecological systems. It opens up opportunity for both problem-setting and problem-solving (Wilkinson, 2012). According to Wilkinson et al. (2010), resilience thinking is beneficial for the comprehensive understanding about a system. It helps to investigate the opportunity to adapt and reorganize within the system with various socio-economic and environmental crises (Folke, 2006; Walker et al., 2004).

3.1 Resilience theory

The concept of resilience recognizes the interconnection and interdependence of social and ecological systems (SES). How this system function across various scale and how the system interact with external and internal disturbances can be also understood using the theory (Walker and Salt, 2006).

Walker and Salt (2006); Folke et al. (2010) have recognized persistence, adaptability and transformability as three main aspects of socio-ecological systems. The system would be considered as persistent only when the socio-ecological system can continue its function without altering the system despite of continuous changes. If the system has capability to adjust and support the system with internal and external disturbances, then, it will be regarded as adaptability. But when a system crosses its critical threshold and enter into a new state to function, then the system will be considered as transformable. The system dynamics can be explained with adaptive cycle and ball in the basin model (Walker and Salt, 2006). Based on this idea, these modes are described below,
3.1.1. Adaptive cycle

The adaptive cycle is a very much useful model to explain how the socio-ecological system changes with various internal and external drivers and reorganizes inside the system to function accordingly (Gunderson and Holling, 2002). This model is comprised of four different phases that represent the different states of a socio-ecological system: rapid growth (r phase), conservation (k phase), release (Ω phase) and reorganization (α phase). During each phase, the interaction among internal component works differently, as a result the system function in different way (Walker and Salt, 2006) (see figure 6).

During the first phase of rapid growth resources are highly available. The components of the system are weakly interconnected that allows the system to be flexible. Actors or species within the system then get opportunity to exploit these resources. In the second phase of conservation or k-phase, Energy and materials gets stored in the system. Internal connections become less flexible and the system becomes stable. However it becomes less resilient due to less flexibility (Ibid.). In the third phase, the release or the collapse phase, the system can be destroyed or broken with disturbances and resources are released (Ibid.). It can happen very fast. This destruction opens up opportunities for new development through renewal and reorganization (Ibid). Finally, the fourth phase is the reorganization or α-phase. In this stage resources are reorganized to a new system identity with the help of experimentation and invention (Ibid).

![Figure 6: The four phases of adaptive cycle to represent the changes in the system. Source: Resilience Alliance (2010)](image)

Interaction across scale is possible to occur both in temporal and geographic scale. This interaction of cross scale dynamics is called panarchy. This interaction, delivers broad understanding of urban systems with various changes like climate change, urbanization etc. (Bures and Kanapaux, 2011).

3.1.2. Ball-in-the-basin model

Changes in social and ecological system can be explained with “ball in the basin model”, as well. According to this model systems can have multiple regimes, which are separated by thresholds (Walker and Salt, 2006). Threshold is also known as tipping point which is one of the determinants to understand the system. If the system is nearer to a threshold, it is the less resilient. When a system crosses the threshold, the system will enter into a new regime. This procedure of changing a stability domain is called a regime shift (Ibid.). How regime shift works
within a system has been represented in the following figure 7.

![Figure 7: The system changes from one regime to another while crossing threshold in ball in the basin model; source: National Assessment and Critiques of State-and-Transition Models, research gate (2015)](image)

### 3.2. Critiques of resilience theory

Resilience perspective is quite new concept in planning. In order to fully understand it and use it as a planning tool requires farther research works. Hornborg (2009) argues that this theory has supported capitalist political economy without questioning the economic system. According to discussion by Shaw (2012), resilience is a radical agenda. This is why to make a system resilient radical transformation is needed. Davoudi (2012) has also questioned about the applicability of this theory in planning practice. This concept has not addressed the power inequality in adaptive management, which plays very significant role in socio-ecological changes (Olsson et al., 2014).

To improve resilience understanding Fabiniyi et al. (2014) has emphasized on power structure that influence both spatial and temporal scale. Resilience is very much dependent on the understanding of the person who perform the action and also whose voices are recognized (ibid). So, Due to lacking in understanding power relations, use of the theory may raise critical question like “who will decide and what is desirable and for whom”. As most of the research concluded with a very positive note with this theory (Berkes and Seixas, 2005), this theory has possibility to become a buzzword in global politics. Looking into the agenda of different international development organizations of past few years, the evidence of using the term resilience as political agenda will be clear.
Chapter 04: Methodology

The primary objective of this research is to assess resilience of the agricultural system of Dhaka. Resilience wordbook for practitioners 2010 has been used as framework to perform the resilience assessment. Five major steps of the workbook have been used in this study. But the entire workbook was not followed, only the relevant questions inside each steps has been followed. Data has been collected from both primary and secondary sources. To conduct field survey for primary data collection two sites at Dhaka have been selected. They two sites are namely Bosila and Purbachol. Questionnaire survey (among local people) and expert interview have been conducted to collect primary data. Ethical issues have been considered in all seven steps (thematizing, designing, interviewing, transcribing, analyzing, verifying and reporting) as suggested by Kvale (1996) which has been described in later section.

4.1. Resilience Alliance Workbook

According to Resilience Alliance Workbook (2010) to, five steps needs to be followed to complete the assessment. They are “Describing the system”, “System dynamics”, “Cross scale interaction”, “Adaptive governance” and “Acting on the assessment”. For data and analysis for the assessment literature review, interviews, field survey and GIS analysis has been conducted. (see figure 8)

1. The first step of the assessment is “describing the system”. The system can be described with the answer of question, resilience of what, resilience to what, what is the focal, larger and smaller scale. To understand and describe the system, literature review has been used as the main method in this step. With this literature review a historical timeline has been developed and two sites have been selected.

2. “System dynamics” is the second steps of the assessment. In this steps how the social and ecological system interaction with various disturbances are investigated. From this system dynamics, the threshold and transition can be determined. It also helps to understand the different states of the system. In this study, to understand system dynamics literature review, GIS analysis, interview and field studies have been used as methods in this step.

3. The third step is “Cross scale interaction”. How the socio-ecological system interacts across larger and smaller scales is possible to understand in this step. General and specified resilience of the system can also be known from this state. To understand the resilience of the system, it is important to know this various interaction. This step has been completed with all the findings from different methods that have been used in previous steps.

4. As, governance system and social networks play important role for maintaining resilience, so for resilience assessment of a system, it must have to identify. How the social networks and the governance processes works within the system, has been discussed in the fourth steps of as “system governance” in the resilience assessment workbook. Essentials informations for this step have been gathered from local residents; experts, governmental organization and government websites for the analysis.

5. In last step “Acting on the assessment”, summarizes the analysis of the system and the suggestion
for transformation and changes are discussed. Based on the findings, different alternatives are discussed to cope the changes and to function properly. The findings from the interviews, literature review, field observations in the previous steps have been used to make suggestion for alternative strategies.

![Diagram of steps]

**Figure 8: Steps of resilience assessment workbook with methods for this research; source; resilience alliance, (2010)**

### 4.2. Site Selection

Two study area has been selected for detail analysis. The reason behind taking these two areas for detail survey are:

- Both of the area were mainly farming land for a long time.
- To see if there is any differences in govt. initiated development and unplanned development
- Both the sites are located around the city boundary.
- The GIS analysis showed both the side had transformed from agricultural to non-agricultural in recent years.

#### Bosila

Bosila is a flood plain area located (23°44'49.2"N and 90°20'59.7"E) in the western part of Dhaka on the bank of river Buriganga. Till 2010 most of the lands of the area were used for agricultural production, which would supply vegetable and other foodstuff to Dhaka. But currently most of the area has been converted as land for urban development. Mostly private individuals and private body are developing land in a much unplanned way in this area.

#### Purbachol

According to Dhaka city development authority, Purbachol has been considered as the biggest Planned township in the country which is located (23°50'38.1"N and 90°30'39.5"E) in the north-eastern side of Dhaka in between the Shitalakhya and the Balu River (RAJUK, 2016). This township is being developed by city authority with about 6150 acres of land, which was formerly used as fertile agricultural land. With this govt. development initiative, adjacent farming lands are also being continuously converted for other uses.
4.3. Literature review

To develop the project and set the research framework, literature review works as an input for ideas (Coughlan et al., 2007). This requires the study and review of an extensive amount of literature from various sources during the research process (Cronin et al., 2008). Various arguments and discussion of relevant contemporary theories can be found through literature study. It also helps to relate these with real world or with practice (ibid). To have a comprehensive understanding of the subjects, literature review is very much needed. It also helps to understand the importance of the study based on empirical data and arguments (Cronin et al., 2008).

Prior and during the project various scientific articles were reviewed. Literature related to resilience, agriculture, land use and policies related to agriculture, sustainable development and climate change impacts were studied and reviewed. At the same time literature and empirical studies on the case study area also has been investigated. Relevant literature was searched for the findings from the interviews and field studies to obtain more information. KTH library primo Academic databases and internet search engines were the major source of the literatures. Moreover, some literatures were chosen from the courses from programs Sustainable Urban Planning and Design, during 2014 - 2015 at KTH Royal Institute of Technology, Stockholm, Sweden.

4.4. Interview

For this resilience assessment interview of the local residents and experts were very significant to gather important primary data. These data contain historical information of urbanization and climate change. Information related to occupation change, agricultural land availability, types of crops provides necessary data for qualitative research for the selected study area. Semi-structured interview has been suggested by Bernard (1988) for gathering qualitative data. Both close ended and semi-structured questions were posed to the respondents. Some of the questions that were asked to the local people were different from those posed to local farmers. To investigate impact of urbanization and climate change on local inhabitants and ecosystems was the one of the objective of the interview. To understand the socio-ecological system, information related to land availability, land quality, occupational changes, types of crops and irrigation have been collected. Information about the frequency of extreme weather events like heavy rainfall, flood and draught also has been asked (see appendix 1).

Questionnaires have been prepared to assist resilience assessment following the questions in the guidelines of the Workbook for Practitioners (Resilience Alliance, 2010). Simple language and communicative questions were included in the questionnaire for local residents.

The respondents were selected from diverse groups to get different perspective on the issue. They were young to aged, male to female, different occupation and from different location of
site area. The respondents were asked first and if they granted permission, then interview was taken. Ideas from experts were integrated to formulate and pose new, more relevant questions for local residents. Conducted interviews worked as the strong foundation for further analysis of resilience.

