

**MINOR FRUIT TREES IN HOMESTEAD AND ITS IMPACT ON FOOD AND  
NUTRITIONAL SECURITY: A CASE STUDY OF NORTHERN BANGLADESH**

**A THESIS**

**BY**

**HABIBULLAH AHAMMED SHAFI**

**STUDENT NO. 1620001**

**SEMESTER: January-June, 2024**

**SESSION: 2023-24**

**MASTER OF SCIENCE (MS)**

**IN**

**AGROFORESTRY AND ENVIRONMENT**



**DEPARTMENT OF AGROFORESTRY AND ENVIRONMENT  
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY  
DINAJPUR-5200**

**JUNE, 2024**

**MINOR FRUIT TREES IN HOMESTEAD AND ITS IMPACT ON FOOD AND  
NUTRITIONAL SECURITY: A CASE STUDY OF NORTHERN BANGLADESH**

**A THESIS**

**BY**

**HABIBULLAH AHAMMED SHAFI**

**STUDENT NO. 1620001**

**SEMESTER: January-June, 2024**

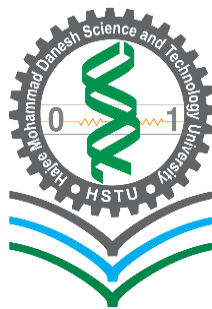
**SESSION: 2023-24**

**Submitted to the Department of Agroforestry and Environment  
Hajee Mohammad Danesh Science and Technology University, Dinajpur  
In partial fulfillment of the requirements for the degree of**

**MASTER OF SCIENCE (MS)**

**IN**

**AGROFORESTRY AND ENVIRONMENT**



**DEPARTMENT OF AGROFORESTRY AND ENVIRONMENT  
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY  
DINAJPUR-5200**

**JUNE, 2024**

**MINOR FRUIT TREES IN HOMESTEAD AND ITS IMPACT ON FOOD AND  
NUTRITIONAL SECURITY: A CASE STUDY OF NORTHERN BANGLADESH**



**A THESIS**

**BY**

**HABIBULLAH AHAMMED SHAFI**

**STUDENT NO. 1620001**

**SEMESTER: January-June, 2024**

**SESSION: 2023-24**

**Approved as to style and content by**

---

**(Md. Manik Ali)**

**Supervisor**

---

**(Professor Dr. Md. Shafiqul Bari)**

**Co-Supervisor**

---

**(Professor Dr. Md. Shoaibur Rahman)**

**Chairman**

**DEPARTMENT OF AGROFORESTRY AND ENVIRONMENT  
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY  
DINAJPUR-5200**

**JUNE, 2024**

***DEDICATED***  
***TO MY***  
***BELOVED PARENTS***  
***AND***  
***HONORABLE TEACHERS***

## **CERTIFICATE OF DECLARATION**

I affirm that the research work presented in this thesis entitled "**MINOR FRUIT TREES IN HOMESTEAD AND ITS IMPACT ON FOOD AND NUTRITIONAL SECURITY: A CASE STUDY OF NORTHERN BANGLADESH**" is solely my own work and has not been submitted for any previous academic degree. Any direct quotations used in this thesis have been appropriately cited with quotation marks, and all sources of information have been duly acknowledged through references to the respective authors.

---

**(Habibullah Ahammed Shafi)**

Student No. 1620001

MS Session: January-June, 2023

Thesis Semester: January-June, 2024

Department of Agroforestry and Environment

Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200,  
Bangladesh

## ACKNOWLEDGEMENTS

*First of all, the author expresses his sincere gratitude to the Almighty Allah whose endless kindness mercy absolutely enabled to accomplish his research work successfully and to prepare the thesis.*

*I express my deepest sense of gratitude, love and ever indebtedness to my revered teacher and supervisor **Mr Md. Manik Ali**, Assistant Professor, Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University, Dinajpur, for his ingenious suggestions, guidance, direction whenever I needed it to complete this study and also for his constructive criticism and meticulous review of the manuscript.*

*I sincerely express my heartiest respect, deepest gratitude and the profound appreciation to my co-supervisor **Professor Dr. Md. Shafiqul Bari**, Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University, Dinajpur, for his co-operation and helpful suggestions to conduct the research work and in the preparation of this manuscript.*

*I also express my respect and thankfulness to all teachers of the Department of Agroforestry and Environment, HSTU, Dinajpur for their good advices and co-operation during the period of this study.*

*Finally, I express my most sincere gratitude to my beloved parents, friends and well-wishers for their inspiration and co-operation throughout the period of my study.*

*June, 2024*

*The Author*

## ABSTRACT

This research investigates into the significant role of minor fruit trees within homestead agroforestry systems as crucial components for fostering food and nutritional security among rural communities facing economic challenges. Drawing on robust empirical evidence from impoverished communities, the research emphasizes the diverse and multi-functional benefits derived from the strategic integration of minor fruit trees. This study investigates the demographic characteristics, botanical diversity, productivity, and socio-environmental impacts of minor fruit species cultivated in rural households. The study investigate the demographic profile of the homesetead. The sample population has a mean age of 45.87 years (SD = 8.381), an average of 6.57 years of schooling (SD = 4.951), and a mean annual income of 107.897 thousand BDT (SD = 59.319). The households have an average family size of 4.99 (SD = 1.398) and homestead size of 0.159 hectares (SD = 0.09). The Botanical diversity assessments show significant clustering of minor fruit species within the Myrtaceae, Arecaceae, and Sapotaceae families, with Boroï (*Spondias pinnata*) emerging as the most prevalent species (relative prevalence of 1.43). Productivity evaluations reveal Tal as the highest-yielding species, averaging 300 units per tree, followed by Kamranga, Jam, and Boroï. Monthly fruit productivity varies seasonally, peaking in July (60 kg) and dipping in December (2.16 kg). The socio-environmental analysis highlights minor fruits' significant contributions to income diversification, nutritional security, and local economic growth. However, constraints such as small homestead size (CFI = 471), pest and disease susceptibility (CFI = 428), and water requirements (CFI = 419) challenge production. The study concludes that integrating minor fruit trees into agroforestry systems enhances food and nutritional security for economically disadvantaged rural communities. These findings advocate for policies promoting the cultivation of high-yield species and sustainable agricultural practices to boost socio-economic resilience and environmental sustainability.

**Keywords:** Minor fruit trees, Homestead agroforestry, Food and nutritional security, Rural poor and Multi benefit

## CONTENTS

CHAPTER	TITLE	PAGE NO.
	<b>ACKNOWLEDGEMENT</b>	<b>i</b>
	<b>ABSTRACT</b>	<b>ii</b>
	<b>CONTENTS</b>	<b>iii-iv</b>
	<b>LIST OF TABLES</b>	<b>v</b>
	<b>LIST OF FIGURES</b>	<b>vi</b>
	<b>LIST OF APPENDICES</b>	<b>vii</b>
<b>CHAPTER 1</b>	<b>INTRODUCTION</b>	<b>1-2</b>
<b>CHAPTER 2</b>	<b>LITERATURE REVIEW</b>	<b>3-13</b>
2.1	Food and nutritional security on a global scale	3
2.2	Homestead and its Composition	4
2.3	Minor indigenous fruits (IFs) in Bangladesh	5
2.4	Dietary importance of minor indigenous fruits	6
2.5	Biochemical composition	7
2.6	Portion that can be consumed	7
2.7	Amino acid	8
2.8	The overall amount of sugar	8
2.9	Carbohydrate	8
2.10	Components of minerals	9
2.11	The amount of vitamins	11
2.12	Phenolic content	12
2.13	The seasonal availability of lesser-known native fruits and vegetables	12
2.14	The current production situation of minor indigenous fruits and in Bangladesh	12
2.15	Constraints for the consumption of minor indigenous fruits in Bangladesh	13
2.16	Methods to overcome the limitations	3
<b>CHAPTER 3</b>	<b>MATERIALS AND METHODS</b>	<b>14-17</b>
3.1	Study Area	14
3.2	Population Sampling	15
3.3	Measurement of independent variables	15

