PRESENT SCENARIO AND PROBLEM CONFRONTATION OF ROOFTOP GARDENING AND ITS EFFICACY IN AMBIENT ENVIRONMENT RECLAMATION IN KHULNA CITY

A Thesis

Submitted to

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BY

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STUDENT ID: MS-160811

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In partial fulfillment of the requirements for the degree of Master of Science in Agricultural Extension and Rural Development

AGROTECHNOLOGY DISCIPLINE
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KHULNA, BANGLADESH

DECEMBER, 2019

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AGROTECHNOLOGY DISCIPLINE
LIFE SCIENCE SCHOOL
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KHULNA, BANGLADESH

DECEMBER, 2019

DEDICATED TO

MY BELOVED MOTHER

ABSTRACT

In the urban area there is scarce of land for planting trees and cultivating agricultural crops. Rooftop gardening might be an alternative to overcome this land problem. The study was conducted to identify the present scenario of rooftop gardening in Khulna city, problems related to this sector and its effects on the ambient environment. Sixty respondents were selected randomly from the study area viz. Nirala and Sonadanga of Khulna City in Bangladesh. Data were collected during March to April of 2018 on nine selected characteristics of the respondent as age, educational qualifications, family size, experience in rooftop gardening, organizational participation, annual income, extension contact, cosmopoliteness and knowledge on rooftop gardening along with a dependent variable as problem confrontation in rooftop gardening. Information on present scenario of rooftop gardening in Khulna city were collected on the parameters such as year of initiation of rooftop gardening, total roof area, suitable roof area for gardening, roof area under gardening, total production, gross and net income from the garden, total expenditure, purpose of rooftop gardening, types of plants grown, intercultural practices, infestation and control of insect and diseases and fertilizers applied. Environmental reclamation of rooftop gardening was determined on the basis of temperature (°C), relative humidity (%) and light intensity (lux) in the rooftop under gardening. Highest proportion (41.67%) of the respondents initiated rooftop gardening recently (i.e. during 2010-2015). The roof area under gardening is small (≤1000 ft^2) in most of the cases (65%). The rooftop gardeners get very poor economic benefit from the garden compared to bearing large expenditure for it. Most of the respondent prefer rooftop garden as a hobby (98.3%) and aesthetics (90%), but, more than half (51.7%) of the respondents considered it as an aspects of ecological balance. Vegetables (16.6%) and flowers (12.5%) are the most dominating plants in the study area for rooftop gardens. Main intercultural operations are being practiced in rooftop garden includes irrigation, weeding, training/pruning and control of insects and diseases. Common insects found are ant, mealy bug, and green leaf hopper with the diseases of die back, viral disease, leaf curling and leaf scorching. Common fertilizers used in the study area were cow dung, compost, urea muriate of potash and sesame cake. Excessive heat (91.7%), lack of proper nourishment (87.1%) and roof load (72.9%) were the most severe problems. Among the 9 selected characteristics only age of the respondents showed significant positive relationship with problem confrontation. Besides, weather parameters showed positive impacts in case of green roof than empty roof. Thus the overall results indicate great contributions of rooftop gardening in urban areas in terms of environmental reclamation.

Key Words: Rooftop gardening, present scenario, environment.

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December, 2019 The Author

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ABBREVIATIONS

BSFB	: Brinjal Shoot and Fruit Borer
DAE	: Department of Agricultural Extension
DAP	: Di-ammonium Phosphate
GLH	: Green Leaf Hopper
Kg	: Kilogram
lx	:Lux (SI unit of illuminance and luminous emittance, measuring luminous flux per unit area)
MoP	:.Muriate of Potash
N	: Number
NASA	: National Aeronautics and Space Administration
NGO	: Non-Government Organization
NS	: Non-significant
PCI	: Problem Confrontation Index
TK.	: Taka
TSP	: Triple Super Phosphate
TV	: Television
Sd	: Standard Deviation
SI	: International System of Units

CHAPTER I

INTRODUCTION

1.1. Background of the Study

Rooftop gardening is an art and science of growing plants on the fallow spaces within the surrounding or adjacent to the residence (www.academia.edu). In other words, a roof of a building that is fully covered with a layer of vegetation is known as a green roof or a rooftop garden. Rooftop farming is usually done by using roofs, aeroponics, hydroponics, air-dynaponics or container gardens. Furthermore, rooftop gardens not only include the rooftop of a building but also other places such as balcony, corridor and other open places. The most common places in a building that can be accommodated vegetation are roof greening, vertical greening, terrace planting and using indoor plants in atria (Raji et al., 2013). Extensive green roofs and intensive green roofs are two categories of rooftop garden (Zimmerman, 2017; Gibler, 2015; Kamarulzaman et al., 2014; Meskin and Preston, 2013; GSA, 2011; Luckett, 2009; Carter and Butler, 2008; Cavanaugh, 2008; Germain et al., 2008). The former one have a thin substrate layer of 5 to 15 cm (0.8 to 6.0 inches) depths with low level planting typically sedum or lawn and it is very light weight in structure. The latter one have a deeper substrate layer with a depth greater than 15 cm to allow deeper rooting plants as like as shrubs and trees to survive (Castleton, 2010; Luckett, 2009; EPA, 2008; Werthmann, 2007; Dunnet and Kingsbury, 2004).

The most famous green roofs were the hanging gardens of Babylon that were constructed around 500 BC (Ahmed and Alibaba, 2016; Sadeghian, 2016; Vijayaraghavan, 2016). In 1960s, green roof technology was developed in Switzerland and then enhanced in many countries, particularly in Germany (Bass and Baskaran, 2003; Doncean, 2014). After 1980s, green roofs were constructed with the idea of bringing vegetation back into urban areas. At present rooftop garden is a modification of modern landscape that can be a part of urban green space in the city. Now, ecological functions of green roofs became more important than its aesthetical properties. Rapid and high rates of urbanization and industrialization have resulted in drastic demographic, economic, land use and climate change. In that case, rooftop garden is a specific urban agriculture niche set of distinctive benefits with scope of energy efficiency, thermal insulation, preventing over heating of building surfaces etc. (Eksi and Uzun, 2013).

Over the past century, there has been an increasing trend towards urbanization. In 1900s, approximately 150 million people lived in urban areas with populations of 20,000 or more and it was less than 10% of the world population. At present this population has grown in urban areas approximately 2.2 billion that constitutes close to 50% of the world population. IPCC (2013) reported that population of the world will grow to about 9.4 billion by the year 2050. The trend of rural to urban migration has also led to increased concentrations of people in cities and suburban areas. Cities have effectively driven out agriculture from their boundaries and that have an impact on human health and environment. Agricultural sector of the world is already threatened by existing factors such as land use changes, scarcity of land, scarcity of water resources, increasing air pollution etc. But people always desire to near foliage and now city planners recognized the values and importance of rooftop garden in aesthetic, economic and protection purpose.

Besides decorative value, rooftop garden offers a number of benefits to a building and its surrounding environment such as storm water management, water runoff quality, urban air quality etc. (Castleton et al., 2010). Vegetation and waterproof membrane of green roofs alleviate the temperature from roof and extend its life (USEPA, 2000). Rooftop garden is an easy solution in reducing external surface temperature of a building. Major environmental issues in urban areas include poor air quality, excessive heat, flooding, lack of ecological biodiversity, increasing waste stream and excessive carbon emissions (Heather, 2012). Rooftop garden can helps in mitigating negative impacts of cities on environment by conserving energy and water, improving air and water quality, assisting in storm water management, absorbing solar radiation, becoming a source of local food production, providing habitat restoration and creating natural retreats. The environmental benefits of rooftop gardens are as like as mitigating urban heat, decreasing air pollution, increase the quality of air through carbon sequestration (Yang et al., 2008; Oberndorfer et al., 2007; Getter and Rowe, 2006 and Onmura et al., 2001). Rooftop gardens also have economic and social benefits such as increase property value through aesthetic element, energy savings through effective thermal conductivity, gathering place for recreational activities in urban society etc. (Dunnett and Kingsbury, 2004 and Wong et al., 2003).

Besides, there are some disadvantages of green roof which include initial installation cost, issues of access, excess heat, roof load capacity, lack of knowledge or incentives, funding, water

supply, safety, water proofing system, wildlife attract (insect-pest), maintenance problem (i.e. removal of debris, control of weeds, deadhead trimming, checking moisture levels and fertilization etc.). Besides these, rooftop conditions are challenging for plant survival and their growth.

However, overall result has shown that rooftop agriculture is becoming popular with time and it is particularly in developing countries.

1.2. Statement of the Problem

All the above facts indicate the need of conducting a research on rooftop gardening. The study seeks to find out present scenario, problem confrontation and environmental reclamation of rooftop garden in Khulna City. Therefore, the study was conducted to find out answers of the following **research questions**:

- What is the present scenario of rooftop gardening in Khulna city?
- What types of problems are faced by rooftop gardener in Khulna city?
- Is there exist any relationship between the selected characteristic of the respondents and their problem confrontation?
- Is there any effect of rooftop garden on the surrounding environment?

1.3. Objectives of the study

There are a variety of utilitarian and non-utilitarian purposes of rooftop gardening. But this study has been conducted by considering the following purposes:

(i) To analyze the selected characteristics of the rooftop gardeners,
(ii) To identify the present scenario of rooftop garden in Khulna city,
(iii) To determine the problem confrontation in rooftop gardening in Khulna city,
(iv) To explore relationship between each of the selected characteristics of the rooftop gardener and their problem confrontation,
(v) To assess the effects of rooftop garden on the surrounding environment.

1.6. Limitations of the Study

Considering time and other necessary resources available to the researcher the following limitations of the study have been observed:

i. The study was confined only in Sonadanga and Nirala of Khulna Development Authority.
ii. There were many respondents in the study area where only 60 respondents were selected as sample of population.
iii. There are many characteristics of the respondents, but only nine of those were selected for the study.
iv. While comparing two facts, one need to collect data in same time from the two; but in this study data on different weather parameters were collected at different point of time of the day.

1.7. Assumptions of the Study

The following assumptions were kept in mind while conducting the study:

i. The views and opinions of the respondents were valid and reliable.
ii. The researcher herself as the interviewer was able to furnish the responses of the respondents with adequate precision.
iii. Data collected by the researcher were free from bias and the respondents give information without any hesitation.

1.8. Statement of Hypothesis

A proposition which66an be put to a test to determine its validity is called a hypothesis (Goode and Hatt, 1952). For empirical testing a set of hypothesis was formulated for relevant data, correlation, analysis and interpretation. For this study, the following null hypothesis was developed to explore relationship between the dependent variable and independent variables.

There is no relationship between the selected characteristics of the respondents (age, educational qualification, family size, experience in rooftop gardening, organization participation, annual income, extension contact, cosmopoliteness and knowledge on rooftop gardening) and their problem confrontation.

1.9. Definition of Terms

Age

Age of respondents refers from the period of his/her birth to the time of interviewing. Age is generally measure in year.

Educational qualification

Educational qualification is the desirable change in knowledge, skill and altitude in an individual through reading, writing and other related activities. It was measured in year of schooling.

Family size

The respondents himself/herself, his wife/husband, children and other permanent members who live and eat together in a family unit is refers to as family size.

Experience in rooftop gardening

The number of year a respondent involve in rooftop gardening considers as his/her experience in rooftop gardening.

Organizational participation

Participation of a respondent in different organizations like youth organization, farmers club, committee (mosque/temple/church), institutional organization, NGO etc. refers as his/her organizational participation.

Annual income

The total amount of money (BDT) earn by a respondents throughout a year refers as his/her annual income.

Extension contact

Extension contact refers to a respondent access or contact to media such as group discussion, DAE officers, NGOs, neighbors/relatives, radio/TV/newspaper/leaflets, agricultural fair etc. to gather information about rooftop gardening.

Cosmopoliteness

Cosmopoliteness of a respondent refers to the movement from his/her place to others like owns city, other city, village, abroad.

Knowledge on rooftop gardening

Knowledge is the amount of facts or information of a person about an idea, object or person. In this study respondent were scores against their knowledge on rooftop gardening.

Initiation of rooftop gardening

The time when a respondent start his/her garden refers as initiation of rooftop gardening.

Rooftop Gardening

A garden practiced in roof of building is considered as a rooftop gardening.

CHAPTER II

REVIEW OF LITERATURE

Literature reviews are needed mainly to analyze the historical records that help to back up the ideas and arguments presented in the research. The need of the chapter "literature review" is to expose the work related to the present study. It helps to support the present work and provides the framework for further research.

2.1. Present Scenario of Rooftop Gardening in Bangladesh and Its Impacts

Safayet et al. (2017) experimented with present practice and future prospects of rooftop farming in Dhaka city and suggested that rooftop farming can provide solutions to increased food demand. Maximum people are willing to practice rooftop farming and want to provide at least 50% of roof space for rooftop farming was one of the significant findings of their study.

According to Gupta and Mehta (2017), urban agriculture has ability to provide direct benefits (food) along with some indirect ecosystem services at a macro level (i.e. conservation of biodiversity).

A study conducted by Celik and Binatli (2017) focused on energy savings and economic impact of green roof systems. They estimated economic impact of rooftop gardening based on sectoral employment multipliers for a period of ten years.

Results of Opitz et al. (2016) showed that learning and innovation in urban agriculture occur in four areas as like as financing and funding, production, technology and infrastructure, markets and demands and social acceptance and cultural learning.

Rahman et al. (2013) from their study on present status of rooftop gardening in Sylhet City Corporation of Bangladesh assessed ecological and economic perspectives of rooftop garden, status of rooftop garden, floristic composition, cost and return from rooftop garden. They found out the reason of people being interested in rooftop gardening (i.e. less investment, less labor, less time, less land and less cultural activities but having high profit like beautification and mental satisfaction). The study reveal that rooftop gardening is generally carried out for mental satisfaction (95.3%) followed by leisure time activity (87.8%). Almost all members of a family

are involved in it. Activities such as collection of planting materials, site preparation and marketing of products were reported to be carried out mainly by males (71.33%). The study also reveals that middle income classes were more interested in rooftop gardening (43.78%). They recorded 53 plant species of 35 families of which Cucurbitaceae family represented the highest eight species. Among the most commonly planted plants shrubs included 28%, herbs 26%, agro-crops 36% and flower species 30%. About 89% of the rooftop gardeners procured planting materials from nursery, market, fair, neighbor, relatives and friends. Almost half (48%) of the respondents mostly prefers to use seedlings from direct seed sowing (21%). The study again reveals that very few people consider rooftop gardening commercially to get profit. Rahman et al. (2013) described the management and silvicultural techniques of rooftop gardening. They showed rooftop gardening as a small scale business that can accelerate additional family income and also showed how rooftop gardens products marketed in the study area.