Interview time with local residents varied from 30 minutes to 45 minutes and for experts 45 minutes to 1.30 hour. Areas chosen for interview were usually tea stall, farming land or bazaar where sitting place and diverse group was available. The interviews with local residents were mostly taken under shade of tree or tea stall to make them comfortable and sometimes inside the veranda of house to avoid the sun and heat. The meetings with the experts were held in their own offices. One interview with expert has been conducted with Skype. All of them were done according to their convenient time.

Interviews with local residents have been carried out with their native language Bengali and was later translated into English. Interviews conducted in native language made it more informative and productive. To convey the idea and collect proper information, questionnaire has been made with simple language. The total amount of interviews conducted is forty-six, twenty in Purbachol, twentyone in Bosila. Five interviews with expert have been done on urban development, climate change and agriculture of Dhaka city. Experts have been mentioned in the report by their Name.

General information about gender, age distribution, professions of the interviewee of each area are shown in table 2.

<table>
<thead>
<tr>
<th>Area</th>
<th>Bosila (total 20)</th>
<th>Purbachol (total 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Female</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Age above 30</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Age 20-30</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Farmer</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Other profession with farming experience (previously farmer)</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Other profession without farming experience</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

**4.5.Field studies**

Field studies can provide a chance to investigate real condition through observation of surrounding environment by interaction with people (Blackstone, 2014). Along with primary and secondary sources of information, field studies can strengthen understanding of real condition (UCSC, 2015). There is also risk and challenges of field studies described by Blackstone (2014), to be lost with various kinds of data that can shift the focus and loosen the depth of the study as
well. In this case study, field studies offer an overall understanding of the site. It also helped to verify the GIS analysis of agricultural land availability, which would not be possible from remote observation.

A total of six field visits took place between the first week of March and first week of April 2016. Three field studies were conducted in Bosila and three were in Purbachol, Dhaka, Bangladesh (see table 3). These amounts of visits were considered sufficient for gathering required data. Prior to the first visit, information about transport, food and other basic info were gathered from acquaintances who are more familiar with those areas. Each visit took approximately between 2 and 4 hours. The documentation was done by taking photographs, video and written notes during site visit. The collected data and information were analyzed immediately after each visit to support the upcoming interviews, and to develop the project.

Table 3: Details of field survey

<table>
<thead>
<tr>
<th>Time</th>
<th>Bosila</th>
<th>Purbachol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st visit (During Week day)</td>
<td>Field visit and interview</td>
<td>Field visit and interview</td>
</tr>
<tr>
<td>2nd visit (Weekend)</td>
<td>Interviewed people who has job other than local business</td>
<td>Interviewed people who has job other than local business</td>
</tr>
<tr>
<td>3rd visit (weekend in Bosila, weekday in Purbachol)</td>
<td>Necessary photographs and rest of the interview were taken</td>
<td>Necessary photographs and rest of the interview were taken</td>
</tr>
</tbody>
</table>

Observations during field survey opened up insights of the issue of concern and helped to dig deeper into different elements of the social-ecological system. That laid the base for understanding cross-scale interactions of the system as well. As this project is considered solely based on empirical data, site visit gives the opportunity to collect information besides the literature reviews.

4.6. Geographic Information Systems analysis (GIS)

In decision-making processes Geographic Information Systems (GIS) helps practitioners to grasp the real world with modeling, analyzing, interpreting and visualization data (ESRI, 2016). For natural resource modeling GIS is considered an extraordinary tool. To perform the analysis of land availability Google Earth images were used. To avoid geometric distortion geo-referencing was done with real world coordinates to the images. GIS and Google earth Software has been used to carry out carried out the analysis. GIS tools help to understand patterns, trends and relationships of geographic related data (ESRI, 2016).
To classify the image and find the land cover change ISO supervised image classification tool was used. Landsat satellite images of year 2006, 2010, 2014 were downloaded from the official website of US Geological Survey (USGS) (see table 4). Because the images were captured in different time periods; the atmospheric conditions were different. In addition to the satellite images, the image processing and digitizing have been carried out using Arc GIS 10.3 software to extract data of agricultural land. Google Earth software was used cross check and to verify the accuracy of the classified images at different time periods. The study area is located in the Landsat path 137 and row 44.

**Table 4: Details of land sat satellite images for GIS, (sources: USGS (2016))**

<table>
<thead>
<tr>
<th>Year</th>
<th>Date acquired (month/year)</th>
<th>Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>March, 2006</td>
<td>L7 ETM+ SLC-off (2003-present)</td>
</tr>
<tr>
<td>2010</td>
<td>March, 2010</td>
<td>L7 ETM+ SLC-off (2003-present)</td>
</tr>
<tr>
<td>2014</td>
<td>March, 2014</td>
<td>L8 OLI/TIRS</td>
</tr>
</tbody>
</table>

The downloaded satellite images of 2006, 2010 and 2014 (see map appendix 2) were classified into four land cover types, as shown in table 4 with the help of supervised classification method. Based on the reference data and other information collected from various sources the sites were developed. To develop training sites all images were analyzed with respect to their spectral and spatial profile. For digitizing, to find out similar land cover, polygons have been used around each training site. RGB = 432, color composite band was used. To identify or separate land cover type, a unique identifier was assigned.

A maximum likelihood classification method was used after completion of digitization of the training sites. With the calculation maximum likelihood classifier of each class the same attribute value has been detected. Consequently, a filtering technique was applied to generalize the classified land cover images. This post-processing operation replaced the isolated pixels to the most common neighboring class. Finally, the generalized images were reclassified to produce the final version of land cover maps for different years.

From the field observation it has been observed that the accuracy of the land cover images has been improved over time because of availability of high-resolution reference maps in recent years.
4.7. Ethical consideration

For conducting qualitative interviews, all required data that affect the research has been carefully, critically and honestly interpreted by following the steps suggested by Kvale (1996) (see table 5). The method and intention of the interview has been clearly described to the interviewee. The interviewee has been taken to a comfortable place and according to the choice of the interviewee. In case of voice recording, permission has been taken beforehand.

*Table 5: Ethical consideration in interview seven steps by Kvale (1996) that has been followed in the research*

<table>
<thead>
<tr>
<th>Steps of the interview study</th>
<th>Potential ethical issues (Kvale, 1996)</th>
<th>How these issues were assured in the present study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thematizing</td>
<td>The purpose of an interview to gain knowledge, and to work for the improvement of the study area</td>
<td>The interview study was aimed to enhance resilience with collecting data and various opinions.</td>
</tr>
<tr>
<td>Designing</td>
<td>Information about possible risks and benefits of interview</td>
<td>Each of the respondents was informed prior to each interview, about the aim and goal of the research.</td>
</tr>
<tr>
<td>Interview</td>
<td>Confidentiality of the interviewees</td>
<td>As most of the local resident prefer to be anonymous, and disagreed to put signature, so their name has not been quoted anywhere. But their voice has been recorded with permission. But only experts have agreed and so their name was used directly for reference.</td>
</tr>
<tr>
<td>Analyzing</td>
<td>Interpretation of the statement of the interviewee.</td>
<td>To avoid make the study understandable most replied statements are used for the analysis.</td>
</tr>
<tr>
<td>Verifying</td>
<td>Verification of reported knowledge</td>
<td>To verify information, few answers were cross checked with aged and knowledgeable about the place.</td>
</tr>
<tr>
<td>Reporting</td>
<td>avoiding usage of personal data in the reporting</td>
<td>Personal information will not be disclosed here</td>
</tr>
<tr>
<td>Transcription</td>
<td>Written transcription</td>
<td>Translation of questionnaire was done very carefully to avoid confusion or changes in meaning</td>
</tr>
</tbody>
</table>
Chapter 5: Result and Analysis

The analysis has been conducted by following the steps of the Resilience Alliance Framework Workbook (RAW) that has been stated in previous methodology section.

5.1. Identify Main issues

Identifying the main issues of the system is the base of the assessment. Changes in agricultural land has been identified as the issue of concern in this study to determine the impact of urbanization and climate. Changes have been investigated with Quality and quantity of on agricultural land based on identified variables.

5.1.1. Defining the focal system the boundaries

Defining the boundaries of the social-ecological system is the very first step of resilience assessment. These boundaries are consisted of both spatial and temporal boundaries. These two boundaries that are closely linked with main issues of concern, need to be identified first (Resilience Alliance, 2010).

Years, starting from 1947s to future has been decided as the temporal boundary of this assessment. In 1947 the British era stopped and Dhaka began to work as capital for East Pakistan (Mahmud and Jahangir, 2015). Future has not specified with a specific year, but as the structure plan for Dhaka for 2016-2035, and Bangladesh government has target to be a middle-income country by 2021 (MOP, 2016). This years have been be taken into account for study.

For assessment of the agricultural system, five km buffer from Dhaka metropolitan area has been considered as the spatial boundaries of the system (see figure 9 and figure 10). As, there is very little amount of agricultural land within current metropolitan area and Dhaka structure plan has been prepared for future expansion, five km buffer has provided the threshold between urban and semi urban area enabling the scope to investigate agricultural. However the interaction with adjacent area has also been taken into account for further assessment. Socio-ecological system has been defined with the interaction of social and ecological subsystem with agricultural land of Dhaka. Within the socio-ecological system, the agricultural land has both direct and indirect uses as shown in table 6.