## CONTENTS (Contd.)

CHAPTER	TITLE	PAGE NO.
3.3.1	Age	15
3.3.2	Sex	15
3.3.3	Education	16
3.3.4	Occupation	16
3.3.5	Family size	16
3.3.6	Homestead size	16
3.3.7	Annual income	16
3.4	Measurement of dependent variable	16
3.5	Data Collection and Analysis	17
3.6	Data Collection and Analysis	17
<b>CHAPTER 4</b>	<b>RESULTS</b>	<b>18-26</b>
4.1	Demographic profile of the household	18
4.2	Common minor fruit species found and their relative prevalence in the house hold	19
4.3	Productivity of Some minor fruit Species found in the study area	20
4.4	Monthly average fruit productivity per house hold	21
4.5	Comprehensive Evaluation of Tree Species for productivity and environmental benefit	22
4.6	Socio-Environmental impacts of minor fruits on the household	24
4.7	Constraint faced by rural household for Minor fruit production	25
<b>CHAPTER V</b>	<b>SUMMARY, CONCLUSION AND RECOMMENDATIONS</b>	<b>27-28</b>
5.1	Summary	27
5.2	Conclusion	28
5.3	Recommendations	28
	<b>REFERENCES</b>	<b>29-36</b>
	<b>APPENDICES</b>	<b>37-45</b>

## LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
1	List of minor indigenous fruits	6
2	Comparison of selected major and minor indigenous fruits in respect to biochemical composition	7
3	Macro and micromineral composition of selected major and minor indigenous fruits	10
4	Vitamin constitutions of some minor indigenous fruits of Bangladesh	11
5	Demographic profile of the household in the study area	19
6	Botanical Diversity and Relative Prevalence of different Minor Fruits Species in the study area	20
7	Comprehensive Evaluation of Tree Species for productivity and environmental benefit	23
8	Socio-Environmental impacts of minor fruits on the household	26

## LIST OF FIGURES

<b>FIGURE NO.</b>	<b>TITLE</b>	<b>PAGE NO.</b>
1	Map Showing study area	14
2	Productivity of different minor fruit Species	21
3	Monthly average fruit productivity per house hold	22
4	Socio-Environmental impacts of minor fruits on the household	25

## LIST OF APPENDICES

APPENDIX NO.	TITLE	PAGE NO.
I	Interview schedule used in this study to assess farmer's socioeconomic condition	37-41
II	Photographs of Experimental Site	42-45

# CHAPTER 1

## INTRODUCTION

Bangladesh, characterized by its dense population and agrarian economy, grapples with issues of malnutrition and limited dietary diversity, particularly in rural areas (BBS, 2016; WB, 2019; Islam *et al.*, 2022). Traditionally, the country's agricultural focus has revolved around major staple crops, often disregarding the untapped potential of minor fruit trees that thrive in the local climate (Nasim *et al.*, 2017). However, these trees possess attributes that render them well-suited for integration into the homesteads of the rural poor (Melo *et al.*, 2013). Small-scale, versatile, and resilient, minor fruit trees have the capacity to augment household diets with a diverse array of nutrients while requiring minimal resources and space (Jamnadass *et al.*, 2006; Schreckenberg *et al.*, 2011). In the rural landscapes of the country, where persistent challenges to food and nutritional security persist, the cultivation of minor fruit trees in homesteads emerges as a promising solution (Baldermann *et al.*, 2016; Mazumdar, B. C. 2004). The agrarian setting of Bangladesh, characterized by small landholdings and limited access to modern agricultural technologies, necessitates a shift towards sustainable and locally adaptable practices (Sarker *et al.*, 2021). The cultivation of minor fruit trees aligns seamlessly with this need, presenting a holistic approach that not only addresses nutritional deficiencies but also fosters resilience in the face of climate variability and economic uncertainties (Roy and Bauri 2015).

Rural communities, grappling with limited access to diverse and nutritious food sources, confront an ongoing struggle against malnutrition and food insecurity (Roy *et al.*, 2015; Monirul *et al.*, 2018). Conventional agriculture, historically fixated on major staple crops, has overlooked the extensive array of minor fruit trees flourishing in diverse ecosystems (Nasim *et al.*, 2017). These lesser-known trees, comprising a variety of fruits with high nutritional value, harbor the potential to significantly contribute to dietary diversity and overall well-being (Fentahun, and Hager 2009). The integration of minor fruit trees into homesteads presents an innovative and sustainable solution, aligning with the principles of agroecology and diversifying local food production (Goenster *et al.*, 2009). Moreover, the distinctive characteristics of minor fruit trees render them well-suited for homestead cultivation. Their adaptability to small spaces, low maintenance requirements, and ability to thrive in diverse climatic conditions make them an attractive

option for resource-constrained rural households.( Chivengeet *al.*, 2015 ) Capitalizing on the potential of these trees not only ensures a more resilient food system but also yields additional benefits such as income generation, biodiversity conservation, and ecosystem services (Omotayo and Aremu, 2020).

Furthermore, within the country context, where agriculture is a cornerstone of the economy and livelihoods are intricately linked to the land, the integration of minor fruit trees signifies a pathway towards diversified income sources (Aworh, 2015). Beyond nutritional gains, this article underscores the economic resilience that can be fostered by embracing minor fruit trees, thereby elevating their importance in the broader spectrum of rural development initiatives. In essence, this study serves as a call to action, advocating for the recognition and promotion of minor fruit trees as catalysts for holistic rural development, improved nutrition, and enhanced food security within the unique socio-economic landscape. The findings also offer practical insights for policymakers, agricultural extension workers, and community leaders seeking sustainable solutions to enhance the well-being of vulnerable rural poor communities. As climate change impacts become more pronounced, the resilience of rural communities is increasingly vital. Minor fruit trees can play a role in enhancing this resilience by providing a stable food source that is often more tolerant to changing climatic conditions compared to annual crops. Despite their potential, minor fruit trees are under-researched and under-utilized. There is a need for comprehensive studies that highlight their benefits and provide evidence-based recommendations for their promotion and management in rural homesteads. Therefore this study was conducted with the following objectives

#### Objectives of the study

1. To analyze the nutritional benefits provided by these minor fruit trees and their impact on the dietary diversity and nutritional security of rural households.
2. To explore the economic advantages that minor fruit trees offer to rural poor communities, including potential income from the sale of fruit and other tree products.
3. To assess the ecological roles of minor fruit trees in homesteads, such as soil improvement, biodiversity enhancement, and microclimate regulation.

## CHAPTER 2

### LITERATURE REVIEW

The primary focus of this study was to assess minor fruit trees in homesteads and their role in nurturing food and nutritional security through their multifunctional benefits, with evidence gathered from the rural poor. This chapter provides a concise overview of previous research and the opinions of relevant scholars, collected from various sources such as books, journals, theses, and reports. The most pertinent information concerning this study is supplied in this chapter.