A study named by investigation of thermal benefits of an extensive green roof was carried out by Eksi and Uzun (2013). According to them green roofs can become ecological solutions for cities in environmental problems that have increased in recent years. They can be used as aesthetic elements as well as they have ecological benefits for the city and urban environment.

A study based on the social, economic, health and environmental benefits of green space development by Brodhead (2009). They found that green space in urban areas, particularly in densely populated areas is beneficial on multiple levels including health, economic, social and environmental safety levels. According to the study, urban green space can help to constitute a framework where urban society and culture can develop and to increase the identity and a sense of community.

Greenstone (2009) showed that rooftop gardens have general environmental, aesthetic and health benefits for cities and their inhabitants.

Oberndorfer et al. (2007) indentified the risks involved in rooftop gardening and they were moisture stress, severe drought, extreme (usually elevated) temperatures, high light intensities and high wind speeds.

Ismail et al. (2007) think that green roofs could provide amenity space for the building user such as growing vegetables, fruits, flowers as well as filtering air pollutants and carbon from air.

Nira (2006) conducted a research on adoption of roof gardening at Mirpur-10 area under Dhaka city. She selected the characteristics of age, family size, family education, annual family income, roof gardening experience, use of information sources, attitude towards roof gardening and knowledge on roof gardening. Nira found that family size, roof gardening experience, use of information sources, attitude towards roof gardening and knowledge on roof gardening had positive significant relationship with their adoption of roof gardening. On the other hand, the characteristics of respondents age, family education and family income did not show any significant relationship with the adoption of roof gardening. The finding reveals that majority (62%) of the respondents were possessed no adoption compared to 15% and 23% have low and medium adoption of roof gardening respectively. The study shows that most of the respondents were interested in flower plants. While the researcher found lack of time as the main problem in roof gardening. The research reported that rooftop gardens provide year round fruits and vegetables, reduces expenditure on purchase of fruits and vegetables, utilize rooftop effectively, rare and unavailable vegetables can be grown in rooftop, it relieve stress and strains, reducing surrounding pollution, increases monetary value of land/apartment and help in avoiding of fruits and vegetables.

Sajjaduzzaman et al. (2005) thought that if city dwellers are well motivated in roof gardening, it can potentially contribute in changing the highly polluted capital city into healthy one. The aim of their study was to clarify the physical and cultural aspects of roof gardening. It also clarifies that roof gardening is financially viable in addition to amenity and recreational gain.

Islam (2004) conducted an experiment on rooftop gardening as a strategy of urban agriculture for food security. He found guava, lemon, papaya, grapes, chili, pumpkin, squash, onion, garlic, coriander leaves, tomato, mushroom, red amaranth, cucumber, bean, bitter gourd, ribbed gourd, ladies finger, amaranth, cowpea, brinjal, various spices and medicinal plants as the most commonly produced fruits and vegetables. Result showed that in almost 90% families have members available to look after the garden. He observed low income consumers as major group for rooftop gardening. There were 50% families had members having knowledge on rooftop gardening and experience in agriculture and gardening. About 65% owners had plans to initiate rooftop gardening in future. There were only 5% owners willing to allow tenants to rooftop gardening. About 75% owners were reluctant to take any help from outside sources. Less than

15% respondents sought partial help from nurseries and friends and about 40% owners were willing to join Rooftop Gardeners Association.

2.2. Problem Confrontations of Rooftop Gardening in Khulna City

Safayet et al. (2017) explore the challenges of rooftop farming in Dhaka city. They indentified the problems such as slope of the roof, load bearing capacity of the building and roof etc.

Barrett (2015) conducted a study on the advantages and disadvantages of rooftop gardening. The main problem addressed in rooftop gardening were moisture and leakage issues and weight issues. According to him, installation of green roof requires more standard measures than a normal roof. It must be used a series of products to achieve good results in terms of water retention, runoff of excess water and prevention of drainage clogging by soil particle erosion and to install a root barrier. Weight issues in rooftop gardening includes installation of materials, water retained itself within the roofing system, soil and particulate matter and vegetation itself. Therefore, use of light weight products can go far toward eliminating weight issues. The issues of high waterproofing integrity, possibility of pesticide leakage from roof materials, wildlife problems (e.g. rats, squirrels, spiders etc.) are some problems related to green roof. Extensive and intensive green roofs projected live loads of higher than 17 pounds per square foot on the roof. So, it requires a greater structural support than a bare roof. Green roofs have certain aspects of challenged in terms of their positive environmental characteristics and sustainability factors. There is no dept that rooftop gardening requires regular irrigation with high maintenance and expenses in terms of supplemental water usage and cost.

Maintenance problem, leak of water and mismanagement are challenges to green roof construction (GSA, 2011).

Research of Nira (2006) revealed out the contrains of installing rooftop garden at Dhaka city in Bangladesh. Lack of time was one of the most common problems in rooftop gardening in that area. The next important problem was that most of respondents consider it as a laborious work.

Possibility of burglary is found as the main problem by Islam (2004). Other problems revealed by him are as like as infestation of insects, birds, monkeys etc.

Dunnett and Kingsbury (2004) identified problems of moisture stress, severe drought, extreme (usually elevated) temperature, high light intensities and high wind speeds increase the risk of desiccation and physical damage to vegetation and substrate.

2.3. Efficacy of Rooftop Gardening on Environmental Reclamation

Safayet et al. (2017) on their study showed that rooftop farming can support environment as like as improving air quality, reducing carbon in the atmosphere etc.

Gupta and Mehta (2017) on their study think that rooftop farming as one solution to meet the growing demand of safe and healthy food, improving air quality, heat influx, reduced corridors for local flora and fauna.

An experiment of Celik and Binatli (2017) found that energy savings of the buildings were evaluated based on the added thermal resistance on the roofs and corresponding heat transmission through the roof.

According to Barrett (2015), rooftop gardens benefited the holders through lowering air temperature, reducing overall utility costs, reduce air pollution and greenhouse gas emissions, help in filtering pollutants from rainwater. He carried out the experiment on smart material choices can prevent garden roof problems.

A comprehensive benefit of green roofs is an experiment conducted by Gibler (2015). He found that evapotranspiration from green roofs dependent on a variety of climatic parameters including temperature, humidity, solar radiation and it has the potential to dissipate energy from a roof surface by means of water vaporization.

It is possible to reduce the indoor climate of buildings through greening the rooftops (Kamarulzaman et al., 2014). It works by mitigating the urban heat island, reducing noise and air pollution and by sequesting carbon from surrounding.

Main aspects of the study conducted by Li and Yeung, (2014) were analyzing performance of green roofs toward the surrounding environments. They also suggested that green roofs can play a critical role in enriching the biodiversity and in purifying the air pollutants. They also worked

with the factors including species that are drought tolerant, solar radiation tolerant and cooling ability of plants.

Eksi and Uzun (2013) in their study showed that extreme temperature fluctuations to the building envelope can be reduced by 79% by green roof system compare to bare roof.

Intensive green roofs lower the monthly median overlying air temperature at 300 mm by up to 1.06°C (Speak, 2013). He observed that day time air temperatures are higher over an adjacent bare roof for a larger proportion of the day than a green roof.

Heather (2012) focused on environmental benefits of urban agriculture on unused, impermeable and semi-permeable spaces in major cities. He believe that rooftop garden can present a unique opportunity to utilize vacant or idle land and rooftops throughout cities and produce healthy, pesticide free food. It also adding green spaces to a neighborhood including community gardens and urban farms and provide a number of social, health, economic and environmental benefits.

A study of NASA (2012) predicted that extensive use of green roofs could reduce summer surface temperatures by as much as 1.6 degrees Fahrenheit.

Castleton et al. (2010) found a passive cooling technique that stop incoming solar radiation from reaching the building structure below.

Experiment of Rashid and Ahmed (2009) on thermal performance of rooftop greenery system at the tropical climate was performed in internal and external roof surface, where temperature and air temperature were measured in two phases. The first phase was carried out when the rooftop was empty and the second phase was conducted after the rooftop was green. From their experiment they found out that green rooftop will tend to experience lower surface temperature than the original exposed roof surface.

Carter and Butler (2008) worked with the ecological impacts of replacing traditional roofs with green roofs in two urban areas. They suggested that vegetated or green roofs are one form of alternative land cover and it has potentiality to provide a variety of ecological benefits in urban areas. Their found that temperature reduced on green roofs compared to asphalt surface.

Rooftop gardening support consequent increases in humidity and evaporation that bring down the ambient temperature observed by Germain et al. (2008).

Green roof technology is a way to improve thermal performance and energy consumption in building (Ismail et al., 2007). They investigated the potentials of green roof technology in improving the thermal performance and energy consumption of buildings. They observed the ecological and economic benefits of rooftop gardening including improvement of thermal performance, reduction energy consumption, mitigation of urban heat effect and many more.

The research on environmental benefits and costs of green roof technology showed that green roofs provide one opportunity to reduce local air pollution levels by lowering extreme summer temperatures, trapping particulates and capturing gases (Banting et al., 2005).

It is possible to lower air temperature by 0.1 to 1.5 degrees Fahrenheit with the addition of 50% green roof infrastructure as assumed by Acks (2003). According to him, cooling is assumed to be necessary for temperatures above 65 degrees and green roofs play a role in lowering temperatures by 0.1, 0.8 or 1.5 degrees and thus reducing in summer by 0.7%, 5% and 10% respectively.

Rooftop gardens can help in reducing urban heat island problems associated with heat stress, energy demand on space conditioning, emissions of green house gases and through direct shading of the roof and evapotranspiration (Liu, 2002).

Green roof can give a protection from solar radiation by reducing thermal fluctuation on the outer surface of the roof as found by Niachou et al. (2001). It also cools the spaces below the roof during summer and increases their heat during winter. But thermal performance also varies according to different types of vegetation.

Based on the discussion and review of literature it can be concluded that rooftop gardens have a broader extent on personal, social, economical and environmental importance in urban area. The reviews indicate that most of the researches conducted were confined in Dhaka City. But no studies have been conducted in Khulna City. So, there is a need to study the problems related rooftop garden as well as its effects on surrounding environment of Khulna City.

2.4. Conceptual Framework of the Study

While constructing a hypothesis properly, a researcher needs to construct at least two important elements i.e. a dependent variable and an independent variable. The dependent and independent variables are the cause and the phenomenon of the variables is effect. The conceptual framework constructed by Rosenbarg and Hovland (1960) was kept in mind while formulating the structural arrangement of the dependent variable and independent variables of this study. Problem confrontation of rooftop gardening is considering as the dependent variable which is supposed to be influenced by the independent variables i.e. the selected characteristics of the respondents. It is not possible for a researcher to deal with all characteristics in a single study. So, it is necessary to limit the characteristics which include age, educational qualification, family size, experience in rooftop gardening, organizational participation, annual income, extension contact, cosmopoliteness and knowledge on rooftop gardening.

Considering the discussion and review of literature, the conceptual framework formulated for this study has been shown in Figure 2.1.

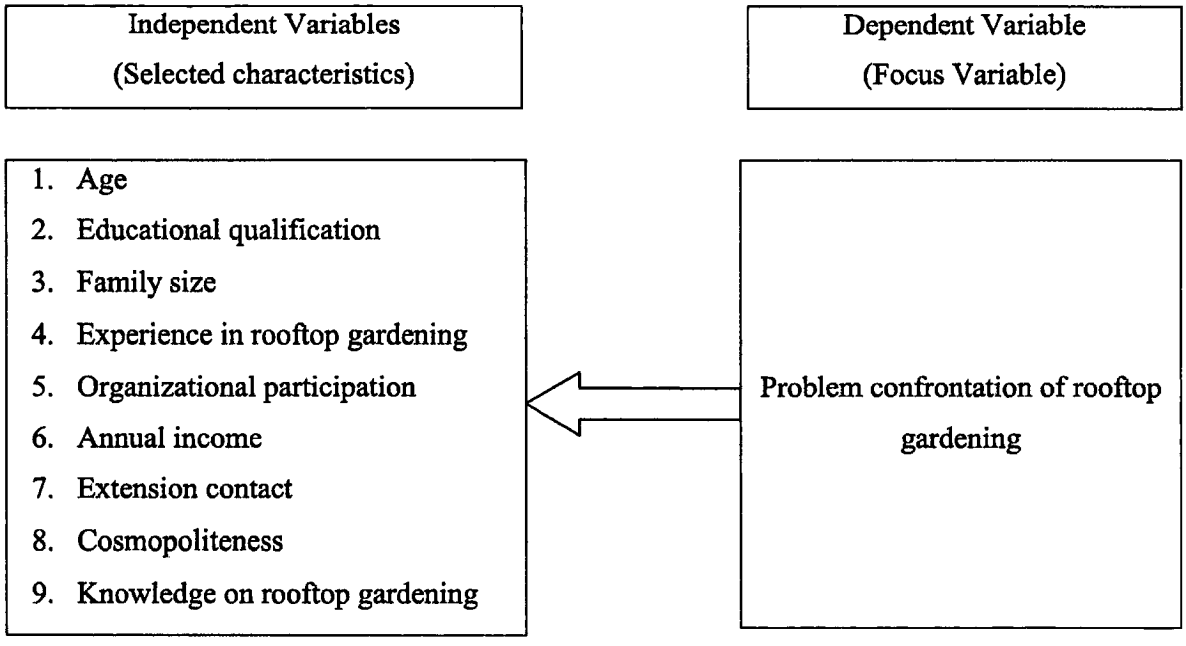

Figure 2.1. The conceptual framework of the study

CHAPTER III

METHODOLOGY

Methodology of a study describes the means by which a researcher conducted the study. It describes the whole processes, procedures and techniques through which a study is completed successfully. The purpose of methodology is to provide information to an investigator to further replicate the study. A research design was developed to structure the research and to show how all the major parts of a study such as the sample, measures and methods of assignment work together to address the central research questions in the study. It requires a very careful consideration on the part of the researcher to collect valid and reliable data, to analyze the data and to come to a meaningful conclusion. The methods and procedures followed in the study are discussed in this section.