Table 6: Direct and indirect uses of agricultural land in Dhaka

<table>
<thead>
<tr>
<th>Direct uses</th>
<th>Food supply, livelihood, job opportunity, affordable and fresh food</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect uses</td>
<td>Permeable land for water retention, clean air, open space</td>
</tr>
</tbody>
</table>

The people of the city centre depend on the resource of agricultural land both directly and indirectly which has been shown in the table. Due to economic drive and the urbanization the socio-ecological interaction with agricultural land has changed over time. Background data for Dhaka has been represented in the table 7 below.
Figure 9: Map showing location of Dhaka in the world and in Bangladesh; source: wikipedia, (2008); map open sources (2012); RAJUK ,(2010). Image edit: Farhana Rashid

Figure 10: Spatial boundary of research area with location of study site., Map source: RAJUK (2010) image edit: Farhana Rashid.
Table 7: Area population and percentage of farmer of Dhaka

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metropolitan area</td>
<td>302.92 km²</td>
<td>BBS (2011)</td>
</tr>
</tbody>
</table>
| Population              | Officially according to 2011
890 million, Unofficially 15 million | BBS (2011)      |
| Percentage of farmer    | Farmer: 11%                                | BBS (2011)      |
| (Dhaka district)        |                                            |                 |

5.1.2. Historical timeline:

Since 1947 the development trend has been studied. From 1971 after independence Dhaka, the capital of Bangladesh gained various momentum of development. But until 1988, it was very stable in terms of agricultural land transformation. Being dominated by agricultural land there was not any single town or city without vast agricultural land. Most of the urban areas were consisted of many agricultural lands (Mahmud and Jahangir, 2015). The urban and rural setting was balanced. Being the centre of economic, education and administration the characteristics of Dhaka started changing and loosing agricultural land. The area occupied by urban and industrial zone was 10.190 ha in 1976. By 2000 this has been increased into 22.795 ha (Hasan et al., 2013, p.8-9). Land conversion in Dhaka division due to urban and industrialization was higher during 2000-2010 in comparison with 1976-2000.

Based on the events from historical timeline, a clear picture of the trend could be drawn to see how the agricultural land has been converted through various development initiatives. Also the policy formulation/update has been shown. This provides a historical contextualization to the rapid changes (see figure 11, 12).

1988: Flood and Beribadh (flood protection embankment)

The city of Dhaka is surrounded by the four rivers. Buriganga to the south, Turag to the west, Tongi khal to the north, and Balu to the east (BBS, 2011). Dhaka was severely affected by the flooding during 1988. This devastating impact of 1988 flood drew attention of the policy maker for flood protection and the embankment was constructed in 1992 to protect Dhaka from further loss in future. Flood Protection Embankment along the river Buriganga was the first initiative taken by govt. to control damage in Dhaka City (Huq and Alam, 2003; Ashraf, 2012). But research has shown that this flood protection embankment, surrounding the river has accelerated the development of the adjacent area and eventually it contributed to encroachment of the river and agricultural land (ibid).

1989: Bridge on River Buriganga

The first Buriganga Bridge started functioning. This bridge development initiated the southward extension of Dhaka city. From Jatrabari towards the bridge road, Zurain and adjacent areas
started changing. As a result, the area along side the road and adjacent to agricultural land converted into urban centers for trade and commerce gradually (Banglapedia, 2016).

1990-2015: Housing development

After independence of Bangladesh in 1971, with the increase of population pressure the urban area, Dhaka started to expand from 1990. New areas were planned and developed by the RAJUK for housing supply. Most these areas were developed by conversion of agricultural land and the trend continues till date. Uttora housing development 1st phase (1990-2005), Basundhara Housing development (1993-present), Purbachol Housing development (1997-present) are some of the major developments (RAJUK, 2016). Along with this unplanned and sporadic growth happened around the planned areas altering more agricultural land.

1993: Dhaka Export processing zone (EPZ)

The country’s second export processing zone was established in 1993 near Dhaka to facilitate rapid economic growth of Bangladesh. Through industrialization (BEPZ, 2016), the government adopted an ‘Open Door Policy’ to attract foreign investment to Bangladesh. EPZ was one of the major steps to encourage industrialization in Dhaka. Garments industry also started flourishing during that time. That development created new jobs and encouraged more migration to the city. This eventually contributed in converting agricultural land to industrial, housing or other types of commercial land. With this industrialization the river water also started to become polluted and excessive use of ground water created water shortage for irrigation (Kanta et al., 2014)

1999: National agricultural Policy

This was the first comprehensive agricultural policy for Bangladesh prepared by Bangladesh the ministry of Agriculture to ensure food security (MoA, 1999). But the document focused more on millennium development goal to eradicate hunger and preservation of agricultural land became a minor issue. But agricultural land preservation in urban area was not focused at all.

2001: National land use Policy:

For the first time, preservation of agricultural land gained importance in National policy level, which was prepared by the ministry of land (MoL, 2001).To minimize loss of cropland and synchronization of land use with natural environment, land use strategies for different regions has been recommended in National land use Policy. But this policy is also more of a national level. It does say anything about preserving agricultural land in urban area.

2001-2009: Two more bridges River Buriganga

After the first one, the second one was opened in 2001 to create connection between Babubazar to Keraniganj, (IEB, 2005) and the third one from Mohammadpur to Bosilaat in 2009 (BSS, 2009). Both of them led to the destruction of agricultural land with development of the entire area on the southern side of the Buriganga from Keraniganj to Bosila and little beyond.
2004: Flood
Dhaka was again severely affected by flood of 2004. 40% of the urban area of Dhaka went under water within a very short period of time. The reason of this flooding was mostly because of poor drainage system rather than impact of climate change (Rahman, 2016). Besides, the land filling and encroachment of wetland, canal, rivers and low-lying areas were mainly responsible for that flood (ibid). It increase more land lanf filling to protect from flood and eventually loss of agricultural land (ibid).

2009: Bangladesh climate change Strategy and action plan
Bangladesh is considered one of the most climate vulnerable countries. To protect the country from the adverse effects of global warming an integrated plan has been prepared by the ministry of environment named Bangladesh climate change Strategy and action plan (MoEF, 2009). This action plan was prepared to deal with six challenges where food security is placed as the first one. This action plan has also emphasized the preservation of agricultural land to ensure food security, but not in urban level.

2013: National sustainable development Policy
To deal with environmental challenges along with economic growth The National Sustainable Development Strategy (NSDS) has been prepared by Bangladesh ministry of environment and forest (MOEF, 2013). This development policy has also highlighted agricultural land along with other development priority sector to ensure food security with increased pressure from urbanization and climate change. Like other previous policies, urban agricultural land was not highlighted.

2015: Dhaka structure plan 2016-2035
Dhaka structure plan has been prepared in 2015 by Rajdhani Unnoyon kotripokkha/Capital Development Authority (RAJUK, 2015). To evaluate the Dhaka Metropolitan Development Plan (DMDP) (1995-2015) and make proposal and strategies for future Dhaka was the main objective of this plan. One of the goals is to make Dhaka increasingly functional and productive (RAJUK, 2015). This plan, has mentioned agricultural land in the city, food production or ecological importance has not been recognized. The plan only considers industrial and service sector as sources of production.

2015: Seventh five year plan 2016-2020 (7FYP)
The seventh five year plan of Bangladesh focused on loss of agricultural land due to climate change and urbanization. The challenges regarding productivity and profitability, reduce instability and production costs, resource-use efficiency etc. has also been included (Planning Commission, 2015,p.3). But the plan has mostly encouraged techno led agricultural innovation.
2015: National agricultural extension policy draft

After the “New Agricultural extension policy 1996” there has been improvement on agricultural production and the production system (MoA, 2015). But still the issues of commercialization of agriculture for employment, sustainable technology to adopt climate change constrains was lagging behind.

Starting from the independence of Bangladesh the historical outline has been shown below in the following figure.

Figure 11: Historical timeline showing major policies and development which have impact on agricultural land (The size of the circles representing urban and rural are not visualizations of hard data. They are approximations)
5.1.3. Resilience of What?

According to Carpenter et al. (2001), to understand resilience, the study should determine “what (and/or who) should be resilient to what”. As, Dhaka is facing rapid change in land use (Dewan and Corner, 2014). The issues of loss of agricultural land in surrounding area of Dhaka due to conversion of land use has been identified as a major concern. The impact of faster economic growth and industrialization became more visible from the year 2000. The rate of urbanization was faster in Dhaka compared to other parts of Bangladesh. Being the center of all activity like economic, education, health, industry, administrative, business Dhaka attracted more people. As a result Dhaka started to lose agricultural land. To prevent the loss of agricultural land, policies for land use, agricultural extension, climate change have also emphasized this issue (MoL 2001; MoEF, 2013; MoA, 2015; RAJUK, 2015). Even the new structure plan has proposed to secure few areas for agricultural land use. Due to lack of law enforcement, policies remain on paper for most part. So, they have not been effective enough to preserve agricultural land around Dhaka. In such context, the resilience of of agricultural system due to urbanization and climate change has been identified the focus of the study.
Land development process:

The exploitation of agricultural land to non-agricultural use started with different development initiatives as illustrated in figure 11. According to the majority of the respondents due to economic profit the groups with political power force farmers or land owner to sell the land for non-agricultural use. As a result, the local inhabitants are sometimes compelled to change the occupation or have to sell their land for non-agricultural use. 35 out of 40 respondents have similar experience with occupational change. With this loss, the opportunities of growing food become almost impossible and instead of farming they have to do other works such as local business, or working in the industry. This process has been shown on figure 13, figure 14, figure 15.

Figure 13: Typical land development process how govt. or powerful people convert agricultural land

Figure 14: Typical sand filling process. sand filling in one agricultural plot split out to adjacent plot.; photograph by Farhana Rashid, 2016)

Figure 15: Typical land development process after sand filling; photograph by Farhana Rashid, 2016)
5.1.4. Main drivers of change

Resilience to what

The key driver and factor that work as a trigger for changes in this socio-ecological system is rapid urbanization. According to LSE cities research, Dhaka has positioned third in urban growth in the world, 74 person per hour just after Lagos and Delhi (The guardian, 2015) (see figure 16).

Figure 16: Dhaka is the fastest growing city in the world with 74 new inhabitants every hour; Source: UN World Urbanization Prospects 2014/LSE Cities, Image post-production by Farhana Rashid.

Due to rapid urbanization, with this increased population, various development initiatives have been taken for housing, industry and commercial use of land either by govt. authority or private organization. At the same time infrastructure like electricity, bridge road, gases etc. were needed to provide for the development area. Both infrastructure and building complex are responsible for changes in the system. Economic growth without considering the environment also plays vital role for creating pressure on agricultural land (Rahman, 2016, Siddique, 2016, Seraj, 2016; expert interview). Due to lack of proper govt. incentive and control in land price, agricultural activities are not considered as profitable as urban development. As a result price of agricultural land always goes up when there is any development initiative adjacent to agricultural land. This intension of single and short-term profit causes the irreversible conversion of agricultural land to non-agricultural use. Lack of law enforcement encourages this conversion of agricultural land for profit driven urban development. But once the conversion /development is completed, it cannot go back to previous state. In other way it increases the import of vegetables and other food from other part of Bangladesh. Consequently it impacts the affordability of food for the city dweller. So, the conversion of land looks profitable for short period, but in long term it creates negative impact on individual earning capability. According to Walker and Salt (2006) greed and overexploitation are not the only reasons for our environmental degradation. Ignorance and
misunderstanding has been considered playing dominant role in the decline of our resource. This is evident in this study which is indirectly connected with urbanization.