#### **2.1 Food and nutritional security on a global scale**

According to Buttriss and Riley (2013), the world's population is expected to exceed nine billion people by the year 2050. The challenge of providing food for such a large number of people creates severe concerns over the quality of food and the safety of food supplies. There are still approximately 490 million people around the world who are undernourished, with 281 million of them residing in South Asia (Li & Siddique, 2020). This is despite the fact that the proportion of undernourished people in the Asia-Pacific region has decreased by half between the years 2000 and 2015 in accordance with the Millennium Development Goals. According to Akhtar (2016), the most common consequence of malnutrition is stunting, and ninety percent of children who are stunted are found in thirty-six different nations around the world. Asia is home to around 70.0% of the world's youngsters who are suffering from malnutrition. Under the age of five, Bangladesh had approximately 20.57% underweight children, 24.67% stunted children, 9.75% wasted children, and 6.80% overweight children in 2019 (Hossain *et al.*, 2020). These statistics were a direct result of malnutrition. The country of Bangladesh is also one of the five countries that suffer from serious deficits in micronutrients. Every every day, the gap that exists between the expansion of the human population and the development of the food supply continues to widen dramatically. In addition, a significant number of individuals often consume a diet that is high in cereal, which ultimately results in deficits in several nutrients. The result of this is that it has been extremely challenging to provide future generations with access to sources of nutrition that are not only safe but also healthful. Therefore, in order to satisfy the desire for food and nutrition, the researchers stressed the importance of searching for some alternative

food sources that are not only healthy but also easily available. These sources should not include conventional meals. According to Shaheen *et al.* (2017), minor indigenous fruits and vegetables have emerged as a noteworthy alternative to conventional options for food consumption. Due to the fact that they are easily accessible in the local area, they are within the price range of the low-income portion of the economy. For the purpose of fully utilizing the contribution that minor indigenous fruits and vegetables provide to food and nutritional security, it is necessary to incorporate them into the diet of the general population.

## **2.2 Homestead and its Composition**

Bangladesh The country is situated within the latitudes of 20°34' and 26°38' north and the longitudes of 88°01' and 92°41' east. It has a subtropical monsoon climate and is mostly characterized by rural areas and agriculture. With an area spanning 148,460 square kilometers and a population over 165 million, this nation ranks as the seventh most populated country globally (The World Factbook, 2023). The agricultural sector, which encompasses 20,810,000 acres of net cultivated area, contributed 14.2% to the GDP in 2017, making it the largest employment sector (BBS, 2022). The fruit cultivation area spans 1,008,190 acres and yields a total production of 4,939,092 metric tons (MT) (BBS, 2022). The market is primarily dominated by five fruits - mango, banana, jackfruit, watermelon, and papaya - which collectively contribute to over 73% of the entire annual fruit production (The Business Post, October 6, 2021, and June 3, 2022).

Baul *et al.*, (2021) acknowledges that the homestead of Bangladesh cover a total area of 0.27 million hectares, which accounts for 10% of the total wooded land. These forests have the capacity to store carbon from the atmosphere and preserve biodiversity. However, there is a lack of credible estimation of carbon stocks and the diversity of tree species in small-scale forestry methods. Due to the fact that REDD+ and other comparable mechanisms focus on large-scale forests, this may interfere with their ability to successfully implement their programs.

This research specifically aims to analyze the composition and function of homestead forests in the Chittagong Hill Tracts of Bangladesh. We assess the potential environmental impact of forests in mitigating carbon emissions resulting from the substitution of fossil fuels with fuelwood. The techniques involve conducting random surveys. In the area being studied, a total of 176 homestead forests and dwellings were

identified. These structures were considered important for the research. They were found at three different hill elevations: low, middle, and high. The results suggest that there is a combined total of 71 species of trees and bamboo that provide specific or versatile value. The presence of these tree species and bamboo in homestead forests contributes to a diverse and abundant collection of tree flowers. The study's findings reveal that the species are uniformly dispersed throughout the forests, as evidenced by a 0.91 evenness rating (Baul *et al.*, 2021a).

Despite an increase in production compared to prior years, it remains inadequate to satisfy the demand generated by a population expanding at a pace of approximately 1.03% per year (United Nations - World Population Prospects, 2022). According to Rahman *et al.* (2022), the average Bangladeshi consumes 212g of fruits and vegetables per day, which falls short of the recommended daily intake of 400g set by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO). This results in a significant disparity in the accessibility of calories, proteins, minerals, and vitamins. Furthermore, the issue of malnutrition is highly common in the country. Approximately 40% of individuals are known to experience vitamin-A deficiency, while 91% suffer from vitamin-C deficiency. Additionally, 30% of people lack adequate amounts of essential minerals such as calcium, iron, and phosphorus. The prevalence of infant mortality and health issues in developing children and pregnant women is elevated as a result of a lack of essential micronutrients and vitamins (Bhuyan and Uddin, 2010). These deficits can be significantly reduced by enhancing the accessibility of fruits and vegetables, as they are crucial constituents of a well-rounded human diet and play a pivotal role in attaining global food security by supplying essential nutrients, vitamins, and minerals.

### **2.3 Minor indigenous fruits (IFs) in Bangladesh**

Bangladesh possesses an immense potential to produce wide range of tropical and sub-tropical fruits. A total of 255 minor edible fruit yielding species belonging to 149 genera under 61 families have been documented (Pasha & Uddin, 2019). Table 1 contains the botanical information of 20 of the fruit species under minor indigenous category.

**Table 1. List of minor indigenous fruits**

Sl. no.	English name	Local name	Scientific name	Family
1.	Aonla	Aamlaki	<i>Phyllanthus emblica</i> L.	Phyllanthaceae
2.	Hog plum	Amra	<i>Spondias mombin</i> L.	Anacardiaceae
3.	Cucumber tree	Bilimbi	<i>Averrhoa bilimbi</i> L.	Oxalidaceae
4.	Elephant apple	Chalta	<i>Dillenia indica</i> L.	Dilleniaceae
5.	Monkey Jack	Dewa	<i>Artocarpus lakoocha</i>	Moraceae
6.	Citron	Jara lebu	<i>Citrus medica</i>	Rutaceae
7.	Melanesian papeda	Satkara	<i>Citrus macroptera</i>	Rutaceae
8.	Ber	Sour kul	<i>Ziziphus mauritania</i>	Rhamnaceae
9.	Toikar	Toikar	<i>Garcinia pedunculata</i>	Clusiaceae
10.	River ebony	Deshi gab	<i>Diospyros discolor</i>	Ebenaceae
11.	Governor's plum	Boichi	<i>Flacourtia indica</i>	Flacourtiaceae
12.	Indian plum	Lukluki	<i>Flacourtia jangomas</i>	Flacourtiaceae
13.	Red pear	Gutgutia	<i>Protium serratum</i>	Burseraceae
14.	Cowa	Kawphal	<i>Garcinia cowa</i>	Clusiaceae
15.	Burmese grape	Lotkon	<i>Baccaurea ramiflora</i>	Phyllanthaceae
16.	Karanda	Karamcha	<i>Carissa carandas</i>	Apocynaceae
17.	Wood apple	Bael	<i>Aegle mermelous</i>	Rutaceae
18.	Star Gooseberry	Orboroi	<i>Phyllanthus acidus</i>	Euphorbiaceae
19.	Longan	Kath lichu	<i>Dimocarpus longan</i>	Sapindaceae
20.	Water chestnut	Paniphol	<i>Trapa bispinosa</i>	Trapaceae

(Source: Molla *et al.*, 2021, Shajib *et al.*, 2013, Hossain *et al.*, 2021)

## 2.4 Dietary importance of minor indigenous fruits

Dietary significance of indigenous fruits that are considered to be insignificant. Fruits provide food that is not only beautiful and flavorful but also diverse, low in calories, delicious, and rich in nutrients. They are considered to be rich providers of a number of key dietary micronutrients and dietary fiber, and more recently, they have been recognized as important sources of a wide variety of phytochemicals that may be beneficial to health either individually or in combination (Yahia, 2017). It has been demonstrated that certain indigenous fruits, however of a lesser size, exhibit greater nutritional characteristics. Particularly in marginalized groups and communities located

surrounding metropolitan suburbs in developing countries, they contribute to the prevention of deficiency symptoms that are associated with a wide range of nutritional deficiency disorders (Hossain *et al.*, 2021).