3.1. Locale of the Study

The study was conducted in two purposively selected area of Khulna City named as Nirala and Sonadanga of Bangladesh (Figure 3.1).

3.2. Population and Sampling Procedure

Householders owning rooftop garden were considered as the sample of population for the research work. The areas constituted a number of 600 rooftop gardens. Among those, a total of 60 rooftop gardens (10%) were randomly selected for research purpose. Face-to-face interview was conducted among the households of the rooftop gardeners from each of the area. Primary data were collected during the period of 15th March to 20th April of 2018.

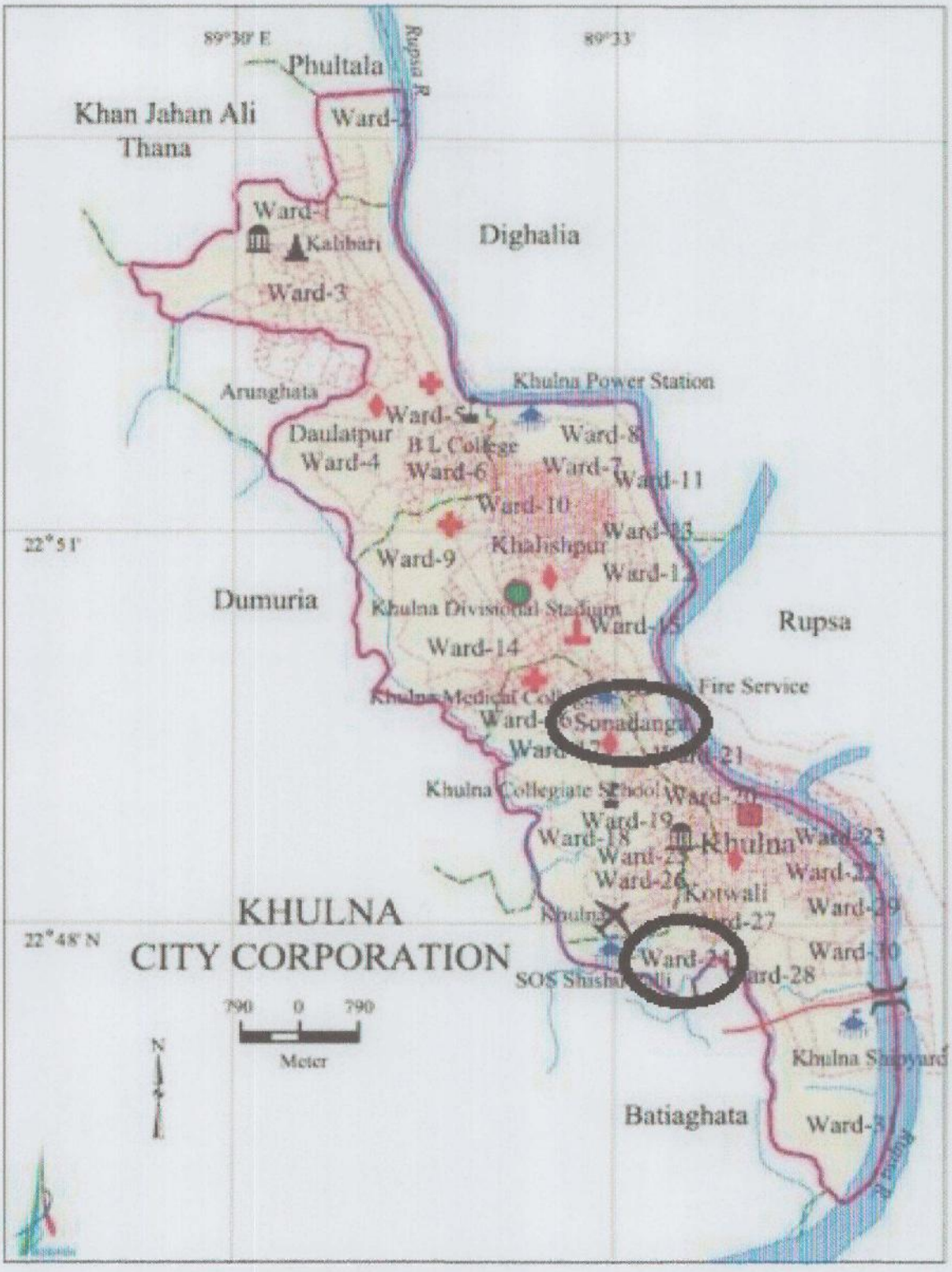

Figure 3.1. Locale of the Study (www.google.com)

3.3. Research Instrument

An interview schedule was prepared for the purpose of data collection considering the objectives of the research in view. It was a semi-structured questionnaire that was developed for collecting data from the respondents through direct observation. The first part of the questionnaire includes the demographic and socio-economic information of the respondents. The second part is formulated to indentify the present status of rooftop gardening in Khulna city. While the third part was aimed to investigate the problem confrontation faced by the rooftop gardener in the study area. The last one, part four of the interview schedule contained the issues related to the effects of rooftop gardening in ambient environmental reclamation. Most of the questions were in simple form and direct while some scales were included regarding the participation, extension contact, cosmopoliteness, knowledge on rooftop gardening and problem confrontation. A draft schedule was pre-tested before using it for data collection. Based on the pre-test experience, necessary corrections, additions, alterations and rearrangements were made in the interview schedule and thus the schedule was prepared for final use. The English version of the interview schedule has been presented in Appendix-1.

3.4. Selection and Measurement of Variables

3.4.1. Measurement of independent variables

Independent variable is the factor that is manipulated by the experimentalists own attempt to ascertain its relationship to an observed phenomenon (Townsend, 1953). There were nine selected personal socio-economic characteristics of the respondents viz. age, educational qualification, family size, experience in rooftop gardening, organizational participation, annual income, extension contact, cosmopoliteness and knowledge on rooftop gardening.

3.4.1.1. Age

Age of the respondents was measured as the period of time from their birth to the time of interview and it was in terms of years. It was located in the serial number A.1 in the interview schedule. Age of the respondents was categorized into three categories; young, middle and old (Table 3.1).

Table 3.1. Categories of the respondents according to their age

Categories	Score (Year)
Young	≤35
Middle	36-50
Old	>50

3.4.1.2. Educational qualification

Educational qualification of the respondents measured based on their year of schooling. If an individual was found illiterate, he/she was given a score of 0 and a score of 1 was assigned for each class one formally completed. The question for this variable appears in the serial number A.2 in the interview schedule. Educational qualification of the respondents was categorized into six categories (Table 3.2).

Table 3.2. Categories of respondents according to their educational qualification

Categories	Score (Year of schooling)
Illiterate	0
Primary	1-5
Secondary	6-10
Higher secondary	11-12
Bachelor	13-16
Above bachelor i.e; post graduate	>16

3.4.1.3. Family size

The term family size refers to the number of members of the respondents such as the husband, wife, children and other dependents living under the same roof and sharing the same kitchen. The question of measuring family size was presented in question number A.3 in the interview schedule. There were three categories of the respondents' i.e. small, middle, large according to their family size (Table 3.3).

Table 3.3. Categories of the respondents according to their family size

Categories	Score (Number)
Small	≤4
Medium	5-6
Large	>6

3.4.1.4. Experience in rooftop gardening

Experience of a respondents in rooftop gardening was measured by counting the number of years a respondents actively involved in rooftop gardening. For each year experience, the respondents were assigned by a score. The question is located in the number A.4 in the interview schedule. There were three categories of the respondents based on rooftop gardening experience (Table 3.4).

Table 3.4. Categories of the respondents according to their experience in rooftop gardening

Categories	Score (Year)
Low	≤6
Medium	7-10
High	>10

3.4.1.5. Organizational participation

The question related to organizational participation of the respondents has been presented in item no. A.5 of the interview schedule (Appendix I). Organizational participation of the respondents refers to the relationship of the respondents to different organizations such as youth organization, farmers club, committee (mosque/temple/church), institutional organization, NGO etc. A four point measurement scale such as no involvement, member, executive member and executive officer was employed against the organization. The respondents were directly asked to indicate the name of the organization they involved with nature of participation. The organizational participation score of the respondents was determined by adding the scores obtained against all the organizations they participated (Table 3.5). The organizational participation score of a respondent could range from 0-18; where '0' indicating no participation and 18 indicate high organizational participation. Based on organizational participation score the respondents were classified in different categories as presented in Table 3.5.

Table 3.5. Categories of the respondents according to their organizational participation

Categories	Score
No participation	0
Low participation	1-6
Medium participation	7-12
High participation	13-18

3.4.1.6. Annual income

Annual income referred to the income earned by the respondents from different sources such as agriculture, business, service and from others sources. Annual income of the respondents was measured in terms thousand taka. The question is located in question number A.6 of the interview schedule (Table 3.6).

Table 3.6. Categories of the respondents according to their annual income

Categories	Score ('000 BDT)
Low	≤120
Medium	121-180
High	>180

3.4.1.7. Extension contact

The item extension contact was included for measuring the use of information sources. Extension contact refers to the contact of the respondent with different sources of information such as group discussion, DAE officers, NGOs, neighbors/relatives, radio/television/newspaper/leaflets, agricultural fair etc. The extent of extension contact of the respondents was classified into four categories namely never, seldom, sometimes and often and they were assigned with the score of 0, 1, 2 and 3 respectively. Here, seldom indicating rare extension contact, sometimes indicating extension contact at times and often indicating frequent extension contact. The use of information sources of a respondent was determined by adding the total responses against the selected media. The total score of an individual could range from 0 to 18; where 0 indicating no use of information sources and 18 indicating very high intensity of using information sources. This was the A.7 question of the interview schedule. The respondents were categorized into four categories according to their extension contact (Table 3.7).

Table 3.7. Categories of the respondents according to their extension contact

Categories	Score
No contact	0
Low contact	1-6
Medium contact	7-12
High contact	13-18

3.4.1.8. Cosmopoliteness

Cosmopoliteness is the orientation of a person to visit outside from his/her own social system. A four point rating scale used for measuring the degree of visitation or cosmopoliteness of the respondents was never, seldom, sometimes and often and the scale was assigned from 0, 1, 2 and 3 respectively. Here seldom indicating rare cosmopoliteness, sometimes indicate cosmopoliteness at times and often indicate frequent cosmopoliteness. An individual score on cosmopoliteness was measured by summing up all of the scores done against four different places. Individual scores ranged from 0 to 18; where 0 indicating no involvement and 18 indicates the highest cosmopoliteness. This question is positioned in A.8 in the interview schedule. Respondents were categorized into four classes according to the score they attain (Table 3.8).

Table 3.8. Categories of the respondents according to their cosmopoliteness

Categories	Score
No cosmopoliteness	0
Low cosmopoliteness	1-6
Medium cosmopoliteness	7-12
High cosmopoliteness	13-18

3.4.1.9. Knowledge on rooftop gardening

Knowledge on rooftop gardening refers to ones idea in rooftop gardening. To measure the knowledge on rooftop gardening of the respondents ten questions on different aspects of rooftop gardening were asked to the respondents. Each respondent was asked all the questions. Each question contains 2 marks and there were a total of 20 marks for a respondent. If an individual answering a question correctly he/she obtained the full marks, while for a partial answer he/she was given marks proportionally. The possible score of a respondents in knowledge on rooftop gardening could ranges from 0 to 20, where 0 indicating no knowledge and 20 indicating the highest knowledge. This variable appears in the number of question A.9 in the interview schedule. The respondents were categorized into 3 categories according to their knowledge on rooftop gardening (Table 3.9).

Table 3.9. Categories of the respondents according to their knowledge on rooftop gardening

Categories	Score
Poor	≤6
Medium	7-12
High	>12

3.5. Present Scenario of Rooftop Gardening in Khulna City

Present scenario indicates the adoption of rooftop garden by the residuals. This question is presented in serial number B.1 in the interview schedule. It was observed under some parameters and they were asked to response the following questions:

- Male and female ratio in rooftop gardening
- Year of initiation of rooftop gardening
- Total roof area (ft^2)
- Suitable roof area for gardening (ft^2)
- Roof area under gardening (ft^2)
- Total production (kg/year)
- Total income (BDT/year)
- Total expenditure (BDT)
- Net income (BDT)
- Purpose of rooftop gardening
- Types and number of plants grown
- Intercultural operations done
- Insect infestation and control
- Disease infestation and control
- Fertilizers used

3.5.1. Male and female ratio in rooftop gardening

The total number of the respondents was grouped into two categories i.e. male and female based on their gender. Category of the respondents has been shown in Table 3.10.

Table 3.10. Distribution of the respondents according to their gender

Category	Respondents (N = 60)
Male	
Female	

3.5.2. Year of initiation of rooftop gardening

Initiation year is the year when the respondents used to start rooftop garden. The number of respondents according to their initiation year of rooftop gardening was calculated from the period of 2000-2018. The categories of the respondents to the starting year of rooftop garden has been shown in Table 3.11 based on their initiation of rooftop gardening.

Table 3.11. Initiation year of rooftop gardening of the respondents

Category	Year
Very early	2000-2003
Early	2004-2009
Recently	2010-2015
Very recently	2016-2018

3.5.3. Roof area under gardening

Roof area under gardening was measured under three parts i.e. total roof area, suitable roof for gardening and roof area under gardening. The area under gardening was measure in square feet. The question was included in serial number B.1 in the interview schedule.

3.5.3.1. Total roof area

The respondents were categorized into three categories: small, medium and large based on the total roof area and that is presented in Table 3.12.

Table 3.12. Categories of the respondents according to their total roof area

Category	Score (ft^2)
Small	≤1000
Medium	1001-2000
Large	>2000

3.5.3.2. Suitable roof area for gardening

Categories of the respondents according to their suitable roof area for gardening are presented in Table 3.13. Three classes of the respondents are small (≤1000), medium (1000-2000) and large (>2000).