Though from the survey all the respondents think that there is not any direct severe impact of climate change on agricultural land (40 out of 40). But as urbanization and climate change are very much interrelated with each other, its indirect impact on agricultural land has been considered as driver of change. For example due to the industrial use of ground water, there is a shortage of supply in ground water for irrigation which is a problem caused by urbanization rather than climate change. But much more electricity is required for irrigation now that also increases the use of energy and as a consequence this energy use impacts the climate change.

In recent years Dhaka is facing higher temperature than previous years according to (BMD, 2016). This increased temperature might have negative impact on soil and crop types. However, enough research of the impact of urbanization and climate change on the soil quality has not been found. But it may change the soil composition and as a consequent type of crops (Ashraf, D., 2016; expert interview).

5.2. System Dynamics

5.2.1 Variables

How the system has changed over time can be understood with key variables. As the changes in agricultural land in terms of quality and quantity have been investigated in this research, there are two different sets of key variables in this case. Quantity of agricultural land or percentage of agricultural land and occupational changes are most important identified key variables in this research. Availability of water and types of crops has been decided as the variables to explore the quality of agricultural land (see figure 17).

Figure 17: Framework for resilience assessment that has been used in the study

Identified Factor for change: Quantity of agricultural land
Variables:
- Availability of agricultural land
- Occupational changes

**Identified Factor for change:** Quality of agricultural land

**Variables:**
- Type of crops
- Ground water for irrigation

**Availability of agricultural land**

Bangladesh is losing agricultural land almost 1% per year which is higher than before (MoA, 2015). From GIS analysis using remote sensing images it is even more clear for the case of Dhaka City. From the analysis of last 12 years it is calculated that Dhaka is losing its agricultural land more than 4% per year. From the representation of GIS analysis the percentage of agricultural land for the year 2006, 2010, 2014 were respectively 38%, 33% and 17% (see figure 18). This has been verified by the survey with local people. Majority of the respondent (38 out of 20) pointed out that there is not enough available land now. The main reason for this change is due to urbanization. No one think the climate change has impact on the availability of agricultural land. It has found from the field survey that the rate is even higher in last few years. Each and every respondent stated that due to political pressure or pressure from powerful group, the farmer or land owner were compelled to sell their land.

*Figure 18: land cover changes from 2006 to 2014 shows the significant decrease in agricultural land in Dhaka (from GIS analysis) for large view see appendix 2*
**Occupational changes:**

Land availability and occupational changes are directly interlinked with each other. According to the majority of the respondent (35 out of 40), occupational changes have been occurred due to unavailability of agricultural land. But none of them had to change their occupation due to climate change. Although there might be other reasons for occupational changes like higher education, socio economic condition and possibilities of more profitable job. Regardless of this issue from the survey findings of for occupational changes reveals that when there was enough land for farming, there were more farmers in the selected site of investigation. People have to change their occupation due to unavailability of agricultural land (see figure 19).

The survey findings also showed that many people (31 out of 40) who have changed occupation from farmer to non farmer aged above 30, are not satisfied with their job, they love to do farming even it was not profitable compared to current income. But farmer to non-farmer aged below 30 don’t want to do farming anymore.

![Figure 19: The less agricultural land there is, the less number of farmers](image)

**Type of crops:**

From the survey, changes in crop types have not been found due to the impact of climate change. Almost every respondent agreed (39 out of 40) that the crops types changes with the quality of arable land due to urbanization only. According to the respondents experience, food grain, vegetables and fruits were available in uninterrupted agricultural land. Due to loss of land quality, the temporary sand filled area or temporarily available agricultural land can grow only vegetables and fruits for time being. After of development, the land barely grow any crops, only few vegetables and they are not even enough for household need. This changes has been shown below in figure 20.

![Figure 20: The less agricultural land there is, the less diverse the agricultural production in terms of crop types](image)
Ground water for irrigation:

Quality of agricultural system has been also investigated with availability of water for irrigation. Majority (35 out of 40 person) thought that water was available previously. The rest of the respondent could not answer this question because of not involving with farming. But ground water table is decreasing in Dhaka in recent years due to sand filling and adjacent industrial use. Though the ground water is condition is also both directly and indirectly affected with climate change and urbanization. But as, Dhaka does not fall under draught prone area in Bangladesh, or there is not enough evidence of draught in Dhaka (BMD, 2016). It can be assumed that urbanization is mostly responsible.

5.2.2. The adaptive cycle

Socio-ecological systems usually experience four distinct phases of change over time. They are, rapid growth (r), conservation (k), release (Ω), and reorganization (α) (Gunderson & Holling, 2002; Folke, 2006 and Davoudi, 2012). Along with the changes over time, this model also help to find out the critical threshold of change This is why to ensure resilience of the system, the understanding of different phases of the cycle is required (Resilience Alliance, 2010). By applying adaptive cycle, changes in agricultural land have been represented with different phase (see figure 20).

Phase of rapid growth (1947-1970):

The rapid growth phase prolonged until the independence of Bangladesh. During this period Dhaka was the capital of East Pakistan. Economic activities were lower and that didn’t hamper the rural setting of the capital. There was abundance of agricultural land in this area. So, with population growth the agricultural system was also growing. There were enough agricultural and agriculture was the main activity during this phase. At the same time number of farmers were very high. Agricultural land use was the main characteristics of the case study areas. These areas were able to provide different types of crops to the local people and also supplied to the city. It has been represented as growth phase.

If we try to connect the ball in the basin model with it, this phase, can be depicted as agriculturally dominated era. Both socio-ecological system were dependent on agricultural system.


Second phase is the conservation phase. In this phase economic growth is faster than before and activities related to urbanization started. Economic profit is the main drive almost in every sector. During this time various planning proposals had been declared in this newly independent country. With all these activities agricultural land started shrinking. But still it was able to grow and provide food to the local residents and the city dwellers. Few real estate agency or individual body or collective organization had started to buy the agricultural land for development. As first step to develop land, sand filling did not start until the end of this phase. Local inhabitant and farmers remain in their own place and continue farming. Changes in occupation from farmer to
non-farmer were not very common. With all these activities, still there were enough agricultural land to support the area and also the city. Dominance of agricultural land were visible in this phase as well. But urbanization was not considered as a problem in this phase and policies to preserve agricultural land was not found.

This phase remain mostly in one state which is agriculturally dominated area. But with increasing urbanization, agricultural land began to change. As, policy or any measurement didn’t consider it as a problem; soon it started loosing dominancy in agriculture. At the end of this era he system became unable to resist that shock. This state might be reversible to its previous state through proper initiative.

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\text{Figure 21: The adaptive cycle showing changes with its four phases in agricultural system of Dhaka}
\]

\[
\text{Figure 22: The regime shift and different state in the ball in the basin model of agricultural system of Dhaka}
\]
**Collapse/ release phase (1992-2016):**

Third phase, (1992-2016), agricultural land started to decrease is at faster rate than previous record. Agricultural land has become unable to grow for all kind crops (See figure20). In this phase sand filling is one of the main activities for land conversion. Due to sand filling the land lost quality to grow food grain, but still they are able to grow few vegetables, but obviously in reduced amount. As the interconnections of the system were destroyed, the resources were released, e.g. farmer had to change occupation from farming to non-farming. Only very few vegetables are grown. But it cannot fulfill the household demand. Food needs to be imported from other part of Bangladesh and sometimes from outside country. Currently the system is in this phase. Lack of law enforcement, more and more road infrastructure project, centralized capital oriented development activity, population migration, demand for housing all are liable to the system’s collapse. All these activities altered the system organization. This is a more chaotic phase. The harmony of rural and urban proportion has been destroyed.

This phase remains in two different state. One is Temporarily available agricultural land and the other one is barely available agricultural land state. This state is irreversible. That means it is impossible to return back to agricultural land from this urban land use. Profit driven economic activity and lack of policy implementation is the main threshold to consider.

**The last phase is the reorganization phase (future)**

Which come after the collapse, has not occurred yet in the system, This phase will open up opportunity for renewal and transformation of the system. It can either preserve agricultural land or not. As Dhaka is still growing and there is still agricultural land in outskirts of the city, so with proper decision, strict law enforcement, public awareness which is most about the good governance can help to reorganize the system into its desirable state and preserve agricultural land properly. But if there is a repetition of same previous rapid urban activity then this agricultural land will not be found in the demarcated zone in the recently proposed Dhaka Structure plan. Consequently, there will be less supply of affordable and fresh food for Dhaka city dweller. Along with the law enforcement for preservation of agricultural land, other innovative measures and incentives for farming, the system can enter into a new state to maintain the socio-ecological system.

5.3. Cross scale Interactions:

5.3.1. Panarchy:

Resilience of social-ecological system is interconnected with both larger-scale systems and with the smaller-scale systems. To describe the interaction across different scales with adaptive model, the term ‘panarchy’ is used. It is also one of the important components of both larger and smaller scale that facilitates the focal system recover after disturbances. Therefore, it is important to explore the dynamics of both larger and smaller scale to find out the critical cross-scale interactions with the system that are related with the main issues (Resilience Alliance, 2010).
The most relevant larger scale systems that needs to be considered is the agricultural system or food security of Bangladesh, as well as the global scale, i.e. specially the other countries from where Bangladesh import food stuff and oil and energy., global economic systems and global climate change issues are also linked with it .The focal system is blended with this larger scale system. Therefore the interaction with larger scale can affect directly the focal system or vice versa. For example, high oil price or energy price, both nationally and internationally, will have impact on the affordability of food for the city dwellers, as Dhaka need to import food from outside Dhaka(see figure 22). Particularly this will affect negatively the urban poor of the city. At the same time as the agricultural lands are altered due to industrial use. Due to excessive use of ground water the industries adjacent to Dhaka metropolitan area will create pressure on the water for irrigation for cropping in Dhaka. That will also impact the affordability of food.