## 2.5 Biochemical composition

**Table 2. Comparison of selected major and minor indigenous fruits in respect to biochemical composition**

	Parameters	Edible portion (%)	Protein (%)	Total sugar (%)	Carbohydrate (%)	Fiber (%)
Major Fruit	Mango	61.28	1.11	4.71	12.83	2.72
	Banana	68.00	5.42	12.23	16.59	0.68
Minor fruit	Aonla	84.62	2.87	7.32	7.11	3.70
	Hog plum	47.59	1.06	5.64	13.90	1.87
	Cucumber tree	98.00	3.70	4.07	4.13	0.62
	Karanda	89.56	0.40	2.63	12.38	2.79
	Elephant apple	79.03	3.26	4.13	4.71	3.54
	Toikar	84.41	2.39	4.02	4.85	5.50
	Ber	88.37	3.18	4.35	4.15	4.76
	Burmese grape	44.50	5.58	4.42	51.90	21.40
	Wood apple	71.50	8.16	5.01	39.25	2.90
	Star Gooseberry	92.50	0.25	4.50	4.80	0.60

(Source: Molla *et al.*, 2021, Ara *et al.*, 2015, Agatonovic-Kustrin *et al.*, 2018)

## 2.6 Portion that can be consumed

The fraction of the meal that is used for human consumption is referred to as the edible component. It is expressed as a percentage, which is comparable to the portion of food consumed by individuals multiplied by 100 divided by the weight of the food that was purchased. The percentage of minor IFs that were edible ranged from 44.50% to 98%, with the highest percentage being found in cucumber tree fruit and the lowest proportion being found in burmese grape. Approximately seventy percent to ninety percent of the minor IFs contained edible portions. Mango and banana, on the other hand, had a

moderate percentage of edible component, with 61.28% and 68.00% respectively representing the percentages.

## **2.7 Amino acid**

These small IFs have a protein concentration that ranges from 0.25% to 8.16% of the total. Wood apple has the largest amount of protein (8.16%), and burmese grape has a slightly larger quantity of protein (5.58%). Both of these fruits have a greater protein content than mango and banana due to their higher levels of protein.

## **2.8 The overall amount of sugar**

The total sugar content of the minor fruit ranged from 2.63 to 7.32%, with the highest concentration being found for aonla (7.32%), which is greater than the sugar content of mango (4.71%). The lowest percentage, 2.63 percent, was recorded for karanda. The majority of the lesser IFs had a total sugar level that was somewhere between 4 and 5 percent, which is approximately identical to the sugar content of mango.

## **2.9 Carbohydrate**

A substantially greater proportion of carbohydrates was found in wood apple (39.25%), hog plum (13.90%), and karanda (12.38%) among the minor IFs. The amount of carbohydrates found in burmese grape was the greatest among the minor IFs, at 51.90 percent. The cucumber tree had the lowest percentage, which was 4.13 percent. Burmese grape and wood apple, both of which have a low IF, contain a significantly larger percentage of carbohydrates than mango (12.83%) and jackfruit (16.59%).

Fiber Fiber is mostly composed of cellulose (60–80 percent) and lignin (4-6 percent), in addition to a small amount of mineral materials. (Madhu *et al.*, 2017) These fibers are effective in the treatment or prevention of a variety of conditions, including but not limited to constipation, hemorrhoids, diverticulosis, coronary heart disorders, and certain types of cancer. The fiber content of the minor IF that was chosen ranged from 0.60 to 21.40% of the total quantity. The star gooseberry had the lowest amount of fiber, which was measured to be 0.60 percent, while the burmese grape had the highest amount, which was calculated to be 21.40 percent. Five and a half percent was discovered in Toikar, four and a half percent in Ber, and three and a half percent in Aonla. When

compared to mango (2.72%) and banana (0.68%), the majority of the minor IFs had a higher or comparable quantity of fiber percentage.

### **2.10 Components of minerals**

As a result of the combustion of food, minerals are the inorganic components that are found in the ash that is produced. There are a variety of mineral elements that are necessary for the human body, including sodium, potassium, iron, calcium, and a substantial number of additional trace elements. According to Akpanyung (2005), sodium and potassium are the primary cations that are found in every cell in the body. These cations are responsible for maintaining the plasma volume, regulating the acid-base balance, and facilitating the contraction of nerves and muscles. phosphorous is the element that

According to Bernardier *et al.* (2007), the nucleus and cytoplasm of all tissue cells include fundamental components that make up their structures. It has been demonstrated that minor IFs are abundant suppliers of all of the necessary minerals that are listed in Table 3.

**Table 3. Macro and micro mineral composition of selected major and minor indigenous fruits**

Parameters		Na	K	Ca	Mg	P	Fe	Zn	Cu
(mg/100g)									
Major fruits	Mango	34.03	10.23	19.45	14.00	1.54	4.29	0.87	1.05
	Banana	4.00	326.00	5.00	22.00	28.00	0.40	0.16	0.10
Minor indigenous fruits	Aonla	4.20	282.00	27.60	28.20	11.80	3.30	1.80	0.28
	Hog plum	5.55	32.84	11.03	32.84	15.09	0.33	-	0.11
	Cucumber tree	1.80	10.70	5.80	0.31	3.10	3.21	0.04	0.41
	Toikar	18.00	37.00	87.00	21.00	49.00	23.82	2.23	39.55
	Ber	22.00	87.00	102.0	12.00	57.00	15.57	1.07	15.57
	Burmese grape	9.49	198.00	52.20	17.10	11.30	1.48	0.90	0.25
	Wood apple	-	427.00	70.30	22.70	16.70	2.23	0.43	2.02
	Star Gooseberry	1.00	104.00	10.80	5.70	3.60	1.17	0.67	0.10
	Karanda	-	207.00	26.20	14.40	7.50	0.95	0.67	0.25
	Elephant apple	19.00	108.00	54.00	11.00	28.00	8.39	1.78	15.77

(Source: Shajib *et al.*, 2013, Molla *et al.*, 2021)

The amount of sodium, potassium, calcium, magnesium and phosphorus in these fruits varied from 1-22mg/100g, 10.7-427 mg/100g, 5.8-102 mg/100g, 0.31-32.84 mg/100g, 3.1-57mg/100g respectively. Ber had the highest amount of sodium and calcium while wood apple and hog plum had the highest amount of potassium and magnesium respectively. Mango contained more sodium (34.03 mg/100g) but less potassium (10.23 mg/100g) and phosphorus (1.54 mg/100g) than any of the minor fruits. Many of the minor fruits had more calcium and magnesium than mango that had 19.45 mg/100g Ca and 14 mg/100g Mg. The micromineral content of minor IFs varied from 0.33-23.8 mg/100g for iron, 0.43-2.23mg/100g for zinc and 0.1-39.55 mg/100g for copper with the highest content being available in toikar. Mango contained higher amount of Fe (4.29mg/100g), Zn (0.87mg/100g) and Cu (1.05mg/100g) than some the minor IFs, but many of them were higher in those micromineral content than mango and most them were higher in content than banana (0.40, 0.16, 0.10 mg/100g Fe, Zn and Cu respectively).

## 2.11 The amount of vitamins

Vitamin is a broad set of chemical compounds that are required by humans or animals in small amounts to ensure normal growth and to maintain health. Vitamins are essential for human and animal health. Vitamins are considered necessary micronutrients because it is impossible for humans to produce sufficient quantities of these substances to meet their daily requirements. Plants are the principal providers of vitamins and other vital nutrients for human nutrition since they are able to produce the majority of the vitamins themselves. Most of the time, a sickness that is characterized by its symptoms is brought on by either an inadequate amount of a vitamin in the human diet or a poor absorption of that vitamin from the digestive tract. Taken in their raw form, fruits maintain all of their nutrients, and the body is able to absorb them with ease.