Table 3.13. Categories of the respondents according to their suitable roof for gardening

Category	Score (ft^2)
Small	≤1000
Medium	1001-2000
Large	>2000

3.5.3.3. Roof area under gardening

Table 3.14 represented the three categories of the rooftop gardeners depending on their roof area under gardening. Small, medium and large are the categories of the gardener in respect of roof garden area.

Table 3.14. Categories of the respondents according to their roof area under gardening

Category	Score (ft^2)
Small	≤500
Medium	501-1000
Large	>1000

3.5.4. Total production

Total output from the rooftop garden was measured in terms of kilogram per year. It included all types of products from a rooftop garden such as flowers, vegetables, fruits and others. This question is included in B.1 in the interview schedule. The respondents were categorized into three categories (Table 3.15).

Table 3.15. Categories of the respondents according to total production

Category	Score (kg)
Low	≤10
Medium	11-30
High	>30

3.5.5. Total income

Total annual income of the respondents was measured by multiplying the total annual production with the market value of the products. Income from rooftop garden was calculated in local unit Taka. This question was attached to the question number B.1 in the interview schedule. The respondents were divided into four categories (Table 3.16).

Table 3.16. Categories of the respondents according to total income

Category	Score (BDT)
Low	≤500
Medium	501-1000
High	>1000

3.5.6. Total expenditure

Total expenditure in the rooftop garden includes the total cost required for the garden. The values of total expenditures i.e. fixed cost, variable cost and total income e.g. fruits, flowers, vegetables etc. were estimated at current price (BDT). The fixed cost of rooftop gardening includes the cost of procuring materials such as earthen pot, plastic containers, cemented drum and its preparation, plastic drum, cost for various planting tools (e. g. hoes, spades, sprinkles), planting materials cost such as seeds, vegetative parts, seedlings etc. The fixed cost also varied according to roof size, species composition and permanent structure needed for maintenance. The variable cost for rooftop gardening includes irrigation, fertilizers, insecticides, pesticides, replanting, training, pruning, shading, soil change, weeding, hoeing etc. This question is presented in the question number B.1 in the interview schedule. Furthermore, the respondents were divided into three categories based on their total expenditure for the garden and that are presented in Table 3.17.

Table 3.17. Categories of the respondents according to total expenditure

Category	Score ('000 BDT)
Low	≤1
Medium	2-5
High	>5

3.5.7. Net income/loss

Annual net income/loss from the garden of the rooftop gardener was calculated by subtracting the total expenditure from the total income. The question about net income was in the question number B.1 in the interview schedule. There were four categories (i.e. low loss, medium loss, high loss and very high loss) of the respondents according to their net income (Table 3.18).

Table 3.18. Categories of the respondents according to net income/loss

Category	Score ('000 BDT)
Low	≤ -1
Medium	-2 – -5
High	> -5

3.5.8. Purpose of rooftop gardening

The survey revealed that peoples practice rooftop gardening in respect of various purposes such as a hobby, for its aesthetic value, for producing vegetables, for fruit production, for its ecological importance, to generate income and for other perspectives. There was someone who carried out the rooftop garden for producing and distributing the plantlets to different institutions such as school, college, university, for road side plantation and so on. The question purpose of rooftop gardening was listed question number of B.2 in the interview schedule.

3.5.9. Types and number of plants grown

Plants like flowers, vegetables, fruits, medicinal plants and some other ornamental plants are mainly cultivated in rooftop gardens. Plants name and their number were recorded from the gardens by asking to the gardeners and through direct observation. The question related to plant types and number was presented in the question number B.3 in the interview schedule. Plants of the gardens were categorized into five categories (Table 3.19) according to their types.

Table 3.19. Categories of the plant types used by the respondents

Category	Respondents Citation
Flowers	
Vegetables	
Fruits	
Medicinal plants	
Others	

3.5.10. Intercultural operations done

The operations practiced during the year round period in rooftop garden were considered as the intercultural operations. The question B.4 in the interview schedule was prepared by considering the operations of irrigation, weeding, shading, pruning, training, thinning, decoration, control of insect-pest and diseases, drainage system and some others operations practiced by rooftop gardeners.

3.5.10.1. Irrigation

Data on this operation were collected by considering the Number or season that the respondents use to irrigate their plants.

3.5.10.2. Weeding

Weeding is the removal of unnecessary plants from the cultivating containers. Data on weeding were collected based on the Number/time the respondents practice on their garden per month.

3.5.10.3. Shading

In the question of shading, the Number and time of shading in the plants was recorded.

3.5.10.4. Training/pruning

Data on training and pruning were recorded based on the Number they practiced throughout the year.

3.5.10.5. Thinning

Information on thinning was collected based on when and how many times they practice it.

3.5.10.6. Decoration

Decoration is the arrangement of the plant containers. It was recorded under the Number of time it is practiced per month or per year.

3.5.10.7. Control of insect-pest and diseases

It was included the number of times the respondents used to take action to control the insect-pest and disease.

3.5.10.8. Drainage system

Drainage system includes the process of removal of excess water from rooftop or plant root zone.

3.5.10.9. Others

If any respondents conducted some others intercultural operations as like as replanting, changing of soil or some others were considered as other intercultural operations.

3.5.10.10. Insect-pest infestation and control

Information on infestation and control of insect-pest was collected in respect of their name and control measures. This question was also included the stage of invasion or the season/time of invasion of insects. The question insect-pest infestation was under the question B.5 in the interview schedule.

3.5.10.11. Disease infestation and control

Information about disease infestation and control included the control measures against the diseases name. Besides these, the stage of diseases infestation or the time of diseases invasion was recorded. This question was presented in B.6 in the interview schedule.

3.5.10.12. Fertilizers used

The name of the fertilizers used by the respondents, their dose of application and their Number of application or time interval were collected as data for fertilizer use. The question of fertilizer use was listed in question number B.7 in the interview schedule.

3.6. Problem Confrontation of Rooftop Gardening in Khulna City

A number of 12 problems were included in the interview schedule. A four point rating scale was employed against the problems. The rating scale was not severe, less severe, moderately severe, severe and highly severe. The scores assigned against the rating scales were 0, 1, 2, 3 and 4. Each of the respondents was asked to identify the problem they faced with its severity. The problem confrontation score of a respondent was calculated by adding all the score s/he obtained against the 12 problems. The problem confrontation score of the respondents could range from 0-48; where '0' indicate no problem confrontation and 48 indicate high problem confrontation. Based on observed problem confrontation score, the respondents were grouped into three categories as shown in Table 3.20.

Table 3.20. Categories of the respondents according to their problem confrontation

Category	Score
Low	≤10
Medium	11-20
High	>20

To identify the severity of problems the Problem Confrontation Index (PCI) was conducted by using the formula

$$PCI = N_{hs} \times 4 + N_{se} \times 3 + N_{ms} \times 2 + N_{ls} \times 1 + N_{ns} \times 0$$

Where,

PCI = Problem Confrontation Index

N_{hs} = No. of respondents rated the problem highly severe

N_{se} = No. of respondents rated the problem severe

N_{ms} = No. of respondents rated the problem medium severe

N_{ls} = No. of respondents rated the problem less severe

N_{ns} = No. of respondents rated the problem not severe

The PCI score could range from 0 to 240 where '0' indicates not at all a problem while '240' indicate highly severe problem. The PCI score was converted to percentage by using following formula for better understanding.

$$\% PCI = \frac{Observed\ PCI\ Score}{Possible\ PCI\ Score} \times 100$$

3.7. Efficacy in Ambient Environment Reclamation

The variables temperature, relative humidity and light intensity were the three parameters selected for measuring the efficacy of rooftop gardening in ambient environment reclamation (Table 3.21). Temperature, relative humidity and light intensity were measured both from the roof with vegetation and from the roof without vegetation. Temperature and relative humidity were measured in '°C' and '%' units using a Fisherbrand 'Hygrothermometer'; light intensity was measured in 'lux' unit using a Lutron 'Lux meter' (Model LX-101, made in Thaiwan). All the instruments used for the mentioned purposes were hand-held and were used for to measure the intended weather parameters during the time of interview of the respondents. The survey duration was kept confined within 10.00 am to 5.00 pm. At the time of data recording for the weather parameters, the researcher recorded data of three places of the roofs, both for green roofs and empty roofs. The roof heights were also maintained the same, i.e., if the green roof was at 3rd floor the control data were collected from an empty 3rd floor roof. This section was listed in part D of the interview schedule.

Table 3.21. Comparison of temperature, relative humidity and light intensity between green roof and empty roof

Environmental Ingredients	Green Roof	Empty Roof
Temperature (°C)		
Relative humidity (%)		
Light intensity (lx)		

3.8. Data Collection

Data for the study were collected from the period March to April 2018. Interviews were performed during daytime with an average duration of about 30 minutes. The respondents were informed and explained the purpose of the study and they were requested to help and cooperate for collecting data for the study. All qualitative and quantitative data were collected in local terms and units. Wherever the respondents felt any difficulties in understanding, the questions were clearly explained. On each survey, the respondents were encouraged to express their views and provide additional information regarding rooftop gardening in the area.

3.9. Compilation of Data

After completing field survey, all of the interview schedules were compiled, tabulated and analyzed according to the objectives of the study. All the qualitative data in the interview schedule were given numerical coded values and scores whenever necessary to facilitate the process. In several instances, scales were constructed through the simple accumulation of scores assigned to individual or pattern of attributes. Scales are considered as the efficient instrument for data reduction and analysis. The responses in the interview schedule were transferred to a master sheet to facilitate the tabulation. Then tabulations and cross tabulations were done based on some categories.

3.10. Data Processing and Analysis

Data analysis was performed by using the SPSS (Statistical Package for Social Science) Computer Package and Microsoft Excel. The descriptive analysis was included the mean, standard deviation, minimum, maximum, range, Number, number and percent and they were used to interpret data. Spearman's Rank Order Co-efficient of Correlation (ρ) was used in order to explore the correlation among the variables.

CHAPTER IV

RESULTS AND DISCUSSION

The findings of a study and related interpretation of the result with necessary discussion have been presented in this chapter "results and discussion". Major findings of the study have been presented in four sections. The first one includes the demographic and socio-economic characteristics of the respondents. Present status of rooftop gardening in Khulna city is under the second section of the chapter. Problem confrontation of rooftop gardening in Khulna city and efficacy of rooftop gardening in ambient environmental reclamation have been shown in section three and section four respectively.

4.1. Selected Characteristics of the Rooftop Gardener

Findings on personal and socio-economic characteristics of the respondents have been discussed below.

4.1.1. Age

Table 4.1 shows that age of respondents ranged from 12 to 86 with the mean of 47.83 and standard deviation of 14.45. It indicates that age of the respondents was markedly varied, while the respondents were grouped into young (≤35 years), middle (36-50 years) and old (>50 years) categories.

Table 4.1. Distribution of the respondents according to their age

Categories	Score (Year)	Respondents (N=60)		Range	Mean	*Sd
		Number	Percent			
Young	≤35	13	21.7			
Middle	36-50	23	38.3	12-86	47.83	14.45
Old	>50	24	40			
Total		60	100			

*Sd = Standard Deviation

Table 4.1 indicates that the two-fifth (40%) of respondents was from middle and the second highest (38.3%) was from old age. The lowest proportion (21.7%) was found from the category young. This result shows that middle and old aged people were mainly involved in rooftop gardening. Rahman et al. (2013) found that age class 31-40 years (41.56%) and 41-50 years

(30.22%) occupied the mentionable percentage of rooftop gardener. Nira (2006) found highest proportion (41%) as the young class. While, Hossain and Hossain (2016) found both the young and middle aged as 45% participate in rooftop gardening.

4.1.2. Educational qualification

Educational qualification of the respondents was measured by the level of his/her year of schooling i.e. the class he/she passed or completed. The education score of the respondents varied from 0 to 16 with the mean of 13.28 and standard deviation of 2.99 (Table 4.2). On the basis of educational qualification, the respondents were grouped into seven categories.

Table 4.2. Distribution of the respondents according to their educational qualification

Categories	Score (Year)	Respondents (N=60)		Range	Mean	*Sd
		Number	Percent			
Illiterate	0	1	1.8			
Primary	1-5	0	0			
Secondary	6-10	11	18.3			
Higher secondary	11-12	11	18.3	0-16	13.28	2.99
Bachelor	13-16	17	28.3			
Above bachelor i.e; post graduate	>16	20	33.3			
Total		60	100			

*Sd = Standard Deviation

About one-third (33.3%) of the respondents were highly educated and had above bachelor i.e; post graduate level educational qualification followed by bachelor and higher secondary (28.3% and 18.3% respectively) categories. In this present study, there was only 1.8% illiteracy among the total 60 respondents. Hossain and Hossain (2016) observed that majority (58.3%) of rooftop gardeners were from graduate and above in academic qualification.

4.1.3. Family size

Family size of the respondents ranged from 2 to 13 with the mean and the standard deviation of 4.53 and 1.97 respectively. On the basis of family size, the respondents were classified into three categories i.e. small (≤4), medium (5-6) and large (>6) in Table 4.3. The majority (55%) fall under the category of small and the rest 40% and 5% fall under the medium and large family

categories. Nira (2006) found that majority 56% respondents are from medium family. Similarly Hossain and Hossain (2016) found that 65% rooftop gardeners are from medium family.

Table 4.3. Distribution of the respondents according to their family size

Categories	Score (Number)	Respondents (N=60)		Range	Mean	*Sd
		Number	Percent			
Small	≤4	33	55			
Medium	5-6	24	40	2-13	4.53	1.97
Large	>6	3	5			
Total		60	100			

*Sd = Standard Deviation

4.1.4. Experience on rooftop gardening

The range of the experience of the respondents in rooftop gardening was from 0.5 to 30. While the mean of 9.28 and the standard deviation of 6.99. According to experience in roof gardening, respondents were classified under low (≤5), medium (6-10) and high (>10) categories (Table 4.4). Findings of the study shows that two-fifth (40%) of the respondents (rooftop gardeners) had low experience in rooftop gardening, while about one-third (33.3%) had high experience and 26.7% had medium experience. Nira (2006) showed that majority (65%) of the respondents had low experience in rooftop gardening. The findings of Hossain and Hossain (2016) and of Nira (2006) i.e; very (56.7%) support the findings from the current study.