Due to pressure from local political body or other power groups, the local residents of a specific area have to move to another place in order to sustain their lives. However, the alteration of some specific area in smaller scale sometimes meets the demand of housing and other facilities in larger scale. It helps to reduce housing shortage of the city. With the impact of sea level rise, Bangladesh will lose its agricultural land mostly in southern part (Rahman, 2016; Seraj, 2016). That will create shortage of food in national level. So there will be need for importing more food from the adjacent country. At the same time there will be increased pressure for climate refugee. The costal people will move to Dhaka or other cities for job and livelihood. Farmers will be compelled to change their occupation. Land alteration in one place will reduce the permeable land for water retention for the whole city. As the drainage system is not good in Dhaka, this change will increase the flooding during monsoon. As Dhaka has very little open space compared to its population and area, the surrounding agricultural land help to reduce heat island effect for the city. But landfill and land alteration will increase the heat island effect. The temperature for the city will be even higher than before. It will increase the energy use for the city dweller for air cooler. At the same time due to this increased temperature there will be more disease for both human and crops. More pesticides will be needed to grow more food with smaller portion of land. There will be more possibility to contamination ground water and river water from the storm water.
5.3.2 Different state

Throughout the adaptive cycle few alternative states that have been found with interview, field study and literature review are discussed below,

**Agriculturally dominated:**

This state has been predominant until 1990. Dhaka was considered as the combination of village and town. Before the economic booming in the city or in Bangladesh, with rapid development there were still enough agricultural land to support the city. The city was able to supply its demand mostly from the adjacent village or agricultural land.

**Temporarily available agricultural land:**

During this state the agricultural land are filled with sand and being prepared for future development. Sometimes it happened just within one night to force people who do not want land conversion. Lack of law enforcement and power play is the most important role for shifting regimes here. Then it loses its capacity to grow and function as agricultural land. But still some vegetables are grown before the completion of development work.

**Barely agricultural land:**

Dhaka is currently in this phase. Economic boom, lack of consciousness for environment and unwise political decision are liable for this state. Non agricultural use of agricultural land is
increasing every day. This non-agricultural use includes housing for city people, industry and other commercial and mixed use. In terms economic perspective, people find it most profitable state. As a result city is gradually going to be dependent on food for distant places.

**Desirable state:**

Balance between urban and rural state is the desire state for sustainable development. Food will be grown close to city and will be consumed by the city. It will reduce the energy use for travel. At the same time this state will provide affordable and refresh food to the city dweller (see figure 23).

**Non Desirable state:**

Considering greater well being and healthy living for the city dweller, Barely available agricultural land are not desirable at all. The city should provide the city people with affordable safe and fresh food to the city dweller in spite of their income group. As this state are unable to meet this demand, it can be labeled as undesirable state (see figure 24).

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![Diagram](image)

**Figure 24:** Desirable state with available agricultural land in the city  
**Figure 25:** Undesirable state without agricultural land in the city

### 5.3.3 General and specified resilience

Both general and specified resilience need to take into consideration for assessing and managing resilience of the system. General resilience does not focus on particular type of disturbances where as , specific resilience looks into specific disturbances that affect the system. (Resilience Alliance, 2010). Only looking into specific disturbances may not bring resilience for the over all system. Same way, concern for general disturbances might not bring resilience to the system. In case of Agricultural system of Dhaka,
Diversity

The variability in the component is referred as diversity is the variety of components in a system. Diversity was found in the growth phase, with seasonal changes or flooding. When low lying agricultural land went under water, paddy were grown there, even they were used as temporary fishing spot. But now the system is not diverse at all which means the system don’t have the capacity to face the disturbances and function as agricultural land.

Tightness of feedbacks

According to Walker and Salt, (2006). Tightness of feedbacks is the response of a part of the system with changes that occurred in other part of the system. Social network and governance system can control these responses. In case of Dhaka, policy guidelines are prepared in national level in response to shrinkage of agricultural land, but due to lack of development control at local level, the desired goal of those policies are not assured. At the same time, in response to change in agricultural land use, people have to shift their occupation from farmer to non farmer. From this perspective, this system doesn’t have ability to respond properly.

Openness

The system is widely open towards any kind of economic and development activity. Agricultural land can be easily bought or developed for any kind development purpose like housing, commercial use or industry. From this study, it is clear that the system has a high degree of openness for urbanization and less degree for climate change.

Modularity

Modularity refers linkage of various components in the system. If the system is more vulnerable to disturbances if the components are highly connected. (Walker and Salt, 2006; Resilience Alliance, 2010). Studying the agricultural system of Dhaka, the firm connection between various component have been found. Which refers that the system has low resilience. For example farmers are highly dependent on this natural resource for livelihood. Due to the agricultural land conversion they are highly affected. Even the low lying agricultural land work as a water retention ground for the city. When they are filled with sand, the city people become more vulnerable to flood.

5.4. System Governance

5.4.1. Adaptive Governance & Institutions and Stakeholders:

According to Davoudi (2012), social and political dynamics cannot be ignored within social-ecological systems. Power structures influence the system across various spatial and temporal scales (Fabinyi et al., 2014; Olsson, 2014). Policies and planning for agricultural land use issues are dealt within the jurisdiction of various government ministries and agencies for example; planning commission, Ministry of land, Ministry of agriculture, ministry of environment, ministry
of housing and public works, ministry of the Local government and rural development cooperatives. Most of the government ministries lack adequate resources and coordination among the ministries (Mandal, 2006). At the same time for development and planning of Dhaka, Rajdhani Unnoyon Kotripokho (RAJUK) and Dhaka city corporation (North and south) are also responsible. The three main responsibility of Rajuk is Planning, development and development control.

**Policies and institution (National level)**

Most of the policies dated from 1993-2014 are largely consistent with the MDGs (Mandal, 2006), now they are following Sustainable Development Goal SDG. To reduce the loss of agricultural land some of the policies have been formulated since 2001. But they are mostly for national level

In 1999, Ministry of Agriculture (MoA), which is in charge for the crop sub sector, prepared the National Agriculture Policy (NAP) statement. After the country’s independence in 1971 it was the first comprehensive document prepared by the Ministry (MoA, 1999).

In 2003 the MoA prepared the Plan of Action (PoA) on NAP with the objective to review the status of implementation of NAP. For implementing NAP, for strengthening partnership PoA has identified six groups of stakeholders which are, i) government, ii) farmers, iii) commercial private sector, iv) NGOs, v) farm organizations, vi) other civil society organizations and private sector, and cooperatives and local government which leads six key areas of intervention. To protect losing agricultural lands to different non-agricultural uses it has suggested getting unused lands back to production (Mandal, 2006).

After the land use policy guideline by MoA in 1999 as NAP, the Ministry of Land (MoL) prepared the National Land Use Policy (NLUP) in 2001 addressing the same issues as in the Action Policy Brief APB. APB identified the problems of implementing land policy, which is because of the fact that land administration falls into the domains of many ministries. The National Land Use Policy (NLUP) was prepared to fill up this important policy gap in the country. The NLUP deals with land uses for several areas including agriculture (crop production, fishery and livestock), housing, forestry, industrialization, railways and roads, tea and rubber.

The NLUP identifies land use constraints in all these sectors. Declining land productivity due to unplanned and improper uses of land and decreasing soil fertility has been stated as some of the major ones. Inter-ministerial coordination has been identified key over the use of land resources since land issues fall in the domain of many ministries (Mandal, 2006, p.22).

After the “New Agricultural extension policy 1996” there have been improvements on agricultural production and the production system. But still the issues of commercialization of agriculture for employment, sustainable technology to adopt climate change constrains was lagging behind. The Draft Agricultural extension policy of 2015 suggests incorporating issues of institutional coordination, salinity, capacity improvement and sustainable technology for farmers against natural disasters. For sustainability of agriculture in the disaster affected areas it proposes to provide disaster resilient crop research and distribution. In the areas with more poor people
more support recommended in terms of agricultural products and knowledge sharing.

Along with these policies, National Sustainable development goal, national climate strategy and action plan have also emphasized on preservation of agricultural land.

**Policies and institution (Local level)**
Most of the policies related to agricultural land preservation are for national level. Dhaka structure plan (2016-2035) is the only local level policy guideline that mention about preservation of agricultural land to guide future development. But this planning guideline doesn’t provide strategy how to preserve this land, rather it emphasize on profit driven industrialization.

### 5.4.2. Planning, Development and monitoring:

In order to control development and to guide future development, Dhaka structure plan (2016-2035) has been prepared by RAJUK (2015) in which agricultural land has been identified as one of the key resources. RAJUK is responsible for development and development control of Dhaka metropolitan area. To develop a land certificate for land use permit, building development permit and other certificate are required. In spite of all these law and policies, RAJUK has completely failed to control development (Mahmud, 2016). Moreover, due to lack of law enforcement all those certificates are given to the land developer without proper investigation.

Land is a major concern for both farming and urban development. Either by private or govt. initiatives, lands are developed and sold as plots for urban uses. Community based organization for farming has not been found but there are examples where community based organization were (cooperatives) have formed to convert agricultural land into urban land. Using political and economic power the profit makers forced people to join these kinds of cooperatives. Also there are no regulation and control over land price. So, agricultural land are the main target for the land buyer and real estate developer. According to the experience of most respondents political leaders own the real estate business, so if they break any land development rule, they never get punished. The voices of the farmer or poor land owner are never heard in decision making. Due to this development practice the adaptive policies does not have any impact on controlling loss of agricultural land at all.

### 5.5. Acting on the assessment

**5.5.1. Developing new strategies for Dhaka**

The resilience assessment helps to know the interactions among different elements of the system and also gives idea about the interconnectedness across various scales from focal to larger scale. It also explains how this system works with external and internal disturbances. In developing resilience strategies this understanding is essential. Thus, depending on state in the adaptive cycle, the strategies should reflect those interconnections of this complex socio-ecological system and when to take these measures. Moreover, the strategies should also be able to cope with future uncertainty.

Bangladesh govt. has set the economic target to be a middle income country by 2021 (Planning
Commission, 2016), so the resilience will depend on the tradeoff between economic growth and environmental concern. The resilience strategies should be coherent with development targets rather than conflicting to deal with future disturbances. As currently the system is in collapse in the adaptive cycle, there is still opportunity to work on both conservation and reorganization phase through proper strategy. Thus both the direct and indirect impact of economic profit driven urbanization, industrialization and climate change can be dealt with. These strategies aim at reducing the disturbances that are manageable and help decreasing the vulnerability. These strategies will be helpful not only for continuing the provision of ecosystem services from agricultural land, it will also create more jobs and recreational places for the city people as well.