**Table 4. Vitamin constitutions of some minor indigenous fruits of Bangladesh**

	Vit A	Thiamine	Riboflavin	Niacin	Vit C
Aonla	✓	✓	✓	✓	✓
Hog plum	✓	✓	✓		✓
Cucumber tree	✓	✓	✓		✓
Elephant apple					✓
Monkey Jack	✓	✓	✓		✓
Melanesian papeda					✓
Ber	✓	✓	✓	✓	✓
Toikar					✓
Indian plum	✓	✓	✓		✓
Cowa	✓		✓		✓
Burmese grape		✓	✓		✓
Karanda	✓	✓	✓		✓
Wood apple	✓	✓	✓	✓	✓
Star Gooseberry		✓	✓		✓
Longan	✓				✓

(Source: Rahman *et al.*, 2014)

Minor IFs are rich source of vitamins. All the minor IFs of Table 4 contained vitamin C. Vitamin A was present in almost all the fruits except elephant apple, Melanesian papeda, toikar, Burmese grape and star gooseberry. Thiamine and riboflavin were also present in

almost all of the minor IFs. Niacin availability in minor IFs was rare, it was only present in aonla, ber and wood apple.

### **2.12 Phenolic content**

Phenolic compounds are the largest group of phytochemicals found in plants. Polyphenolic compounds are the major contributors to the antioxidant properties of fruits and vegetables. To date, only a very limited information on phenolic compounds is available for the scientific community, especially phenolic compounds in the minor fruits yet the available data informs that minor indigenous fruits are great source of total phenol. The aonla had the highest amount of TPC, 474 mg GAE/g. Comparatively lower TPC was observed in star gooseberry (73 mg GAE/g), cucumber tree (65 mg GAE/g) and Burmese grape (57 mg GAE/g). The lowest amount of TPC was available in hog plum (8 mg GAE/g) followed by wood apple (23 mg GAE/g). TPC of Mango and banana was 5.01 and 1.6 mg GAE/g respectively which was lower than any of the minor IFs. It depicts that minor IFs had higher antioxidant capacity than major fruits. (Agatonovic-Kustrin *et al.*, 2018, Sulaiman *et al.*, 2011, Rahman *et al.*, 2016, Oladunjoye *et al.*, 2021, Hasanuzzaman *et al.*, 2013, Sultana *et al.*, 2022, Chakraborty *et al.*, 2012, Hazra *et al.*, 2020)

### **2.13 The seasonal availability of lesser-known native fruits and vegetables**

The phenology of minor edible fruit-yielding plant species exhibits considerable variation in terms of flowering and fruiting period. While most minor fruit-bearing plants typically produce fruit from March to September, the fruits are often available year-round. In terms of fruit yield, June has the greatest percentage at 11.51%, followed by May at 11.37% and July at 10.41%. According to Pasha and Uddin (2019), January has the lowest fruit output rate at 5.50%, followed by December at 6.07% and November at 6.48%.

### **2.14 The current production situation of minor indigenous fruits and in Bangladesh**

Minor fruit accounts for 3.01% of the total land and 8.38% of the total fruit production in Bangladesh (BBS, 2011). Wood apple has the largest cultivation area among the minor indigenous fruits, at 17,975 acres. Hog plum covered the second greatest area, spanning 11,737 acres, yet its yield of 43,801 metric tons was more than that of wood apple, which produced 29,305 metric tons. The elephant apple ranked third in terms of area coverage,

including 3376 acres, and also in fruit output, yielding 10679 metric tons in the year 2021-2022.

Several small indigenous vegetables thrive in their natural habitat with minimal cultivation requirements and little to no human intervention. Exotic vegetables are not readily available or affordable for rural people, thus they rely heavily on other types of vegetables to meet their daily nutritional needs. This is a significant factor in their diet (Pearson *et al.*, 2014). These ingredients are commonly used with staple cuisine in both urban and rural areas of Bangladesh to improve the flavor and appearance of the diets. The economic potential of underutilized vegetables is inadequately addressed, resulting in their limited function primarily confined to local and traditional usage.

### **2.15 Constraints for the consumption of minor indigenous fruits in Bangladesh**

The limited utilization of minor indigenous fruits and vegetable crops may be attributed to the lack of awareness among the public regarding their nutritional and therapeutic benefits, as well as their low appeal. The productivity of agricultural systems is hindered by the absence of high-quality seeds and planting material, as well as the limited use of advanced technologies such as biotechnology and plasticulture. poor understanding of post-harvest management measures, insufficient marketing support, and poor infrastructure for transportation, storage, and processing are further hindrances to the effective utilization of valuable minor indigenous fruits ( Jena *et al.*, 2018).

### **2.16 Methods to overcome the limitations**

Promoting awareness among the general public about the abundant nutritional value of lesser-known indigenous fruits and vegetables should be actively encouraged. The focus should be on cultivating possible wild species through farmhouse agriculture to domesticate them. There is a need for greater attention to be given to the documentation of indigenous knowledge, particularly through the implementation of ethnobotanical studies. Strategies must be formulated specifically at the national and regional levels to cultivate and distribute promising selections/varieties, while addressing the challenges related to the production of high-quality seed material, planting material, and in-vitro/tissue cultured material. Enhancement of production and processing techniques is essential for the effective exploitation of lesser-known native fruits and vegetables. (Jena *et al.*, 2018)

## CHAPTER 3

### MATERIALS AND METHODS

#### 3.1 Study Area

The study area comprises the districts of Dinajpur (Latitude: 25.6217° N, Longitude: 88.6356° E), Thakurgaon (Latitude: 26.0330° N, Longitude: 88.4614° E), and Panchagarh (Latitude: 26.3417° N, Longitude: 88.5667° E) in Bangladesh, providing a diverse and fertile landscape for investigation. These northern districts share common agroecological features while displaying distinct socio-economic and environmental characteristics. Dinajpur, renowned for its agricultural significance, forms the contextual backdrop with its fertile plains and cultural heritage. Thakurgaon, situated adjacent to Dinajpur, contributes to regional dynamics with its agrarian landscapes and vibrant communities. Panchagarh, positioned to the northwest, offers insights into ecological variations within the study area. Together, these districts showcase the intricate interplay of agriculture, demographics, and environmental factors, making them an ideal context for exploring the multifaceted role of minor fruit trees in enhancing food and nutritional security among rural communities facing economic challenges.

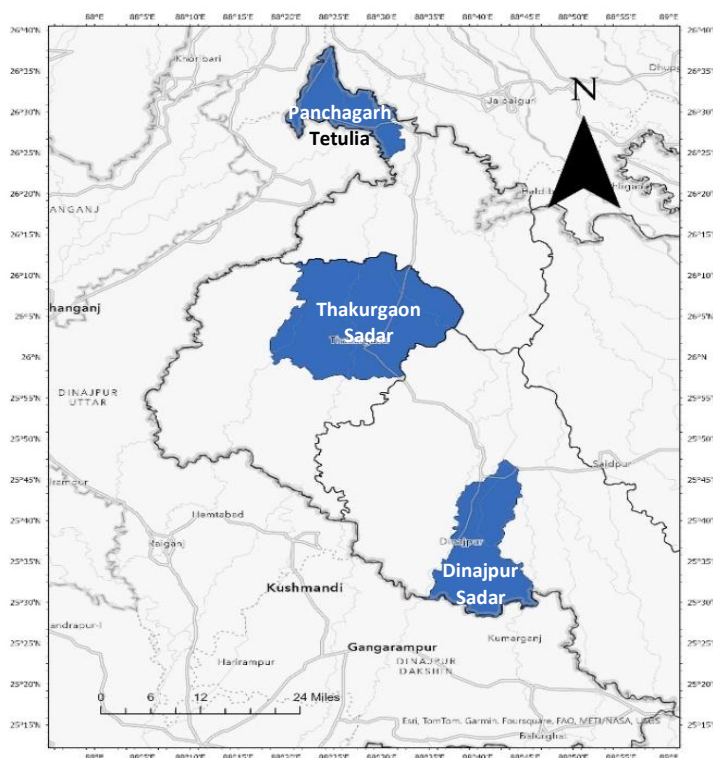


Figure 1: Map Showing study area

### 3.2 Population Sampling

To ensure a representative demographic profile, a stratified random sampling method was employed, stratifying based on factors such as age, gender, education, and income levels. The sample size was determined using statistical techniques to achieve a confidence level suitable for the study objectives. This selection process adhered to Cochran's formula (1997) to ensure statistical rigor and representativeness.

$$n = \frac{Z^2 \cdot p \cdot q \cdot N}{e^2(N-1) + Z^2 \cdot p \cdot q} \dots\dots\dots (i)$$

Here,

n=sample size.