Table 4.4. Distribution of the respondents according to their experience on rooftop gardening

Categories	Score (Year)	Respondents (N=60)		Range	Mean	*Sd
		Number	Percent			
Low	≤6	24	40			
Medium	7-10	16	26.7	0.5-30	9.28	6.99
High	>10	20	33.3			
Total		60	100			

*Sd = Standard Deviation

4.1.5. Organizational participation

Organizational participation scores of the respondents ranged from 0 year to 8 year with the mean of 1.07 year and standard deviation of 1.84 (Table 4.5). The rooftop gardeners were grouped into four categories namely no (0), low (1-6), medium (7-12) and high (13-18).

4.1.7. Extension contact

The result presented in Table 4.7 show that the minimum and maximum score of the respondents against the extension contact varied from 0-14 with mean of 5.75 and standard deviation of 3.39. Respondents were divided into four categories (never, seldom, sometimes, often) in Table 4.7 based on their extension contact scores. Two-third (66.7) of the respondents showed low extension contact behavior followed by medium (23.37) and high (8.3). A very few (1.7) of the respondents had no contact with information sources. Hossain and Hossain (2016) found similar type of result. They found that 76.7% of the respondents had low extension contact.

Table 4.7. Distribution of the respondents according to their extent of extension contact

Categories	Score (Year)	Respondents (N=60)		Range	Mean	*Sd
		Number	Percent			
No contact	0	1	1.7			
Low contact	1-6	40	66.7	0-14	5.75	3.39
Medium contact	7-12	14	23.3			
High contact	13-18	5	8.3			
Total		60	100			

*Sd = Standard Deviation

4.1.8. Cosmopoliteness

The range, mean and standard deviation of the variable cosmopoliteness of the respondents have been presented in Table 4.8 and they are 0-8, 4.87 and 1.89 respectively. Based on the degree of visitation the respondents were sampled under four categories which are presented in Table 4.8.

Table 4.8. Distribution of the respondents according to their cosmopoliteness

Categories	Score (Year)	Respondents (N=60)		Range	Mean	*Sd
		Number	Percent			
No cosmopoliteness	0	1	1.7			
Low cosmopoliteness	1-6	49	81.7	0-8	4.87	1.89
Medium cosmopoliteness	7-12	10	16.7			
High cosmopoliteness	13-18	0	0			
Total		60	100			

*Sd = Standard Deviation

Findings show that most (81.7%) of the respondents fell under low cosmopoliteness, where 16.7% and 1.7% were under medium and no cosmopoliteness respectively. Hossain and Hossain (2016) also found that most (91.7%) of the respondents bear low cosmopoliteness.

4.1.9. Knowledge on rooftop gardening

The knowledge on rooftop gardening score of the respondents could range from 0 to 20, while the observed score ranged from 8 to 20. Mean and standard deviation were 14.25 and 2.62 respectively (Table 4.9). Respondents were divided into three categories i.e. poor, medium and high based on their knowledge on rooftop gardening which have been presented in Table 4.9.

Table 4.9. Distribution of the respondents according to their knowledge on rooftop gardening

Categories	Score (Year)	Respondents (N=60)		Range	Mean	*Sd
		Number	Percent			
Poor	≤6	0	0			
Medium	7-12	14	23.3	8-20	14.25	2.62
High	>12	46	76.7			
Total		60	100			

*Sd = Standard Deviation

Above three-fourth (76.7%) of the respondents had high knowledge on rooftop gardening while about one-fourth (23.3%) had medium knowledge on rooftop gardening. Hossain and Hossain (2016) found that 88.3% and 11.7% of the respondents have high and medium knowledge on rooftop gardening respectively. Survey reflected that all most all of the respondents have enough knowledge on gardening. Islam (2004) found 50% families having different level of knowledge on rooftop gardening.

4.2. Present Scenario of Rooftop Gardening in Khulna City

The present scenario of rooftop gardens in Khulna city were studied under the following parameters:

- Male and female ratio in rooftop gardening
- Year of initiation of rooftop gardening
- Total roof area (ft^2)
- Suitable roof area for gardening (ft^2)

- Roof area under gardening(ft^2)
- Total production (kg/year)
- Total income (BDT/year)
- Total expenditure (BDT/year)
- Net income (BDT/year)
- Purpose of rooftop gardening
- Types and number of plants grown
- Major plants grown in rooftop garden
- Intercultural operations done
- Insect infestation and control
- Disease infestation and control
- Fertilizers used

4.2.1. Male and female ratio in rooftop gardening

There were two categories (i.e. male and female) of the respondents based on their gender. As Table 4.10 shows, among the 60 respondents majority (55%) of the respondents were female and rest (45%) were male. That means in the study areas, females were more interested in rooftop gardening than males.

Table 4.10. Distribution of the respondents according to gender

Category	Respondents (N = 60)	
	Number	Percent
Male	27	45
Female	33	55
Total	60	100

4.2.2. Year of initiation of rooftop gardening

The respondents initiated roof gardening during 2000-2018. The initiation time was divided into four categories for the purpose of revealing out the highest number of the respondents started rooftop gardening. The highest proportion (41.67%) of the respondents initiated rooftop gardening recently (i.e; during 2010-2015) followed by early, very recently and very early (Table 4.11).

Table 4.11. Distribution of the respondents according to the year of initiation of rooftop gardening

Category	Year	Respondents (N = 60)		Rank	Range
		Number	Percent		
Very early	2000-2003	9	15	4th	
Early	2004-2009	16	26.67	2nd	2000-2018
Recently	2010-2015	25	41.67	1st	
Very recently	2016-2018	10	16.67	3rd	
	Total	60	100		

4.2.3. Total roof area

Total roof area of the respondents was measured in square feet and grouped into three categories i.e. small, medium and large of area have been shown in Table 4.12. Majority of the respondents (56.67%) had medium sized roof area (1001-2000 ft^2) followed by small (33.33%) and large (10%) respectively. The roof area of the respondents varied from 100 to 3000 square feet.

Table 4.12. Distribution of the respondents according to their total roof area

Categories	Score (ft^2)	Respondents (N = 60)		Range	Mean	*Sd
		Number	Percent			
Small	≤1000	20	33.33			
Medium	1001-2000	34	56.67	100-3000	1305	628
Large	>2000	6	10			
Total		60	100			

*Sd = Standard Deviation

4.2.4. Suitable roof area

The respondents were classified into three categories (small, medium and large) based on the suitable roof area they belonged. Majority (65%) of the respondents owned small roof area (≤1000 ft^2) that is suitable for gardening. The rest 31.67% and 3.33% of the respondents had medium and large suitable roof area for gardening (Table 4.13). Suitable roof area of the respondents ranged from 100 to 3000 ft^2 with the mean of 949.17 and standard deviation of 572.72.

Table 4.13. Distribution of the respondents according to their suitable roof area

Categories	Score (ft^2)	Respondents (N = 60)		Range	Mean	*Sd
		Number	Percent			
Small	≤1000	39	65			
Medium	1001-2000	19	31.67	100-3000	949.17	572.72
Large	>2000	2	3.33			
Total		60	100			

*Sd = Standard Deviation

4.2.5. Roof area under gardening

Respondents were categorized into small, medium and large categories according to their actual roof area under gardening (Table 4.14). Majority (56.67%) of them had small roof area (≤500 ft^2) actually under roof gardening while the rest 33.33% and 10% medium and large area actually under roof gardening. The roof area actually under gardening ranged from 30 to 2400 ft^2 with a mean and standard deviation of 582.67 ft^2 and 504.38 respectively.

Table 4.14. Distribution of the respondents according to their roof area under gardening

Categories	Score (ft^2)	Respondents (N = 60)		Range	Mean	*Sd
		Number	Percent			
Small	≤500	34	56.67			
Medium	501-1000	20	33.33	30-2400	582.67	504.38
Large	>1000	6	10			
Total		60	100			

*Sd = Standard Deviation

4.2.6. Total production

Total production from the rooftop garden of the respondents was measured in terms of kilogram per year. Total production around the year includes the products of all types of plants as like as flowers, vegetables, fruits, medicinal plants and all other types of plants that the gardeners grown in their garden. Table 4.15 presented the three categories (low, medium and high) of the respondents depending on their total production throughout the year from their rooftop garden. The table figured out that maximum (45%) gardeners had low production (≤10 $kgyr^{-1}$) from their garden. The rest, 43.33% and 11.67% of the respondents had harvested medium (10-30 $kgyr^{-1}$) and high (>30 $kgyr^{-1}$) production respectively from their rooftop garden (Table 4.15). The range

of total production among the respondents was from 0.025 to 100 kilogram around the year. The mean of total production was 18.53 and the standard deviation was of 23.09.

Table 4.15. Distribution of the respondents according to their total production from the rooftop garden

Category	Score (kg/year)	Respondents (N = 60)		Range	Mean	*Sd
		Number	Percent			
Low	≤10	27	45.00			
Medium	11-30	26	43.33	0.025-100	18.53	23.09
High	>30	7	11.67			
Total		60	100			

*Sd = Standard Deviation

4.2.7. Total income

Rooftop gardeners did not concentrate on the purpose of income generation. However, the total output from rooftop garden was considered as their total income. Table 4.16 shows the categories of the respondents according to their year round total income from the garden along with their range (minimum and maximum income), mean and standard deviation. Findings indicated that both the low (≤500 BDT) and high income (>1000 BDT) constituted 45% while one-tenth (10%) of the respondents had medium income from the garden. Total annual income of the respondents ranged from BDT 25 to BDT 7500. The mean of total income was BDT 2144 with the standard deviation of 2345.89.

Table 4.16. Distribution of the respondents according to their total income (BDT) from the rooftop garden

Category	Score (BDT)	Respondents (N = 60)		Range	Mean	*Sd
		Number	Percent			
Low	≤500	27	45			
Medium	501-1000	6	10	25-7500	2144	2345.89
High	>1000	27	45			
Total		60	100			

*Sd = Standard Deviation

4.2.8. Total expenditure

Minimum total expenditure for a rooftop garden was estimated as BDT 650 and maximum as BDT 99,900 with the mean of BDT 11,577.33 and standard deviation of 16,408.31 (Table 4.17).

Data also reveal that the majority i.e. 56.67% of the rooftop gardeners spent high amount of taka for their gardening. About one-third (33.33%) of them spent medium and the rest 10% respondents spent low amount of money for rooftop gardening.

Table 4.17. Distribution of the respondents based on their total expenditure (BDT) for rooftop garden

Categories	Score ('000 BDT)	Respondents (N = 60)		Range	Mean	*Sd
		Number	Percent			
Low	≤1	6	10			
Medium	2-5	20	33.33	0.65-99.90	11.58	16.41
High	>5	34	56.67			
Total		60	100			

*Sd = Standard Deviation

4.2.9. Net income/loss

The respondents practiced rooftop gardening as hobby and aesthetic purpose. Consequently the expenditure was higher than that of income. The net loss from rooftop gardens varied from BDT -84900 to BDT -760. Mean and standard deviation on net income was BDT -8920.83 and 14203.71 respectively. About half (48.33%) of the respondents fell under the category high loss and the rest 26.67% and 25% respondents fell under the category low loss and medium loss net loss respectively (Table 4.18). That means rooftop gardeners generated very low products compare to their high expenditure. Furthermore, people were not interested in income generation from their rooftop garden except a few cases. Actually people were not considering rooftop gardening commercially to get profit. Rahman et al. (2013) also found the same result. Most of the people consider it as a place of relax, calm down and clear minds (Korpela and Hartig, 1996; Korpela, 1992). Rooftop gardeners are not financially benefited; but benefited economically. From financial consideration, it is not a viable option but it has impact on environment which helps them to live a healthy life. Besides, the respondents establish rooftop garden as a hobby and also for aesthetics.

Table 4.18. Distribution of the respondents based on their net income/loss from their rooftop garden

Category	Score ('000 BDT)	Respondents		Range	Mean	*Sd
		Number	Percent			
Low	≤ -1	15	25			
Medium	-2 – -5	16	26.67	-84.90 – -0.76	-8.92	14.20
High	> -5	29	48.33			
Total		60	100			

*Sd = Standard Deviation

4.2.10. Purpose of rooftop gardening

In case of purpose of rooftop gardening (Table 4.19), hobby (98.33%) and aesthetic value (90%) was taking respectively the 1st and 2nd position along with ecological balance (51.67%), fruit production (48.33%) and vegetable production (46.67%) as 3rd, 4th and 5th position respectively. In contrast of those, there were only 1.7% people who considered rooftop garden for income generation and as a source of production and distribution of plantlets.

Again, 10% of the respondents had variety of purposes in carrying out rooftop garden. Though rooftop garden can be considered as a small business and it provides an additional income to a family, people actually are not interested to take it as a source of income and commercially to get profit. Rahman et al. (2013) also found the same result observed that 95.3% carried out rooftop garden for mental satisfaction, 87.8% for leisure activity and 54.9% for environmental amelioration.

Table 4.19. Distribution of the respondent based on their purpose of rooftop gardening

Purpose Name	Citation Number	Percent	Rank
Hobby	59	98.33	1st
Aesthetic	54	90.00	2nd
Vegetable production	28	46.67	5th
Fruit production	29	48.33	4th
Ecological balance	31	51.67	3rd
Income generation	1	01.67	7th
Production and distribution of plantlets	1	01.67	7th
Others	6	10.00	6th

4.2.11. Types and number of plants grown

This sub-section is about the types of plants that the rooftop gardeners grown in their garden. Table 4.20 indicate that most (83.33%) of the respondents were interested in growing flowers plants than those of others. Besides, flowers, 81.67% respondents prefer vegetables, 76.67% fruits, 73.33% medicinal plants and 61.67% some other plants (i.e. ornamental plants, bonsai, exotic plants etc). Rahman et al. (2013) in their study categorized rooftop gardeners into the categories of agri-crops (36%), flower species (30%), fruit species (21%) and medicinal plants (13%). Hossain and Hossain (2016) found that 100% respondents are interested on flower and vegetable cultivation. Nira (2006) found flower and ornamental plants as the most dominating plants followed by fruits, vegetables and medicinal plants. However, in respect of number of plants, the vegetable plants ($\bar{x}$ = 16.57) were dominant one followed by flowers ($\bar{x}$ = 12.53) and fruits plants (Table 4.20). But flower plants were highly preferred by the respondents (83.33%) than that of vegetables (81.67%).