The resilience strategies for restoration phase can be done in two different ways. Therefore, two alternative strategies has been proposed based on the analysis. They are

1. Without major administrative reorganization

2. Decentralizing the administrative and economic system

Since administrative reorganization is a complex and long term process the first strategy can also work as initial phase or short term strategy as adaptive sollution. The second strategy might come as long term strategy. Nevertheless whether to use either strategies or chose one over other requires deeper research on administ

Without administrative reorganization

Considering the economic growth and based on projected population migration to Dhaka, land ownership issue, Govt. may acquire agricultural land (see figure 25). Either any govt. or private body can take the responsibility of farming. It can also be leased to some other agencies for farming. As it is very hard to make profit by farming compared to urban land use, govt. should introduce incentive for farming. More research is required for profitable farming. At the same time the unused small open space can be converted into urban agricultural land. Public awareness can also play important role in this case. Involving social media, television and printing material will be helpful. This can be done with collaboration with various N.G.O and research organization. To ensure affordable and refresh food, this strategies should be equally prioritized.
Decentralizing the administrative and economic system

To work on reorganization phase, the strategies are basically focused on reorganizing the administrative system. As currently all kind of activity like, administrative, industry, higher educational facility, health care, job opportunity everything are concentrated around Dhaka. Decentralization of Dhaka and strengthening and empowering of other small town can help to divert population flow which can help to reduce the land pressure on Dhaka. Moreover, the other cities are following the development trend of Dhaka. So if economic growth continues and people started to living in urban area, it is assumed that other cities can be as bad as Dhaka. This strategy is possible to implement with public private collaboration. Figure 26 shows how this alternative works.

Figure 26: Strategies without administrative reformation to preserve agricultural land in Dhaka

Figure 27: Strategies with administrative reformation and strengthening small town to preserve agricultural land
Other general strategies

To restore the system beside this two main strategies along with strong political will few other general strategies will be required to activate both the strategies.

a. **Proper Impact assessment before any kind of development:**
The strategies and policies are only on paper. The impacts are not often analyzed properly before the development. So, before any kind of development initiative there should be proper impact analysis and follow up of the development. Specially for development of new project like Construction of the bridges, highway, residential area, shops, industry or just basic infrastructure facility like drainage, gas, electricity that turn an agricultural area the area into an urbanized one.

b. **Enabling incentive:**
Without proper enforcement and incentive, it will be even harder in future to preserve land. There is not enough regulation to control the land price. Incentive can encourage people to prevent loss of agricultural land. Incentive like loan with low interest for farming or reduced income tax for preserving agricultural land should be introduced. The owner with agricultural land can get other facilities like health, educational or housing facilities at reduced price from govt.

c. **Reducing power gap:**
There is a huge power gap between land owner and land developer. Due to political and economic power the voice of the farmer or the land owner are not often heard in decision making. To stop this land conversion, it is very much desired to reduce this power inequality.

d. **Finding root cause problem:**
Only making the policies and strategies for preservation of agricultural land without considering the economic pressure might not be effective. In current practice there is a practice to deal with symptoms. But there should be detail investigation about root cause investigation about the situation. Environmental awareness is also essential.

e. **Planning implementation and monitoring:**
There should be strict planning enforcement. To monitor slow-changing variables and other key parameters of the system, regular follow-up of the strategies are also important.

f. **Strengthen rural and semi rural:**
Infrastructure and urban facilities are the main determinant for land price in most of the places in Bangladesh. Without strengthening rural and semi rural area, population migration from rural area is not possible to reduce.

g. **Wet land preservation:**
To deal with water crisis for irrigation and to keep the cost lower for irrigation, wetlands that are the source of surface water must have to be preserved. During dry season this wet land can be cultivated for a short period of time as well.
h. **Agricultural innovation**
Bangladesh has progressed a lot with various agricultural innovations for high yielding and various disaster tolerant crops. Along with further technical innovations, innovative ideas like farming in small paces, rooftop gardening, farming along with street, other ideas could be introduced.

i. **Public participation:**
As most of the lands are privately owned, so without public participation, agricultural land preservation will not be possible at all. Before any development decision, local people should be included in the decision process.
Chapter 6: Concluding Discussion

Findings

With the main research question “How do urbanization and climate change impact the resilience of the agricultural system in relation with quantity and quality of agricultural land of Dhaka?”, the following results have been found.

Based on the analysis of the survey, it has been found that the system has little diversity. According to the tightness of the feedback, it cannot respond properly with disturbances. The system is also too much open for economic development and very connected with the other component of the system. The investigation have found that there is still scope for resilient agricultural system for Dhaka metropolitan development area, only if resilience thinking is realized into planning and development practice. In order to enhance the system’s resilience, resilience increasing diversity has been recommended by Marcus and Colding (2014). Strategies for both spatial diversity and institutional diversity for Dhaka city have been proposed by this research.

Prior to the field study the main aim was to look into how agricultural system of Dhaka changes within the socio-ecological system. But after analyzing the field study and interviews, it became clear that, for Dhaka climate change does not have any direct impact. As, urbanization has its implication on climate change (Satterthwaite, 2009), so the agricultural system will be affected with climate change in an indirect way. From the study this indirect impact is evident in case of irrigation. Due to geographic location Dhaka is not a draught prone area. But the groundwater table is decreasing as a consequence of urbanization. So, irrigation problem has been understood here as a consequence of urbanization rather than direct impact of climate change.

From the GIS analysis on land cover change in Dhaka metropolitan area with five km extended buffer have been found that 38%, 33% and 17% respectively for year 2014, 2010, 2006. From which it can be said that from 2006-2010, Agricultural land has been decreased 1.25% rate per year. That is slightly higher than the percentage of land decrease in national level (1% per year) (BBS, 2011). But from 2010-2014 the rate is 4% per year. This statistics gives the idea of rapid conversion of Agricultural land in recent years. Both from the literature review and interview, urbanization has been understood as the main disturbances for this change.

According to the majority (35 out of 40) of the respondents, with the changes and decrease in agricultural land, due to unavailability of land, farmers had to change their occupation. At the same time, due to unavailability of land and due to sand filling, both variation and amount in crops have also declined in comparison to previous years. Ground water level has decreased over time as well. For all these variables, urbanization is the key reason of changes.

From the policy analysis, it has been found that agricultural land preservation has been prioritized in national level policy discourses in Bangladesh, but there are not sufficient policies for urban area. For example, national agricultural policy (1999), national land use policy (2001), climate change strategy and action plan (2009), national sustainable development strategy (2013), seventh five year plan (2016-2021) etc. has not emphasized the importance of preservation
agricultural land in urban development sector. Rather cities are planned for service oriented and industrial development (RAJUK, 2015).

Key findings can be summed up in following way,

- From the analysis it has been found that the resilience of agricultural system of Dhaka is very low and right now which is in the collapse or release phase. But there is still scope to make the system resilient.
- Climate change has indirect impact on agricultural system.
- The impact of urbanization has been found on each of the variables (land availability, occupational change, types of crops and groundwater). So urbanization is the main disturbances to the agricultural system of Dhaka.
- Agricultural land within the spatial boundary has been decreased 1.25% rate per year from 2006-2010. But the rate is 4% per year from 2010-2014
- The farmers have to change their occupation due to unavailability of agricultural land.
- National policies have addressed the issue agricultural land preservation, but they lack sufficient policies for urban areas.

Relevance of the study with other area

The development trend of the case study area is quite similar with other areas of Dhaka development planning area. Even this trend is followed in other growing town and cities in Bangladesh as well. But as the urbanization rate is slower in other town or cities, based on the time perspective, those areas will have much more possibilities to adaptation or reorganization of the system. It will be easier to preserve agricultural land in those areas with proper planning and monitoring. However in terms climate change impact, due to the variation of geographic location, the result for other areas of Bangladesh may vary from Dhaka. For example, the town and cities in southern part of Bangladesh (area close to Bay of Bengal) will be directly affected by sea level rise (Rahman, 2016; expert interview), which will have impact on agricultural land as well. Thus the level of resilience would be different.

Reflection on resilience assessment workbook

The main aim of this study is to understand, the socio-ecological dynamics of the systems that has been investigated in this research. In order to have a holistic idea, agricultural system of Dhaka has been decided as focal system with its identified temporal and spatial boundary. Then within this focal system, agricultural land has been identified the main issue of concern. Main investigation was done based on the impact of urbanization and climate change on agricultural land. The attribute and variables for the study has been done based on this issue of concern. Other relevant issue related to agricultural system for example food system, demand and supply of food, economic activity etc. has been considered to understand the main issue of agricultural land. Since the wordbook is prepared for multidisciplinary research and application, for which different study with different field might face different complexity at different steps. For this research it was hard to follow the entire workbook and to answer each question of the workbook of resilience assessment. The questions given in identifying main issue in workbook, were good to explore the existing condition. At first it was a bit ambiguous to define the boundary of focal system. Throughout the study the main concern was about the agricultural land. So, main
dilemma was to decide which one would be more appropriate as focal system, “agricultural land” or “agricultural system”. But at the same time, these questions do not guide the research how to trade off different emerging issues like focal system or main issues.

The temporal boundary for this research started from 1947. Again it was tricky to fix the end date of the temporal boundary of the system. But the limit for temporal boundary does not have a fixed date rather than open, it has been decided just as future. Minor change in time frame may result in different way in adaptive cycle. According to resilience assessment workbook (2010), it has been mentioned that the whole assessment process is iterative. This statement has been found true for different steps of the workbook. With several back and forth, it seems more logical to keep the time limit open. So, with the changes in setting the temporal boundary, there might be different results. With this investigation, one more question raised for performing adaptive cycle would be, if the system could not be represented with four distinguished phase yet, then how to draw the results from the assessment. For example, at first the starting point of the temporal boundary has been decided the independence year 1971. With this time frame the agricultural system had only two phases (conservation and collapse phase). In which the growth phase in the system was missing. In case of this research there was scope to revise the temporal boundary. Which gives an idea that the both temporal and spatial boundary should be flexible to conduct the assessment.