N=total number of households

Z<sup>2</sup>= confidence level

p= estimated population proportion.

q= 1-p

e= error limit of 5%

### 3.3 Measurement of independent variables

The following independent variables were included in the study:

- i. Age
- ii. Sex
- iii. Education
- iv. Occupation
- v. Family size
- vi. Homestead size
- vii. Annual income

#### 3.3.1 Age

The age was defined as the period of time from the birth of a respondent to the time of interview. It was operationally measured in terms of actual age in years.

#### 3.3.2 Sex

Sex scores of the respondent farmers denoted by 1 for male and 2 for female.

### **3.3.3 Education**

Education of a respondent was measured on the basis of classes he had passed in formal educational institution. For example, if a respondent passed class-VII, his education score was 7 whereas if a respondent had no reading or writing ability was given a score of zero (0).

### **3.3.4 Occupation**

Occupation of a respondent was measured in terms of working by him and respondent to the time of interview. It was operationally measured in terms of actual occupation.

### **3.3.5 Family size**

Family size of a respondent was measured in terms of actual number (dependents) of members in his family (including himself) during interview. The scoring was made by the actual number given by the respondent. For example, if a respondent had five members in his family then his score was five (5).

### **3.3.6 Homestead size**

It was measured by the area of the raised land in which the household has its entire living room, livestock and poultry shed, yard under vegetable, home garden, fruit and timber trees, backyard, bushes, bamboo bunches, pond etc. It expressed in hectare.

### **3.3.7 Annual income**

Annual income from tree species diversity was measured in the amount of taka. From January to December, every farmer can sell some of his or her produced fruits. The actual amount of money was calculated by information given by the farmers.

## **3.4 Measurement of dependent variable**

Tree species diversity of homestead was the dependent variable of the study. It consists of change in socio-economic aspects of the farmers. It was described under the following heads.

### **3.5 Socio-economic aspect of the farmers**

The change in socio-economic aspect of the farmers was defined as the improvement of social status as well as economic status. The farmers were asked to give their opinion regarding the improvement of their livelihood due to the direct or indirect contribution of tree species diversity in homestead agroforestry. It was measured on the basis of opinion obtained from the respondents on 17 statements containing information on the improvement of socio-economic aspect of their livelihood. A 3-point modified Likert-type scale such as strongly agree, agree and disagree was used to measure the extent of agreement of farmers. Cells of the scale of individual consequence with its corresponding score such as 2 for 'strongly agree', 1 for 'agree', and 0 for 'disagree'. Finally adding all the frequency of each of the cells of the scale, the value was calculated.

### **3.6 Data Collection and Analysis**

Surveys and interviews were conducted to gather detailed demographic information. Parameters included age, gender, education, occupation, family size, homestead size, and annual income. The survey instruments were designed with input from experts in social sciences and agriculture. A comprehensive botanical survey identified common minor fruit species in the study area. Systematic sampling methods were employed to collect data on botanical families, scientific names, and relative prevalence. This involved collaboration with local experts in botany and agriculture. The productivity of selected minor fruit species was assessed by measuring the average yield per tree. High-yield species were identified, and variations in productivity were analyzed. This involved direct field measurements, considering factors like tree age, health, and environmental conditions. Monthly fruit production per household was monitored to understand seasonal variations. Data was collected through regular visits and interviews. The analysis aimed to identify peak and off-peak months, providing insights into the natural fruiting seasons and enabling effective resource planning. A structured questionnaire was used to evaluate the perceived impacts of minor fruits on income diversification, nutritional security, livelihood opportunities, economic growth, and cultural significance. Respondents were interviewed, and qualitative data was analyzed alongside quantitative measures. Statistical methods, including means, standard deviations, and ranges, were employed to analyze demographic and productivity data. Botanical and socio-environmental data were subjected to qualitative content analysis to identify patterns, themes, and relationships.

## CHAPTER 4

### RESULTS

#### 4.1 Demographic profile of the household

The study showed a comprehensive demographic profile within the studied population or sample. Notably, the mean age of individuals is 45.87 years, with a moderate standard deviation of 8.381, indicating some variability in age distribution. The average number representing sex is 1.35, suggesting a coding scheme where 1 and 2 represent different genders, with a standard deviation of 0.481. Education levels, measured in years of schooling, show an average of 6.57 years of schooling and a considerable standard deviation of 4.951, reflecting diversity in educational backgrounds. Occupation numbers have a mean of 2.95 and a standard deviation of 2.196, indicating a moderate level of variability. Family size, with a mean of 4.99 and a relatively small standard deviation of 1.398, suggests a degree of homogeneity in family sizes. Homestead size, measured in hectares, has an average of 0.159 and a standard deviation of 0.09. Finally, annual income, in thousands, has a mean of 107.897 with a notable standard deviation of 59.319, indicating a wide range in income levels within the sample. Overall, this table provides valuable insights into the distribution and central tendency of key characteristics in the examined population (Tab.1). The age of the farmers had a strong and favorable link with their adaptability, according to a study by Devi *et al.* (2020); comparable findings were previously reported by Sarker (2012) and Hoque (2009). In the survey, the researcher discovered that most farmers with low levels of education. According to Devi *et al.* (2020), farmers' inventiveness was found to have a highly significant relationship with their adaptation techniques to the consequences of climate change. Uddinet *al.* (2014), Acquah (2011), Sorhang and Kristiansen (2011), and Quayum and Ali (2012) all found similar results in their concern investigations. Most responders had small families and land holding. That suggests that due to their tiny land holdings, most farmers are conscious of the family population.

**Table 5. Demographic profile of the household in the study area**

<b>Characteristics</b>	<b>Measuring Unit</b>	<b>Observed Range</b>	<b>Mean</b>	<b>Standard deviation</b>
Age	Years	32-69	45.87	8.381
Education	Years of schooling	0-14	6.57	4.951
Occupation	Numbers	1-7	2.95	2.196
Family size	Numbers	3-7	4.99	1.398
Homestead size	Hectares	0.06-0.41	0.159	0.09
Annual income	Thousand ( $\pi C$ )	55-250	107.897	59.319

#### **4.2 Common minor fruit species found and their relative prevalence in the household**

We found considerable amount of minor fruit species grown in the homestead. Notably, it reveals clustering of fruits within specific botanical families, such as Myrtaceae, Arecaceae, and Sapotaceae. The relative prevalence values, ranging from 0.03 to 1.43, highlight the varying degrees of abundance among the listed fruits, with Boroi (*Spondias pinnata*) standing out as the most prevalent. When one investigates the variety of common small fruit species, one discovers a rich tapestry of botanical diversity. Not only does the prevalence of these fruits within particular groups, such as the Myrtaceae, Arecaceae, and Sapotaceae families, demonstrate clustering tendencies, but it also has the potential to hint at the ecological harmony that is embedded in the farming practices of the local community. Particularly noteworthy is the fact that Boroi, also known as *Spondias pinnata*, emerges as the dominant species, with a relative prevalence of 1.43, which attests to its possible cultural significance and prominence. The different relative prevalence numbers, which range from 0.03 to 1.43, help to a more comprehensive understanding of the flora of the region and the ecological implications of its presence. In the process of transitioning to the productivity of minor fruit species, the complexities of the cultivation practices come to the foreground.