Table 4.20. Distribution of the respondents depending on the types and number of plant grown in their rooftop garden

Plant Types	Plant Number ($\bar{x}$)	Respondents (N=60)		Rank
		Number	Percent	
Flowers	12.53	50	83.33	1st
Vegetables	16.57	49	81.67	2nd
Fruits	6.80	46	76.67	3rd
Medicinal plants	5.97	44	73.33	4th
Others	5.78	37	61.67	5th

4.2.11.1. Major plants grown in rooftop garden

The name of major plants under different types has been listed in Table 4.21. Most of the rooftop gardeners in the study area prefer mainly flowers, vegetables and fruit plants for their garden. The next important plants were medicinal plants and then other types of plants. The most common flower plant in the study was rose (51.67%) followed by marigold (23.33%), bougainvillea (21.67%), Arabian jasmine (21.67%), chrysanthemum (20%), Cape jasmine (18.33%), Chinese rose (16.67%), periwinkle (16.67%), zinnia (13.33%) and night jasmine (11.67%) (Table 4.21). Other flowers were dahlia, gardenia, orchid, wild flowers, lady of night,

butterfly pea etc. Rose and marigold were the mostly grown flowers in rooftop garden (Nira, 2006).

Main vegetables constituted chili (60%), brinjal (40%), Indian spinach (36.67%), tomato (30%), bottle gourd (20%) and bitter gourd (18.33%) (Table 4.21). Respondents like to planted chili as vegetables as the need of their family (Nira, 2006). Other minor types of vegetables includes lady's finger, pumpkin, coriander, red amaranth, sweet potato, amaranth, bean, scarlet gourd, taro, cucumber, elephant foot, potato, swamp cabbage, winged yam, wax gourd, jute leaf, notey shak, mustard, onion, garlic etc. Among the vegetable spices, Rahman et al. (2013) recorded Cucurbitaceous vegetables as highest eight species followed by plants of Solanaceae and Amaranthaceae family.

Table 4.21. Major plants grown in rooftop gardens in the study area

Plant Name	Major Plants	Respondents (N = 60)		Rank
		Number	Percent	
Flowers	Rose	31	51.67	1st
	Marigold	14	23.33	2nd
	Bougainvillea, arabian jasmine	13	21.67	3rd
	Chrysanthemum	12	20.00	4th
	Cape jasmine	11	18.33	5th
	Chinese rose, periwinkle	10	16.67	6th
	Zinnia	8	13.33	7th
	Night jasmine	7	11.67	8th
	Dahlia	6	10.00	9th
	Gardenia, orchid, wild flower	5	8.33	10th
	Lady of the night, butterfly pea	4	6.67	11th
	Daffodil, petunia, cosmos	3	5.00	12th
	China box, tube rose	2	3.33	13th
	Adenium, peacock flower, madaplata, climbing yang yang etc.	1	1.67	14th
	Others	5	8.33	17th
Vegetables	Chilli	36	60.00	1st
	Brinjal	24	40.00	2nd
	Indian spinach	22	36.67	3rd
	Tomato	18	30.00	4th
	Bottle gourd	12	20.00	5th
	Bitter gourd	11	18.33	6th
	Lady's finger	8	13.33	7th
	Pumpkin, coriander	7	11.67	8th
	Red amaranth	6	10.00	9th

	Sweet potato	5	8.33	10th
	Amaranth, ridged gourd, bean	4	6.67	11th
	Capsicum, mustard	3	5.00	12th
	Cowpea	2	3.33	13th
	Scarlet gourd, taro, cucumber, elephant foot, potato, swamp cabbage, winged yam, wax gourd, jute leaf, onion, garlic, ginger etc.	1	1.67	14th
Fruits	Lemon	33	55.00	1st
	Mango, guava	30	50.00	2nd
	Sapota, jujube	13	21.67	3rd
	Pomegranate, wax jambu	12	20.00	4th
	Lime	10	16.67	5th
	Malta, orange	8	13.33	6th
	Hog plum, litchi, papaya	7	11.67	7th
	Wood apple, jamun	5	8.33	8th
	Grape, carunda, strawberry	4	6.67	9th
	Custard apple	3	5.00	10th
	Bel, jackfruit, shaddock, carambola, banana, date palm, cherry	2	3.33	11th
	Musk melon, pineapple, almond, tamarind, chinese guava etc.	1	1.67	12th
Medicinal Plants	Aloe	36	60.00	1st
	Basil	18	30.00	2nd
	Air plant	13	21.67	3rd
	Mint	4	6.67	4th
	Centella, diabetic plant	3	5.00	5th
	Neem, aonla, pepper mint, bead tree, green chiretta etc.	1	1.67	6th
Other Plants	Cactus	17	28.33	2nd
	Bonsai (bengal fig, pakur, dwarf bamboo)	15	25.00	3rd
	Dracaena	11	18.33	4th
	Palm	10	16.67	5th
	Henna, croton	8	13.33	6th
	Money plant,	6	10.00	7th
	Caladium	5	8.33	8th
	Shame plant	3	5.00	9th
	Tejpat, chab, lettuce	2	3.33	10th
	Cane, fennel	1	1.67	11th
	Others	24	40.00	1st

Lemon (55%), mango (50%), guava (50%), sapota (21.67%), jujube (21.67%), pomegranate (20%), wax jumbo (20%), lime (16.67%), orange (13.33%), malta (13.33%), hog plum (11.67%), litchi (11.67%) and papaya (11.67%) were the main grown fruit plants in rooftop garden (Table 4.21). Some other fruits grown in rooftop garden were banana, carambola, shaddock, wood apple, jamun, grape, carunda, strawberry, cherry, musk melon, pineapple, Chinese guava etc. Nira (2006) found mango and guava as the major fruits in her study area.

Aloe (60%), basil (30%) and air plant (21.67%), diabetic plant (5%), centella (5%) were the main medicinal plants with some minor plants such as neem, aonla, green chiretta etc. Besides these, cactus (28.33%), bonsai (25%), dracaena (18.33%), palm (16.67%), henna (13.33%), croton (13.33%) were the most common types of plants grown in rooftop garden. There were some other (40%) exotic unanimous ornamental plants around the study area (Table 4.21).

4.2.12. Intercultural operations done

In the study area, different intercultural operations were practiced by the gardeners. Number percentage and rank of different intercultural operations have been presented in Table 4.22.

Table 4.22. Intercultural operations practiced by the respondents

Name of Intercultural Operations	Respondents (N = 60)		Rank
	Number	Percent	
Irrigation	60	100	1st
Weeding	60	100	1st
Shading	6	10	6th
Training/Pruning	49	81.67	2nd
Thinning	31	51.67	5th
Decoration	42	70	4th
Control of insects and diseases	45	75	3rd
Drainage system	3	5	8th
Others	5	8.33	7th

Irrigation, weeding, training, pruning, control of insect and pest, decoration and thinning were the main intercultural operations practiced in rooftop gardens. The rest intercultural operations i.e. shading, drainage system were practiced rarely. All of (100%) of the respondents practiced irrigation and weeding. Besides, training/pruning (81.67%), control of insects and diseases (75%), decoration (70%) and thinning (51.67%) were the next important intercultural operation

as practiced by the respondents (Table 4.22). But, most of the intercultural operations were conducted as per demand and in that case the respondents did not follow any regular Number.

4.2.12.1. Irrigation

Table 4.23 shows that majority of the respondents (68.33%) irrigated their garden 1 time per day. Among the rest, 30% used irrigation 2 times per day. Furthermore, there were some respondents who used to irrigate their plants two times in summer and one time in winter season.

4.2.12.2. Weeding

Respondents were classified into 5 categories based on their weeding practice. Findings indicate that two-fifth (40%) of the respondents practiced weeding 2 times per month. Among the rest, 28.33%, 18.33%, 8.33% and 5% respondents practiced weeding at 1 time/month, 3 times/month, <1 time/month and 4 times/month respectively (Table 4.23).

Table 4.23. Distribution of the respondents depending on intercultural operations practiced

Name of Intercultural Operations		Respondents (N = 60)		Rank
		Number	Percent	
Irrigation Pattern	1 time/day	41	68.33	1st
	2 times/day	18	30	2nd
Weeding	<1 time/month	5	8.33	4th
	1 time/month	17	28.33	2nd
	2 times/month	24	40	1st
	3 times/month	11	18.33	3rd
	4 times/month	3	5	5th
Shading	Daily	2	3.33	3rd
	Occasionally	4	6.67	2nd
	Never	54	90	1st
Training/Pruning	1 time/year	39	65	1st
	2 times/year	7	11.67	3rd
	3 times/year	3	5	4th
	Never	12	20	2nd
Thinning	Never	48	80	1st
	Seldom	4	6.67	3rd
	Sometimes	6	10	2nd
	Often	21	35	4th
Decoration	1 time/year	5	8.33	4th
	2 times/year	5	8.33	4th
	3 times/year	2	3.33	5th

	4 times/year	7	11.67	3rd
	>4 times/year	23	38.33	1st
	Never	18	30	2nd
Control of Insect, Pest and Diseases	1 time/month	24	40	1st
	2 times/month	8	13.33	4th
	3 times/month	2	3.33	5th
	4 times/month	1	1.67	6th
	Occasionally	10	16.67	3rd
	Never	15	25	2nd
Drainage System	Never	57	95	1st
	Seldom	3	5	2nd
	Sometimes	0	0	3rd
	Often	0	0	3rd
Others	Never	55	91.67	1st
	Seldom	2	3.33	3rd
	Sometimes	3	5	2nd
	Often	0	0	4th

4.2.12.3. Shading

Most (90%) of the respondents who never shaded their plants. On the other hand, a few (6.67%) of the respondents shade plants occasionally and a very few (3.33%) shaded daily (Table 4.23). The gardeners shade their plants for a few days just after planting of seedlings and later they used to keep their plants in shade for a certain period during the day time.

4.2.12.4. Training/pruning

Majority (65%) of the respondents carried out training and pruning operations 1 time per year, followed by 2 times/year (11.67%) and 3 times/year (5%). There were one-fifth (20%) of the respondents who never practiced training and pruning operations (Table 4.23).

4.2.12.5. Thinning

Most (80%) of the respondents did not carried out thinning operation; whereas 35%, 10% and 6.67% of the respondents carried out thinning operation often, sometimes and seldom respectively (Table 4.23).

4.2.12.6. Decoration

The highest proportion (38.33%) of the respondents carried out decoration >4 times per year, 11.67% for 4 times/year, 8.33% for 1-2 times/year and 3.33% for 3 times/year. About one-third (30%) of the respondents had never carried out decoration (Table 4.23).

4.2.12.7. Control of insect, pest and diseases

Highest proportion (40%) of the respondents took action against insect-pest 1 time/year, 16.67% occasionally, 13.33% 2 times/year, 3.33% 3 times/year and 1.67% 4 times/year (Table 4.23). Furthermore, 25% of the respondents who initiated rooftop garden very recently did not take any action for controlling insect, pest and diseases.

4.2.12.8. Drainage system

Drainage system was practiced very rarely in case of rooftop gardening. Most of the respondents (95%) did not require any drainage operation throughout the year (Table 4.23). There were only a few numbers of respondents who needed drainage operation only during the rainy season.

4.2.12.9. Others

A small number of respondents carried out some other intercultural operations as like as gap filling.

4.2.13. Insect infestation and control

Insect problem was found as a year round problem for rooftop gardening. Major insect name, their infestation time and control measures have been presented in Table 4.24.

4.2.13.1. Insect name

Name of major insects in rooftop garden have been listed in Table 4.24. Majority (65%) of the respondents reported about the infestation of ant followed by mealy bug (36.67%) and green leaf hopper (13.33%) (Table 4.24). Very few (1.67%) of the respondents were complained about termite, fruit borer and Brinjal Shoot and Fruit Borer (BSFB). But a good number (21.67%) of rooftop gardeners who started garden very recently did not face any insect problem.

Table 4.24. Distribution of respondents based on insect infestation in their rooftop garden

Items		Number	Percent	Rank
Insect Name	Ant	39	65	1st
	Mealy bug	22	36.67	2nd
	Whitefly	5	8.33	6th
	Lemon butterfly	2	3.33	8th
	Red pumpkin beetle	6	10	5th
	Green leaf hopper (GLH)	8	13.33	4th
	Aphid	3	5	7th
	Termite, fruit borer, BSFB	1	1.67	10th
	Others	2	3.33	9th
	Not at al	13	21.67	3rd
Stage of Invasion	Summer	4	6.67	3rd
	Rainy season	3	5	4th
	Winter	8	13.33	2nd
	All Season/year round	32	53.33	1st
Control Measure	Finish	17	28.33	1st
	Ash	5	8.33	3rd
	Cultural practice, solution of wheel powder and water, simanta	3	5	4th
	Water, Ripcord	2	3.33	5th
	Neem and mehagoni solution, kerosene, tobacco + water, cucumber sap, warm water, nitro, green tonic, sevin, linothrin, simithion	1	1.67	6th
	Others	5	8.33	3rd
	Not at all	14	23.33	2nd

4.2.13.2. Stage of invasion of insect

The respondents were divided into four categories (i.e. summer, rain, winter and all season) according to the stage of invasion of insect-pest in rooftop garden. Result shows that majority (53.33%) of the respondents faced insect infestation as a year round problem. Insect invasion was also observed in winter (13.33%), summer (6.67%) and rainy season (5%) (Table 4.24).

4.2.13.3. Control measures of insect

Measures for controlling insect-pests have been presented in Table 4.24. The highest proportion (28.33%) of the respondents used finish against ant followed by ash (8.33%), cultural practices i.e. manual control of insects, removal of the infected parts (5%). Minority of the respondents

used the control measures neem + mehagoni solution, kerosene, tobacco + water, cucumber sap, warm water, nitro, green tonic, sevin, linothrin, simithion etc. Other 8.33% respondents used a variety of control measures to protect plants from different insects and pests. But none of them follow any regular pattern to control insect-pest infestation. There were 23.33% rooftop gardeners who did not take any action against insect-pest infestation; though some of them had more or less severe insect infestation.