But if there is a given time frame for any specific system, then how to decide the result was not clear at all. From that perspective the applicability of adaptive cycle in the assessment process is questionable. The workbook has not mentioned this kind of issue. It also seems more applicable for biological changes like forest. But it is hard to represent social changes.

Moreover, along with the limit of temporal issue, other questions that have raised for performing adaptive cycle is how to define different phases in the adaptive cycle. As urbanization as a disturbances in broader perspective is a continuous process, it was difficult to draw hard line especially between different phases. For example, in this study conservation and growth phase had been difficult distinguish. From the interview it has been found that, in most cases the change is very fast. The changes in agricultural land to sand filled land sometimes happens just overnight. Other challenge was to determine the regime shift. According to Olsson et al. (2014) there is not any specific technique to distinguish regime shift. Sellberg et al. (2015) has suggested to experiment and research for identification thresholds. According to Walker and Salt (2006), it is difficult to understand the shifting unless it crosses the threshold. But if the threshold cannot be identified beforehand, then it will not be possible to make the system persistent. Regardless of the focal area, to identify the threshold, there isn’t any other way than to experiment more on that issue.

Resilience has wide range of meaning. Resilience has become a political term and used in different global and national agenda. Specially, in UN sustainable development goal among 17 goal, the word “resilient” has been used twice in two different goal (UN, 2016). Most of the studies related to resiliency for Dhaka or for Bangladesh have understood resilience just as a system to manage disaster. Issue of resilience has been brought up as technique to adapt the
system after the shock or the disaster (CCC, 2008; RAJUK, 2015; UDD, 2014; LGD, 2011; The World Bank, 2014).

Regardless of all these above discussed issues, resilience assessment workbook is helpful in some way for a wide and long term perspective. It provides a holistic idea of the system. But to perform assessment specially for planning various adjustments in the process is needed. It Which also gives idea that lot more research is required to use it in planning.

**Reflection on methods**

This research has been done mostly in a qualitative way using data from field survey; questioner survey, expert opinion and analysis of land cover change using GIS. However, it is possible to do it in a quantitative way as well by using detail measurements of various aspects.

Using resilience assessment method this research considers future changes within the research framework. But still combined use future studies and resilience assessment could be another alternative way explore this investigation. Future studies would be helpful to explore the future and also gives idea what the future will look like (Borjesson et al, 2005). Using different scenario technique of future studies, it would be possible to project what is going to happen in future with urbanization and climate change impact on agricultural land of Dhaka. As, there were difficulties to set the time limit in this study; using future studies method along with resilience assessment might be beneficial in this case. At the same time it will be helpful for more realistic strategic recommendations for future development.

As, this research has been done using qualitative survey and interview, it could not unfold the exact future impact of climate change on agricultural land using numbers. To verify the climate change impact on agricultural land, impact analysis for climate change may be carried out in future studies. If impact analysis of climate change is done using different methods it might bring different result than this research.

**Recommendation**

The investigation suggest that there is still scope for resilient agricultural system for Dhaka metropolitan development area, only if resilience thinking is realized into planning and development practice. In order to enhance the system’s resilience, resilience increasing diversity has been recommended by Marcus and Colding (2014). In this study, strategies for both spatial diversity and institutional diversity has been proposed.

To deal with uncertainty both technological and social innovations are usually decided by top down approaches. Without much knowledge about the local context these innovations does not have positive impact on the system (Olsson et al., 2014). Research for inclusive innovation has been suggested that will include diverse stakeholder. In case of Dhaka, it has been obvious that there is no or limited involvement of stakeholders during the formulation of policy. As current top down decision-making approach is not able to facilitate building resilience of agricultural system of Dhaka, farmers, real estate business, researchers, land developer, local residents, policy makers etc. should be included in the process.
Beatley and Newman (2013) have emphasized on importance for preservation of urban and peri-
urban agriculture to make cities sustainable and resilient. Other than providing food to the city
dwellers, it will keep the food price affordable and will help to bridge between city dweller and
the nature. Agricultural land preservation has been prioritized in policy discourses in Bangladesh.
But importance of agricultural land has not been emphasized in urban development sector.
Rather cities are planned for service oriented and industrial development (RAJUK, 2015;
UDD, 2014). Local food production issue should be prioritized in the policy and planning.

Fabinyi et al. (2014) have recognized the critical understanding of power in socio-ecological
system. As power relation determines whose voice will be heard and whose will be silenced,
resilience will very much depend on the understanding of power relation in a system (Fabinyi et
al., 2014). As majority of the respondent in this study had experienced political pressure to sell
land, it can be said that there is an unequal power structure in agricultural system. This power
issue should be handled very carefully. As land use is very complex issue, by promoting
collaborative decision-making approach, the current power inequality can be disseminated. To
discuss about power issue Campbell and Fainstein (1996) has stated that Political power plays
most important role to shape planning and decision-making. This is also true in case of
Bangladesh. The voice of planner and other development professionals often are not heard,
rather political agendas are given priority in politics and decision making. The success of
alternative strategies suggested in this paper will mostly depend on political will and decision
making. So, planner, architect and other urban development professionals should be
empowered.

To enhance resilience investigation, on institutional strategies has been encouraged by Marcus
and Colding (2014). From the assessment profit driven urban development has been identified as
the main driver of change. This impact has been amplified due to lack of law enforcement and
development control. RAJUK has completely failed to control development (Mahmud, 2016).
Mahmud and Jahangir (2015) have recommended introducing urban local government as an
institutional change to solve this, which would be helpful for ensuring resilience of the system.

Resilience could be perceived in different ways. As resilience has gained political attention and
has become a buzz word in various agendas. Studying the agricultural land and urban
development related policies in Bangladesh, (CCC, 2008; RAJUK, 2015; UDD, 2014; LGD,
2011), reviles that resilience has been just understood as a tool to manage the post disaster
situations. With this partial understanding, the benefit of resilience thinking might not be
successful. Brand and Jax (2007) also have argued to understand resilience as a thinking or
perspective. To deal with various uncertainty for Dhaka city, resilience thinking in planning
would be helpful in long term development practice.

Though Govt. has prepared few policies for environmental protection, but still it’s the profit
driven economic growth has been prioritized in every sector. But without environmental
concern, ensuring resilience will be almost impossible for any development practice. This
conflict between economic development and environmental preservation is very common in
development practice. This conflicting rationalities among economic growth and environment
issue has been discussed by Campbell (1996). To deal with this conflict, collaboration between
public private partnerships has been suggested as a solution (ibid). Keeping this issue in mind,
for a resilient agricultural system, relying on only govt. authority will not be feasible at all. Public-private partnerships should be promoted in planning practice.

To ensure food security Beatley and Newman (2013) has emphasized the importance for preservation of urban and peri-urban agriculture to make cities sustainable and resilient. Other than providing food to the city dwellers, it will keep the food price affordable and will help to bridge between city dweller and the nature. They have also suggested few options like rooftop garden, garden at left over and unused space along with agricultural land within and periphery of the city that can grow food. By providing affordable food during natural disaster or high oil price that affect the supply and price will enhance urban resilience. In case of Dhaka, these possibility of these different form of farming along with preservation of agricultural land could be practiced. Architect, urban designer, planner, city official and city dweller should work together to find out different innovative solutions for Dhaka. At the same time more research on building typology would be beneficial to make efficient land use with the growing demand of land for housing, industry, or other commercial use.

From the literature review of different policies related to land and agriculture, lack of reliable data has been identified as one of the main issue that affects analysis. Even, before the policy recommendations adequate researches are not completed. So, to make agricultural system resilient there is no other way than to do more research before finalizing policies. Without proper background work, these policies will not be effective and goals of those policies will not be possible to achieve.

It’s also very much important to analysis the impact before any kind of development initiatives. The impact on environment, economy and also on social life should be investigated prior to any development project. During the impact analysis both long term and short term impact should be investigated.

Chelleri and Olazabal (2012) have discussed about the trade of among different important issue to ensure urban resilience, for example the trade off between climate issue and economic crisis. Being a developing country it is much more complicated to trade off between economic gain and environmental benefit for Bangladesh. But without focusing only on economic benefit government should also take initiative to incorporate environmental benefits through research and policy.

Key recommendation

• Cities should be understood not only for service and industry. Importance of agricultural, nature, rural life should be focused with equal importance in policy discourse and should be reflected in decision making.

• Adequate research and background work should be done before any kind of policy recommendation.

• Prior to Any kind of development initiative, impact analysis should be carried out.
• Public-private partnerships should be promoted other than relying on only govt. authority
• Bottom up decision making approach should be practiced which will be very helpful to reduce power inequality
• To preserve agricultural land with the growing demand of land Architect, urban designer, planner, city official should work together and more research should be done.
• Along with economic benefit, environmental consciousness among citizens should be raised.
References:


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Hayes, G. and Jones, G., 2015. The Impact of the Demographic Transition on Socioeconomic Development in Bangladesh: Future prospects and Implications for Public Policy.