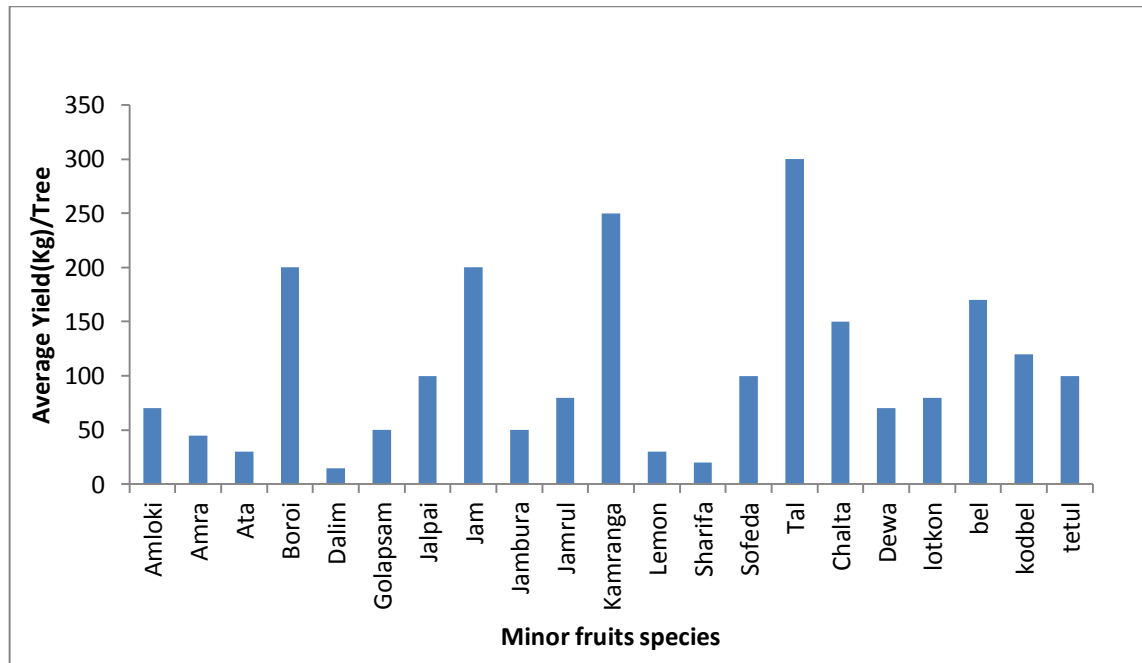
**Table 6. Botanical Diversity and Relative Prevalence of different Minor Fruits Species in the study area**

SI No.	Common name	English Name	Scientific Name	Family	Relative Prevalence
1	Amloki	Emblica	<i>Syzygium cumini</i>	Myrtaceae	0.17
2	Amra	Hog plum	<i>Syzygium samarengense</i>	Myrtaceae	0.09
3	Ata	Custard apple	<i>Phoenix sylvestris</i>	Arecaceae	0.03
4	Boroi	Jujube	<i>Spondiaspinnata</i>	Anacardiaceae	1.43
5	Dalim	Pomegranate	<i>Syzygiumjambos</i>	Myrtaceae	0.09
6	Golapsam	Rose apple	<i>Achrassapota</i>	Sapotaceae	0.04
7	Jalpai	Indian olive	<i>Punica granatum</i>	Punicaceae	0.17
8	Jam	Blackberry	<i>Borassus flabellifer</i>	Arecaceae	0.05
9	Jambura	Pomelo	<i>Annona reticulate</i>	Annonaceae	0.21
10	Jamrul	Wax apple	<i>Annona squamosal</i>	Sapotaceae	0.09
11	Kamranga	Star-apple	<i>Citrus lemon</i>	Rutaceae	0.17
12	Lemon	Lemon	<i>Citrus grandis</i>	Rutaceae	0.35
13	Sharifa	Custard apple	<i>Elaeocarpusfloribundus</i>	Elaeocarpacea	0.07
14	Tentul	Tamarind	<i>Tamarindus indica</i>	Leguminosae	.06
15	Sofeda	Sapodilla	<i>Phyllanthusembelica</i>	Euphorbiaceae	0.04
16	Tal	Palmyra tree	<i>Averrhoacarambola</i>	Oxalidaceae	0.7
17	Chalta	Elephant Apple	<i>Dillenia Indica</i>	Dilleniaceae	0.03
18	Dewa	Monkey fruit	<i>Artocarpus lacucha</i>	Moraceae	0.03
19	Lotkon	Burmese grape	<i>Baccaurea motleyana</i>	Phyllanthaceae	.05

#### 4.3 Productivity of Some minor fruit Species found in the study area

This table presents the average yield per tree for various fruit species, showcasing notable variations in productivity. Tal stands out with the highest average yield at 300, followed by Kamranga, Jam, and Boroi. Conversely, species like Sharifa and Dewa exhibit comparatively lower yields at 20 and 70, respectively. The information provides valuable insights for farmers and agricultural planners, highlighting high-yield species that may be of interest for commercial cultivation and underscoring variations in productivity that can inform resource allocation and agricultural decision-making

processes. Tal's remarkable average production of 300 per tree places it in a position to be a significant contributor to the agricultural environment, and it may also provide opportunities for commercial cultivation. Because of the enormous yields they provide, Kamranga, Jam, and Boroï are significant in terms of their role in determining the agricultural lives of the local population. On the other hand, decreased yields in Sharifa and Dewa inspire contemplation on optimizing agricultural practices and alternate uses, which results in the requirement of a balanced approach to sustainable agriculture.