4.2.14. Disease infestation and control

Winter season was revealed as the main disease infestation time. Table 4.25 figured out the major diseases faced by the rooftop gardeners. Besides these, the number of respondents faced the problem, stage of different disease infestation and their control measures have also been included in that.

4.2.14.1. Diseases name

Highest proportion (35%) of the very recent rooftop gardeners reported that there were no diseases infestations in their rooftop garden. Among the rest, 23.33% of the rooftop gardeners informed about die back followed by viral diseases (21.67%), leaf curling (18.33%), leaf scorching (15%) and fungal diseases (13.33%) (Table 4.25).

4.2.14.2. Stage of invasion of diseases

The highest proportion (43.33%) of the respondents reported that disease infestation was occurred in winter season followed by rainy season (11.67%), all season (10%) and summer (8.33%) (Table 4.25).

4.2.14.3. Control measures of diseases

Two-third (66.67%) of the respondents followed a number of control measures against different diseases such as cultural practices (i.e. removal of disease infested parts), tilt, malathion, vertimex, noin powder, aora, mancozeb, flora, uromil etc. Among all of these, one-fifth (20%) of the respondents prefer various, noin powder, aora, mancozeb, flora, uromil etc. (Table 4.25). Other 5% interviewers used a variety of control cultural practices, 5% used tilt and 3.33% used malathion. The rest 1.67% respondents applied vertimex measures in reference to the nursery

from where they bought plants and from the shops of insecticide and pesticide. One-third (33.33%) of the respondents did not followed any control measure against disease infestation. Some of them had disease problem and others had no disease problem.

Table 4.25. Distribution of the respondents according to the diseases infestation in their rooftop garden

Items		Number	Percent	Rank
Disease Name	Die back	14	23.33	2nd
	Leaf curling	11	18.33	4th
	Leaf scorching	9	15	5th
	Viral disease	13	21.67	3rd
	Fungal disease	8	13.33	6th
	Not at al	21	35	1st
Stage of Invasion	Summer	5	8.33	4th
	Rainy season	7	11.67	2nd
	Winter	26	43.33	1st
	All Season	6	10	3rd
Control Measure	Cultural practice	12	20	2nd
	Tilt	3	5	3rd
	Malathion	2	3.33	4th
	Vertimex, noin powder, aora, mancozeb, flora, uromil	1	1.67	5th
	Others	3	5	3rd
	Not at all	20	33.33	1st

4.2.15. Fertilizers used

List of the fertilizers used by the respondents along with their dose and Number of application have been presented in Table 4.26.

4.2. 15.1. Fertilizer name

Majority (51.67%) of the respondents used cow dung in their rooftop garden followed by compost, urea, MoP, sesame cake, TSP and DAP with the proportion of 43.33%, 36.67%, 25%, 23.33%, 21.67%, and 8.33% respectively (Table 4.26). Minor fertilizers used by the respondents were vermi-compost (5%), birds litter (5%), bio-salary (1.67%) and egg shell (1.67%). But no one follow any regular pattern in fertilizer application. Around 11.67% respondents did not apply any fertilizer in their rooftop garden.

Table 4.26. Distribution of the respondents based on the fertilizers used in their rooftop garden

Items			Number	Percent	Rank
Fertilizer Name	Cow dung		31	51.67	1st
	Compost		26	43.33	2nd
	Sesame cake		14	23.33	5th
	Urea		22	36.67	3rd
	TSP		13	21.67	6th
	MoP		15	25	4th
	DAP		5	8.33	8th
	Vermi-compost, birds litter		3	5	9th
	Bio-salary, egg shell		1	1.67	10th
	Others		7	11.67	7th
Fertilizer Dose	Cow dung	≤0.5 kg/plant	5	8.33	3rd
		0.5-1.0 kg/plant	18	30	1st
		1.5-2.0 kg/plant	8	13.33	2nd
		>2.0 kg/plant	1	1.67	4th
	Compost	≤0.5 kg/plant	6	10	2nd
		0.5-1.0 kg/plant	13	21.67	1st
		1.5-2.0 kg/plant	6	10	2nd
		>2.0 kg/plant	1	1.67	3rd
	Vermi-compost	0.5-1.0 kg/plant	1	1.67	2nd
		1.5-2.0 kg/plant	2	3.33	1st
	Sesame cake	≤0.5 kg/plant	6	10	3rd
		0.5-1.0 kg/plant	13	21.67	1st
		1.5-2.0 kg/plant	7	11.67	2nd
	Urea	≤10 g/plant	3	5	2nd
		10-15 g/plant	2	3.33	3rd
		>15 g/plant	16	26.67	1st
	TSP	≤5 g/plant	2	3.33	3rd
		6-10 g/plant	8	13.33	1st
		>10 g/plant	4	6.67	2nd
	MoP	≤5 g/plant	3	5	2nd
		6-10 g/plant	10	16.67	1st
		>10 g/plant	3	5	2nd
	DAP	≤5 g/plant	2	3.33	2nd
		6-10 g/plant	0	0	3rd
		>10 g/plant	4	6.67	1st
Time of Fertilizer Use	Cow dung	Only during pot preparation	6	10	3rd
		Seasonally	17	28.33	1st
		Monthly	7	11.67	2nd
	Compost	Only during pot preparation	0	0	3rd

		Seasonally	11	18.33	2nd
		Monthly	15	25	1st
	Vermi-compost	Only during pot preparation	1	1.67	1st
		Seasonally	1	1.67	1st
		Monthly	1	1.67	1st
	Sesame cake	Only during pot preparation	4	6.67	2nd
		Seasonally	2	3.33	3rd
		Monthly	6	10	1st
	Urea	Only during pot preparation	0	0	3rd
		Seasonally	9	15	2nd
		Monthly	10	16.67	1st
	TSP	Only during pot preparation	0	0	3rd
		Seasonally	5	8.33	2nd
		Monthly	8	13.33	1st
	MoP	Only during pot preparation	0	0	3rd
		Seasonally	5	8.33	2nd
		Monthly	8	13.33	1st
	DAP	Only during pot preparation	0	0	3rd
		Seasonally	4	6.67	1st
		Monthly	1	1.67	2nd
	Birds litter	Only during pot preparation	0	0	2nd
		Seasonally	1	1.67	1st
		Monthly	1	1.67	1st
	Bio-salary	Only during pot preparation	0	0	2nd
		Seasonally	0	0	2nd
		Monthly	1	1.67	1st

4.2. 15.2. Fertilizer application dose

Highest proportion (30%) of the rooftop gardener applied cow dung at the rate of 0.5-1.0 kg/plant, 21.67% compost at 0.5 to 1.0 kg/plant, 3.33% vermi-compost at 1.5-2.0 kg/plant, 21.67% sesame cake at 0.5-1.0 kg/plant, 26.67% urea at >15 g/plant, 13.33% TSP at 6-10 g/plant, 16.67% MoP at 6-10 g/plant and 6.67% DAP at >10 g/plant. On the other hand, minimum 1.67% respondents applied cow dung at the rate of >2.0 kg/plant, 1.67% compost at

>2.0 kg/plant, 1.67% vermi-compost at 0.5-1.0 kg/plant, 10% sesame cake at ≤0.5 kg/plant, 3.33% urea at 10-15 g/plant, 3.33% TSP at ≤5 g/plant, 5% MoP at ≤5 g/plant and >10 g/plant and 3.33% DAP at ≤5 g/plant (Table 4.26). Though stage of fertilizer applied was included in the interview schedule, none but one respondent in the study area followed it.

4.2.15.3. Time of fertilizer application

Respondent were classified into the categories of only during pot preparation, seasonally and monthly based on the Number of fertilizer application. Highest proportion (28.33%) of the respondents applied cow dung seasonally, compost monthly (25%), sesame cake monthly (10%), urea monthly (16.67%), TSP monthly (13.33%), MoP monthly (13.33%), DAP monthly (6.67%), birds litter both seasonally and monthly (1.67%) and bio-salary monthly (1.67%) in their rooftop garden (Table 4.26).

4.3. Problem Confrontation of Rooftop Gardening in Khulna City

The farmers faced 12 problems to different extent. The most severe problem was excessive heat while transportation was the least severe problem. Some of the major problems were lack of proper nourishment, roof load, lack of sunlight and shade of other nearby buildings etc.

Other main problems included lack of proper sunlight and shade of other buildings (45%), insect-pest and disease infestation (43.75%) and lack of proper training, skill and experience (40%) (Table 4.27). On the other hand, the least severe problems were appeared as the transportation problem (2.08%), lack of proper marketing facilities (5.42%), lack of suitable planting materials (7.50%) and so on. There were a few people who talked about the problem of lack of time and scarcity of water; whereas a large number of people consider rooftop gardening as a laborious work.

Table 4.27. Severity of different problem confrontation of the respondents in rooftop gardening

Problems	Number of Respondents Faced the Problem	Individual Problem Score	Problem Confrontation Index (PCI)	Rank
1. Lack of sufficient area	25	60	25.00	7th
2. Lack of proper management	23	46	19.17	8th
3. Insect, pest and disease infestation	55	105	43.75	5th
4. Lack of proper sunlight and shade of other buildings	57	108	45.00	4th
5. Disturbance by child, pet animals and thieves	25	34	14.17	9th
6. Transportation problem	2	5	02.08	12th
7. Lack of proper marketing facilities	7	13	05.42	11th
8. Lack of proper training, skill and experience	49	96	40.00	6th
9. Lack of proper nourishment	60	209	87.08	2nd
10. Lack of suitable planting materials	11	18	07.50	10th
11. Problem of roof load	59	175	72.92	3rd
12. Problem of excessive heat	60	220	91.67	1st

The problem confrontation (PC) scores of the respondents ranged from 12-29 with an average and standard deviation being 18.15 and 3.61 respectively. Based on PC scores, the respondents were distributed into different categories as shown in Table 4.28. About four-fifth (78.3%) of the respondents marked out medium severe problem confrontation in rooftop gardening and the rest, 21.7% rated problems as highly severe. The respondents of the areas were faced as much as 12 problems in different extent. Where, the most severe problems were listed as excessive heat, lack of proper nourishment and roof load with the PCI percentage of 91.67%, 87.08% and 72.92% respectively (Table 4.27).

Table 4.28. Distribution of the respondents according to the severity of problem confrontation

Severity	Score (Number)	Respondents		Range	Mean	*Sd
		Number	Percent			
Low	≤10	0	0			
Medium	10-20	47	78.3	12-29	18.15	3.61
High	>20	13	21.7			
Total		60	100			

*Sd = Standard Deviation

4.4. Relationship between the Selected Characteristics of the Respondents and Their Problem Confrontation in Rooftop Gardening

Spearman's Rank Order Co-efficient of Correlation (ρ) was used to explore relationship among the variables. Table 4.29 furnished the relationship between the 9 selected personal socio-economic characteristics and the problem confrontation. Among the 9 selected personal characteristics only age of the respondents showed a significant positive relationship with the problem confrontation at 5% level (Table 4.29). As Table 4.1 indicated the majority of the respondents from the age group of old (>50 year); so it can be explained in such a way, the higher the age of the respondents the higher they experienced about rooftop gardening. Thus, they are able to identify more problems related to the sector. Other eight variables i.e. family size, organizational participation, annual income, extension contact and their knowledge on rooftop gardening had non-significant and positive relationship with problem confrontation. Besides, respondents educational qualification, experience in rooftop gardening and cosmopoliteness showed inverse relationship with the problem confrontation.

Table 4.29. Computed rank order co-efficient of correlation (ρ) between the selected characteristics and problem confrontation

Selected Characteristics (Independent Variables)	Dependent Variable (Focus Variable)	Coefficient of Correlation (ρ)
Age	Problem confrontation of rooftop gardening	0.289*
Educational qualification		-0.071^{NS}
Family size		0.015^{NS}
Experience in rooftop gardening		-0.003^{NS}
Organizational participation		0.073^{NS}
Annual income		0.030^{NS}
Extension contact		0.097^{NS}
Cosmopoliteness		-0.024^{NS}
Knowledge on rooftop gardening		0.206^{NS}

NS = Non-significant, *Correlation is significant at the 0.05 level (2-tailed).

4.5. Efficacy of Rooftop Gardening in Ambient Environmental Reclamation

This sub-section deals with the environmental impacts of rooftop gardening on its ambient environment. Previous literature proved that rooftop gardens have significant beneficial impacts on surrounding environment. Some studies show that green roofs have thermal benefits in building and urban areas (Susca et al., 2011; Fioretti et al., 2010; Santamouris et al., 2007;

Kumar and Kaushik, 2005; Lazzarin et al., 2005; Liu, 2002;). Green roofs contribute to the thermal benefits in buildings and their surrounding environments (Wong et al., 2003). Shade provided by plants reduces the cooling load of the building and also help to reduce the buildings contribution to the urban heat (Ong, 2003). Again, green roofs significantly reduce energy use efficiency in buildings with poor insulation values both in summer cooling and winter heating (Castleton et al., 2010). Green walls and roofs help to reduce urban heat, improve air quality and storm-water runoff (Greenscreen, 2012; Carter and Butler, 2008).

To compare roofs with plants and roofs without plant, 32 green roofs and empty roofs were selected purposively from the study area and the findings have been presented in Figure 4.1, Figure 4.2 and Figure 4.3 respectively.

Figure 4.1 presented temperature in green roof of 32.78 °C in case of empty roof of 32.93 °C. Again, relative humidity in green roof is of 64.1%; whereas 63.3% in empty roof (Figure 4.2). An average of 1204 lux and 1677 lux were light intensity from green roof and empty roof, respectively (Figure 4.3). As the results indicate, temperature (difference is not so high) and light intensity are high in empty roof than green roof; where relative humidity is much higher in green roof compare to empty roof.