Mandal, M. 2006., A synthesis of agricultural policies in Bangladesh. *Agriculture Sector Review, Ministry of Agriculture (MoA), Dhaka.*


**Expert Interviews**

Ashraf, D., 2016. Lecturer, Department of Spatial Sciences. Western Australian School of Mines, Curtin University. *Discussion on Dhaka city, land use changes and Agricultural system*. Skype, Interview conducted on: 10-03-2016


Mahmud, A., Professor, Department of Urban & Regional Planning, Jahangirnagar University, Savar, Dhaka, Planners Tower, Dhaka. *Discussion on Dhaka city, urbanization, urban governance and Agricultural system*. Interview conducted on: 14-03-2016


Siddique, R. K., Professor and Agriculture development expert Savar College, Dhaka. *Discussion on urban growth, climate change and Agricultural system of Dhaka*. Interview conducted on: 20-03-2016
## Appendix 1. Questionnaire

### 1.1. Questionnaire Summary:

<table>
<thead>
<tr>
<th>objective</th>
<th>variable</th>
<th>question</th>
<th>findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>To understand the impact of urbanization and climate change</td>
<td>Land availability, occupational change, Soil fertility</td>
<td>How long are you living in this place?</td>
<td>most of the people have been living there for more than 20 years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>To understand the impact of urbanization and climate change</th>
<th>Land availability, occupational change, Soil fertility</th>
<th>Availability of agricultural land for farming in this place?</th>
<th>changes are more visible in last 0-5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>○ 0-5 years, a) yes, b) no,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>○ 10 years , a) yes, b) no,</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>○ 20 years, a) yes, b) no,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>○ More than 20 years, a) yes, b) no,</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>To understand the impact of urbanization and climate change</th>
<th>Land availability, occupational change, Soil fertility</th>
<th>What is the reason for this changes in agricultural land?</th>
<th>economic benefit, political pressure</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>○ loss of fertility</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>○ economic benefit</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>○ occupational change,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>○ climate change and other, political pressure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Land availability, occupational change</th>
<th>Which changes is more dominant in last 0-5 years changes in farming occupation</th>
<th>Agricultural land to built up area changes in occupation were faster in last 0-5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>○ 0-5 years, a) yes, b) no,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>○ 5-10 years, a) yes, b) no,</td>
<td></td>
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<tr>
<td></td>
<td>○ 10-20 years, a) yes, b) no,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>○ more than years, a) yes, b) no,</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Land availability, occupational change</th>
<th>Which changes is more dominant in last 0-5 years and 5-10 years?</th>
<th>Farmer to non-farmer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>
| Reason for this changes in occupation? | Loss of land (90% changes due to loss of land)  
<table>
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<tbody>
<tr>
<td>o loss of fertility, sandy soil</td>
<td>sandy soil or other (10%)</td>
</tr>
<tr>
<td>o loss of land</td>
<td></td>
</tr>
<tr>
<td>o other</td>
<td></td>
</tr>
</tbody>
</table>

| Impact of climate change/natural disaster | Have you experienced any climate changes or disaster and its impact in farming and what are they (?)  
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>o 0-5 years, a) yes, b) no</td>
<td>Not much</td>
</tr>
<tr>
<td>o 10 years, a) yes, b) no</td>
<td></td>
</tr>
<tr>
<td>o 20 years, a) yes, b) no</td>
<td></td>
</tr>
<tr>
<td>o more than 20 years, a) yes, b) no</td>
<td></td>
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</tbody>
</table>

| Impact of disaster on soil fertility | if yes, then does it affect the fertility of the land  
|-------------------------------------|------------------------------------------------------------------------------------------------------|
| o 0-5 years, a) yes b) no           | No  
| o 10 years, a) yes b) no            | (there is shortage of ground water because of adjacent factory which is more impact of urbanization) |
| o 20 years, a) yes b) no             |                                                                                                      |
| o more than 20 years, a) yes b) no   |                                                                                                      |

| Land quality | type of crops are grown in this place?  
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>o 0-5 years, a) crops, vegetable and fruit b) mainly vegetable, c) mainly crops d) none</td>
<td>-0-5 years, <em>mainly vegetable</em></td>
</tr>
<tr>
<td>o 10 years, a) crops, vegetable and fruit b) mainly vegetable, c) mainly crops d) none</td>
<td>-0-10 years crops and vegetable</td>
</tr>
<tr>
<td>o 20 years, a) crops, vegetable and fruit b) mainly vegetable, c) mainly crops d) none</td>
<td>-10-More than 20 years, a) crops, vegetable and fruit</td>
</tr>
<tr>
<td>o More than 20 years, a) crops, vegetable and fruit b) mainly vegetable, c) mainly crops d) none</td>
<td></td>
</tr>
</tbody>
</table>
1.2. Questionnaire for farmers:

General Information:
Name:
Age:
Sex:
Occupation:
Area/Address:

Confidentiality: Would you like your answers to be anonymous? Yes No

For farmers: (to know about availability, fertility and occupational changes)

- How long are you living in this place?
  - 0-5 years
  - 10 years
  - 20 years
  - More than 20 years

- Availability of agricultural land for farming in this place?
  - 0-5 years, a) yes, b) no, and partially yes
  - 10 years, a) yes, b) no
  - 20 years, a) yes, b) no
  - More than 20 years, a) yes, b) no

- What is the reason for this changes in agricultural land?
  - loss of fertility
  - economic benefit
  - occupational change, partially
  - other, political pressure

- Have you seen any land use changes here in your area?
  - Which changes is more dominant in last 0-5 years:
    - a) No changes
    - b) Agricultural land to built up area
    - c) Wetland to agricultural land
    - d) other
  - Which changes is more dominant in last 10 years:
    - a) No changes
    - b) Agricultural land to built up area
    - c) Wetland to agricultural land
    - d) other
  - Which changes is more dominant in last 20 years:
    - a) No changes
b) Agricultural land to built up area

c) Wetland to agricultural land

d) other

○ Which changes is more dominant in last more than 20 years:
  a) No changes
  b) Agricultural land to built up area
  c) Wetland to agricultural land
  d) other

● what is the reason for this changes in agricultural land?
  ○ loss of fertility
  ○ economic benefit
  ○ occupational change
  ○ other

● Have you seen any changes in farming occupation in your area?
  ○ 0-5 years, a) yes, b) no
  ○ 5-10 years, a) yes, b) no
  ○ 10-20 years, a) yes, b) no
  ○ more than years, a) yes, b) no

If yes, then

○ Which changes is more dominant in last 0-5 years:
  a) farmer to non farmer
  b) non-farmer to farmer
  c) unemployed

○ Which changes is more dominant in last 10 years:
  a) farmer to non farmer
  b) non-farmer to farmer
  c) unemployed
  d) no change

○ Which changes is more dominant in last 20 years:
  a) farmer to non farmer
  b) non-farmer to farmer
  c) unemployed
  d) no change

○ Which changes is more dominant in more than 20 years back:
  a) farmer to non farmer
  b) non-farmer to farmer
  c) unemployed
  d) no change

● what is the reason for this changes in occupation?
  ○ loss of fertility, sandy soil
  ○ loss of land
  ○ other
• Have you experienced any climate changes or disaster and its impact in farming and what are they ()?
  ○ 0-5 years, a) yes, b) no
  ○ 10 years, a) yes, b) no
  ○ 20 years, a) yes, b) no
  ○ more than 20 years, a) yes, b) no
• if yes, then does it affect the fertility of the land
  ○ 0-5 years, a) yes b) no
  ○ 10 years, a) yes b) no
  ○ 20 years, a) yes b) no
  ○ more than 20 years, a) yes b) no
• what kind of foods are grown in this place?
  ○ 0-5 years, a) crops, vegetable and fruit b) mainly vegetable, c) mainly crops d) none
  ○ 10 years, a) crops, vegetable and fruit b) mainly vegetable, c) mainly crops d) none
  ○ 20 years, a) crops, vegetable and fruit b) mainly vegetable, c) mainly crops d) none
  ○ More than 20 years, a) crops, vegetable and fruit b) mainly vegetable, c) mainly crops d) none
1.3. Questionnaire for local residents:

( to know about availability and occupational changes)

General Information:
Name: 
Age: 
Sex: 
Occupation: 
Area/Address: 

Confidentiality: Would you like your answers to be anonymous? Yes No

● Are you local resident living in this place?
  o yes
  o no

● How long are you living in this place?
  o 0-5 years
  o 10 years
  o 20 years
  o More than 20 years

● Have you seen any land use changes here in your area?
  o Which changes is more dominant in last 0-5 years:
    a) No changes
    b) Agricultural land to built up area
    c) Wetland to agricultural land
    d) other
  o Which changes is more dominant in last 10 years:
    a) No changes
    b) Agricultural land to built up area
    c) Wetland to agricultural land
    d) other
  o Which changes is more dominant in last 20 years:
    a) No changes
    b) Agricultural land to built up area
    c) Wetland to agricultural land
    d) other
  o Which changes is more dominant in last more than 20 years:
    a) No changes
    b) Agricultural land to built up area
    c) Wetland to agricultural land
    d) other

● Have you experienced any climate changes or disaster and its impact in your area from?
  o 0-5 years, no
  o 10 years, no
  o 20 years, no
○ More than 20 years

- Have you experienced any changes in occupation in your area from?
  ○ 0-5 years, a) yes, b) no
  ○ 10 years, a) yes, b) no
  ○ 20 years, a) yes, b) no
  ○ More than 20 years, a) yes, b) no

If yes, then

○ Which changes is more dominant in last 0-5 years:
  a) farmer to non farmer
  b) non-farmer to farmer
  c) unemployed

○ Which changes is more dominant in last 10 years:
  a) farmer to non farmer
  b) non-farmer to farmer
  c) unemployed

○ Which changes is more dominant in last 20 years:
  a) farmer to non farmer
  b) non-farmer to farmer
  c) unemployed

○ Which changes is more dominant in more than 20 years back:
  a) Farmer to non farmer
  b) non-farmer to farmer
  c) unemployed

1.4. Questionnaire for experts:
(to know about availability, fertility and occupational changes in terms of impact of urbanization and climate changes on agricultural system)

Climate change and urbanization

Land Availability:
- what are the impact of urbanization on agricultural land?
- what are the impact of climate change on agricultural land?
- Is there any impact of land availability on occupational changes?
- Preserving agricultural land has been emphasized in Govt. policy in recent years, but still agricultural land is being converted by both govt. and private authority. Is it just for lack of policy implementation?

Soil Fertility:
- what are the impact of urbanization on soil fertility of agricultural land?
- what are the impact of climate change on soil fertility of agricultural land?
- Does soil fertility affect occupational change?
- If an urban area is converted into agricultural land, will it affect the soil fertility? Is it possible to do farming in this land?

Occupational changes:
- what are the impact of urbanization on occupational change?
- what are the impact of climate change on occupational change?

Resilience:
- What do you think about the resilience of agricultural system of Dhaka, Bangladesh?

Future Dhaka:

Urbanization:
- How do you envision future Dhaka or cities Bangladesh? How will our future Dhaka look like with or without agricultural land? Will there be available land for farming in future to meet the demand of the city?
- If majority/most people live in cities and do non farming job, will it affect our food security with this fast urbanization and climate change? What could be the ways to minimize

Climate change
- Will there be available land for farming in future to meet the demand of the city?
- In climate adaptation policy, lots of emphases have been given on innovation in climate resistant agriculture and drainage system for Dhaka. Is there any thing else that we need to consider?
Appendix 2 Maps

2.1. GIS Map for land cover changes for 2006
2.2. GIS Map for land cover changes for 2010
2.3. GIS Map for land cover changes for 2014