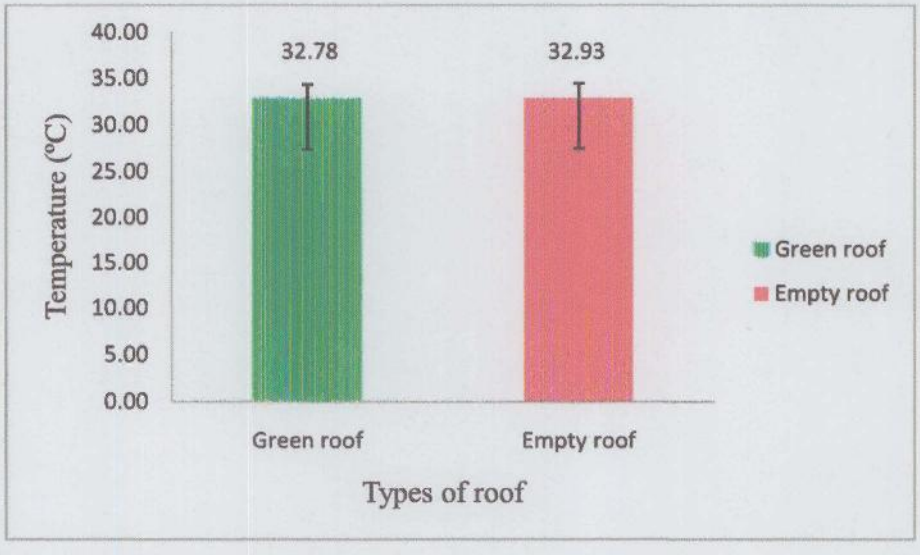

Figure 4.1. Comparison of temperature between green roof and empty roof

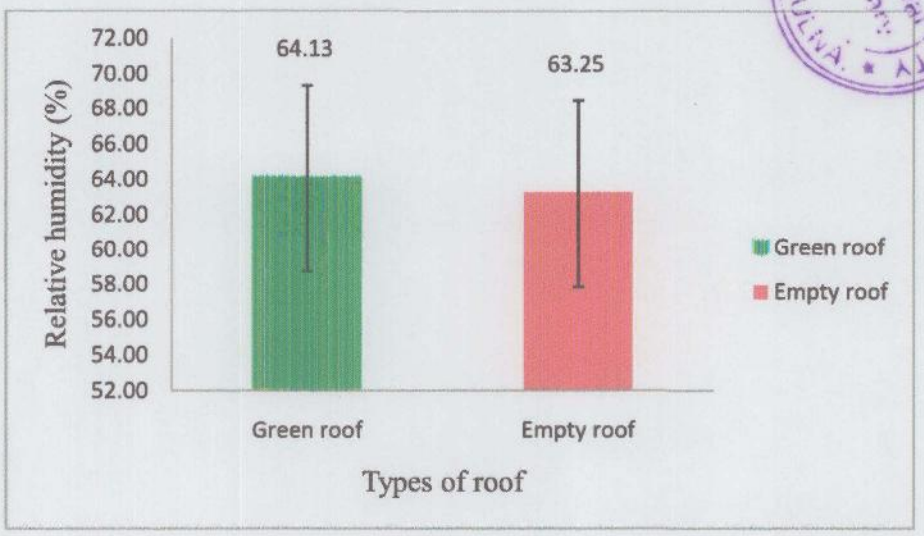

Figure 4.2. Comparison of relative humidity between green roof and empty roof

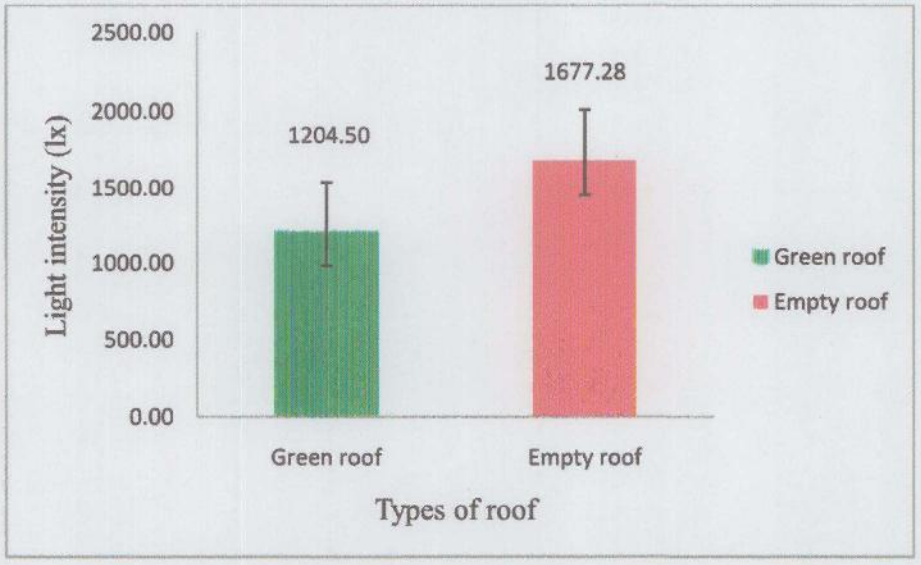

Figure 4.3. Comparison of light intensity between green roof and empty roof

Speak (2013) also found the similar result. The reason behind these might be that, traditional buildings soak up direct solar radiation or light intensity. On the other hand, plants on rooftop absorb and transform sunlight and regulate ambient temperatures through evapotranspition. Again, plants act as a solar filter and have the ability to prevent the absorption of heat radiation into the materials of the building (Perini et al., 2011). Furthermore, implementation of green roofs shows potential temperature reductions of about 0.3 to 3.0 °C (Santamouris, 2014).

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

Popularity of rooftop gardening is increasing day by day because of its ability to provide fresh and healthy vegetables and fruits. Besides these, it has environmental, economical and social benefits. The current study was conducted to collect information on present scenario and problem confrontation in rooftop gardening in Khulna City; to assess the effects of rooftop garden on the surrounding environment and to explore relationship between selected characteristics of the rooftop gardener with their problem confrontation.

Inhabitants of Nirala and Sonadanga who had garden on their rooftop were the population for the research work. Randomly selected 60 respondents were the sample of the study. A semi-structured interview schedule was used as the instrument for collection of data from the respondents. Data were collected from the period of March to May of 2018. Problem confrontation of rooftop gardening was the dependent variable and nine selected characteristics were the independent variables of the study. Number, number, percent, range (minimum, maximum), mean, standard deviation etc. were the statistical measures in describing the selected dependent and independent variables. Spearman's Rank Order Co-efficient of Correlation (ρ) was used for determining the relationship between the independent and dependent variables.

Two-fifths of the respondents were old aged (40%) and low experienced in rooftop gardening (40%), majority were highly educated (61.6%), holding small sized families (55%), having no organizational participation (58.3%), with an annual income 15 to 800 ('000BDT). Majority of them also showed low extension contact (66.7%), low cosmopoliteness (81.7%), however having high knowledge on rooftop gardening (76.7%). while about one-fourth (23.3%) had medium knowledge on rooftop gardening. The highest proportion (41.67%) of the respondents initiated rooftop gardening recently (i.e., during 2010-2015) having medium sized roof area (1001-2000 ft^2., 56.67%) as majority (65%) of the respondents owned small roof area ($\leq$1000 ft^2) that is suitable for gardening. Actually majority (56.67%) of them hold small roof area ($\leq$500 ft^2) and majority (45%) of the gardeners obtain low production ($\leq$10 $kgyr^{-1}$) from their garden, with an annual income ranging from $\leq$500 BDT to >1000 BDT from the garden. However, majority

(56.67%) of the respondents spent high amount of taka for their gardening. Highest proportions (98.33%) of the respondents consider rooftop gardening as hobby having a preference for flowers (83.33%). Almost all (100%) of the respondents practiced irrigation and weeding as intercultural operations in their garden. Ant (65%), mealy bug (36.67%) and green leaf hopper (13.33%) were the major insects in these gardens. On the other hand, die back (23.33%), viral diseases (21.67%), leaf curling (18.33%), leaf scorching (15%) and fungal diseases (13.33%) were main diseases. The gardeners use cow dung, compost, urea, MoP, seasum cake, TSP and DAP as fertilizers in the gardens.

Main problems faced by rooftop gardeners were excessive heat problem (91.67%), lack of proper nourishment (87.08%), roof load problem (72.92%) and lack of proper sunlight and shade of other buildings (45%). Transportation problem was revealed as the least severe problem (2.08%) among the twelve problems.

It was also revealed that, only age of the respondents showed significant positive relationship to the problem confrontation. Other independent variables indicated non-significant relation with problem confrontation.

From the study it revealed that temperature, relative humidity and light intensity are not significantly different in green roof and empty roof.

5.2. Conclusion

Reviewing the overall results, the conclusion can be made that rooftop gardening is becoming popular among all aged and all classes of people in urban areas. All most all of the respondents had more or less experience and knowledge on rooftop gardening. Most of the people consider rooftop gardening as a hobby with next importance of its aesthetic appeal. Flower plants were the first choice followed by vegetables, fruits and medicinal plants. According to the cost return analysis, most of the rooftop gardeners were not economically viable from the garden. However, rooftop gardening have a significant impact on food security, income generation and meeting nutritional deficiency to the gardeners. It has the possibility to generate employment and economic facilities through its backward and forward linkages. Lack of proper nourishment, excessive heat and roof load were exposed as the most common and severe problems. It requires adequate training and motivation to encourage people to cultivate plants on rooftop with

sustainable management. In that case, Government and NGOs could play a vital role by providing training and motivate people with technical aspects of rooftop gardening. Furthermore, it can be concluded that rooftop garden has the aspects of social, recreational, economical and environmental benefits.

5.3. Recommendations for Further Study

Research on rooftop gardening faced certain shortcomings. Limitations of this present study need to be acknowledged. Further research efforts, public education and communication of green roof benefits can help policymakers to overcome institutional barriers to this technology. Considering the scope and limitations of present study and observation the following recommendations are made for further study:

- The study was confined in areas of Nirala and Sonadanga of Khulna City Corporation. Similar research need to be conducted in other cities in Bangladesh.
- Data on rooftop gardening and on different weather parameters were collected at different point and time during data collection that demands further research to figure out real impacts of green roof on its ambient environment.
- Further study need to measure impacts of green roofs on its ambient air ingredients such as O_2, CO_2, SO_2, NO, NO_2, NOx, CO and dust particles.
- More research need to focus to find out relationship between urban green space and health both at a personal and community level.
- Rooftop gardeners' use a number of chemicals like insecticides, pesticides, fertilizers etc. on their garden those have negative impact on environment. So, it demands further research to figure out the negative impacts of rooftop gardening on the environment.

CHAPTER VI

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APPENDIX I

ENGLISH VERSION OF THE INTERVIEW SCHEDULE

AGROTECHNOLGY DISCIPLINE
KHULNA UNIVERSITY
KHULNA

PRESENT SCENARIO AND PROBLEM CONFRONTATION OF ROOFTOP GARDENING AND ITS EFFICACY IN AMBIENT ENVIRONMENT RECLAMATION IN KHULNA CITY

(Data provided by you will be used only for research purpose. Your identity will be concealed and other research ethics will be maintained.)

Sample Number: ..... **Date:** ...../...../ 2018

Respondent Name: .....

Fathers'/ Husbands' Name: .....

Location/ Town: Sonadanga / Nirala **Ward:** .....

Mobile no.: +8801...

PART: A

INDEPENDENT VARIABLES

1. **Age:** .....years
2. **Educational Qualification:**
    a. Do not know read and write
    b. Only name signature
    c. Passed class .....
3. **Family Size:** .....
4. **Experience in Rooftop Gardening:** .....years

5. **Organization Participation:**

Name of Organization	Degree of Involvement			
	No Involvement	Member	Executive member	Executive officer
Youth organization				
Farmers club				
Committee (mosque/ temple/ church)				
Institutional organization				
NGO				
Others				

6. **Annual Income:**

Source of income	Amount (TK)
Agriculture	
Business	
Service	
Day laborer	
Others	

7. **Extension Contact:**

Serial No.	Media	Extant of Contact			
		Never	Seldom	Sometimes	Often
1.	Group discussion				
2.	DAE officers				
3.	NGOs				
4.	Neighbors/ Relatives				
5.	Radio/TV/Newspaper/Leaflets				
6.	Agricultural fair				

8. **Cosmopoliteness:**

Places	Degree of Visitation			
	Never	Seldom	Sometimes	Often
Own city				
Other city				
Village				
Abroad				

9. **Knowledge on Rooftop Gardening:**
   a. What type of plants are more efficient for rooftop gardening? .....
   b. What type of growth media, container are used? .....
   c. What is the number of growth media would be needed per square meter? .....
   d. Name 2 weeds related to rooftop gardening. .....
   e. Name 2 insects related to rooftop gardening. .....
   f. Name 2 disease related to rooftop gardening. .....
   g. Name 2 shade loving plants. .....
   h. Name 2 vegetables suitable for rooftop gardening. .....
   i. Name 2 fruits suitable for rooftop gardening. .....
   j. Name 2 varieties suitable for rooftop gardening. .....

PART: B
PRESENT STATUS OF ROOFTOP GARDENING IN KHULNA CITY

1. **Initiation of Rooftop Gardening:**

Year	Total roof area	Suitable roof for gardening	Roof area under gardening	Total production	Total income	Total expenditure	Net income
2012							
2013							
2014							
2015							
2016							
2017							

2. **Purpose of Rooftop Gardening:**
   a. Hobby
   b. Aesthetic
   c. Vegetable production
   d. Fruit production
   e. Ecological balance
   f. Income generation
   g. Others

3. **Plant Types and Number:**

Sl. no.	Plant Types	Plant Name	Number
1.	Flowers		
2.	Vegetables		
3.	Fruits		
4.	Medicinal plants		
5.	Others		

4. **Intercultural Operations:**

Sl. no.	Operations	Number
1.	Irrigation	
2.	Weeding	
3.	Shading	
4.	Pruning	
5.	Training	
6.	Thinning	
7.	Decoration	
8.	Control of insects and diseases	
9.	Drainage system	
10.	Others	

5. **Insect Infestation and Control:**

Sl. no.	Name of Insect	Stage of Invasion	Control Measure
1.			
2.			
3.			
4.			
5.			

6. **Disease Infestation and Control:**

Sl. no.	Name of Disease	Stage of Invasion	Control Measure
1.			
2.			
3.			
4.			
5.			

7. **Fertilizer Use:**

Sl. no.	Name of Fertilizer	Dose	Number	Stage
1.				
2.				
3.				
4.				
5.				