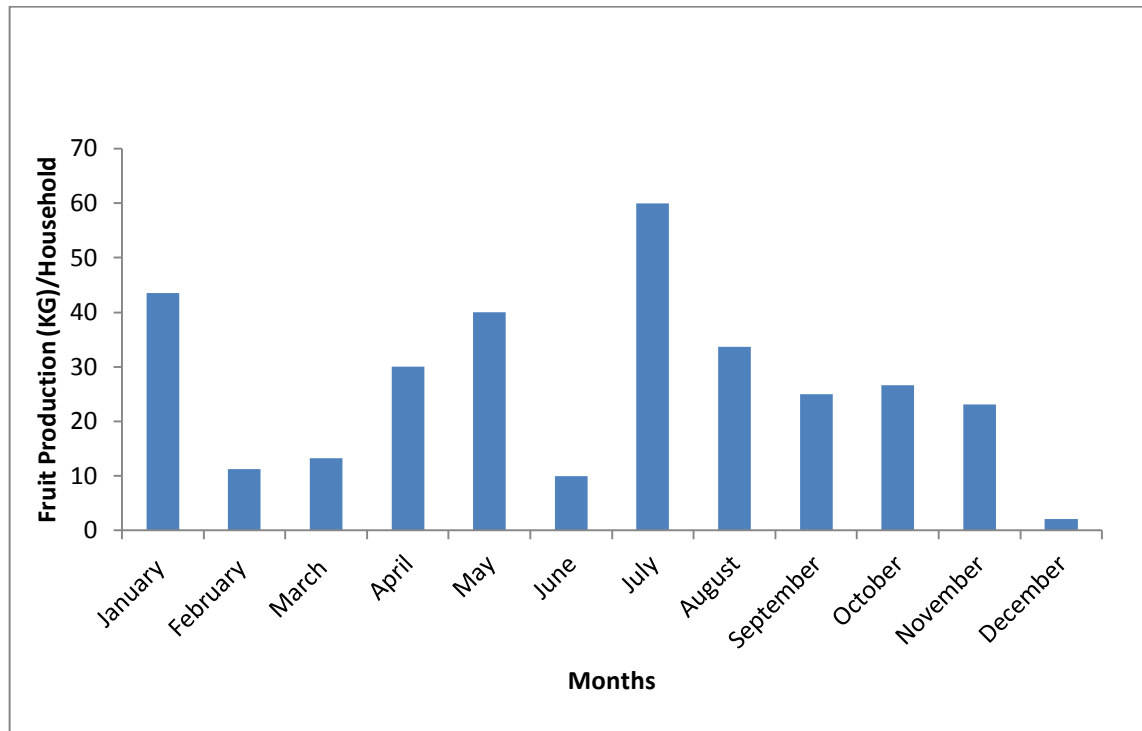


**Figure 2: Productivity of different minor fruit Species**

#### 4.4 Monthly average fruit productivity per house hold

The average monthly fruit production per household, measured in kilograms, demonstrates distinct seasonal variations. July emerges as the peak month with 60 KG, while December exhibits the lowest production at 2.16 KG. The data underscores the importance of understanding the natural fruiting seasons for effective resource planning, storage, and market strategies. This information is crucial for households and agricultural planners seeking to optimize fruit availability throughout the year, ensuring a stable and well-managed supply of fresh produce. When looking at the monthly average fruit productivity of each household, it is clear that the ebb and flow of fruit production corresponds with natural cycles. The peak of sixty kilograms occurred in the month of July, which coincides with the best times for fruiting, highlighting the underlying

connection that exists between agricultural methods and seasonal subtleties. The lowest point, which occurred in December, was 21.16 kg, which brings to light the difficulties that are connected with fruiting during the off-season and emphasizes the significance of strategic resource planning.



**Figure 3: Monthly average fruit productivity per house hold**

#### **4.5 Comprehensive Evaluation of Tree Species for productivity and environmental benefit**

The table provides a comprehensive evaluation of various tree species based on their productivity and quality in terms of fuelwood, timber, nutritional value, medicinal benefits, and ecosystem services. Amloki and Tentul emerge as the highest performers, offering high-quality fuelwood and timber, alongside exceptional nutritional, medicinal, and ecosystem service values. Amloki has medium productivity but high quality for fuelwood and timber, and is very high in ecosystem services, making it a highly versatile tree. Tentul also offers medium productivity and quality in both fuelwood and timber, with high nutritional and medicinal values, and excels in ecosystem services.

In contrast, species like Dewa and Lotkon have the lowest overall utility. Both have very low productivity and quality for fuelwood and timber, and only moderate nutritional

quality, with Dewa also having low medicinal and ecosystem service values. Golapsam, Sharifa, and Ata are similarly limited, with generally low productivity and quality across most categories.

Sofeda stands out for its very high nutritional and medicinal quality despite low fuelwood and timber utility. Trees like Jalpai, Jamrul, Kamranga, and Lemon have high nutritional and medicinal quality but are otherwise limited in their utility for fuelwood and timber, making them more specialized in their applications.

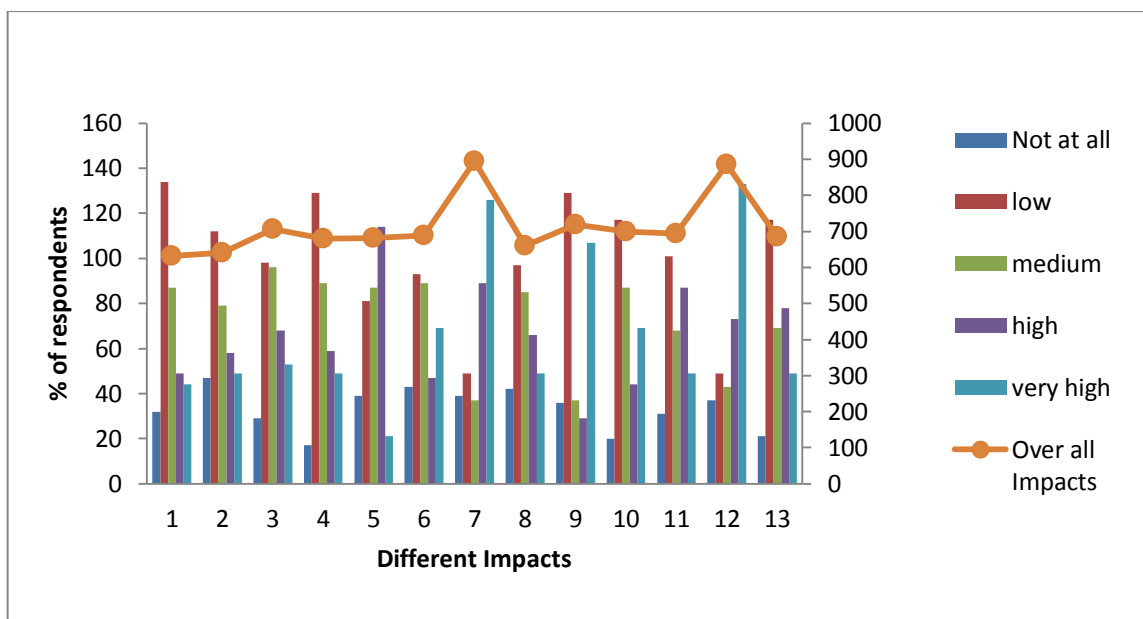
Overall, Amloki and Tentul are the most versatile and beneficial trees, suitable for a range of uses, from fuelwood and timber to nutrition and medicine, with significant contributions to ecosystem services. On the other end of the spectrum, Dewa and Lotkon have limited uses, being suitable mainly for their moderate nutritional benefits. This detailed assessment helps in understanding the multiple uses and benefits of each tree species, guiding decisions for planting and conservation based on specific needs such as fuelwood, timber, nutrition, medicine, and ecosystem services.

**Table 7. Comprehensive Evaluation of Tree Species for productivity and environmental benefit**

Sl No.	Common name	Fuelwood		Timber		Nutritional Quality	Medicinal Quality	Ecosystem Service Quality
		Fuelwood Productivity	Fuelwood Quality	Timber Productivity	Timber Quality			
1	Amloki	Medium	High	Medium	Medium	High	High	Very High
2	Amra	Medium	Medium	Medium	Medium	Medium	Medium	Medium
3	Ata	Low	Medium	Low	Low	Low	Low	Low
4	Boroi	High	Medium	High	Medium	Medium	Medium	Medium
5	Dalim	Medium	Medium	Medium	Medium	Medium	Medium	Medium
6	Golapsam	Low	Low	Low	Low	Medium	Low	Low
7	Jalpai	Low	Low	Low	Low	High	High	Medium
8	Jam	Medium	Medium	Medium	Medium	Medium	Medium	Medium
9	Jambura	Medium	Low	Medium	Low	Medium	Medium	Medium
10	Jamrul	Medium	Medium	Low	Low	High	High	Low
11	Kamranga	Low	Low	Low	Low	High	Medium	Medium
12	Lemon	Low	Low	Low	Low	Very High	High	Medium
13	Sharifa	Low	Low	Low	Low	Medium	Low	Low
14	Tentul	Medium	Medium	Medium	Medium	High	High	Very High
15	Sofeda	Low	Low	Low	Low	Very High	Very High	Medium
16	Tal	Medium	Low	Low	Low	High	Medium	Medium
17	Chalta	Low	Low	Low	Low	Medium	Medium	Medium
18	Dewa	Very Low	Very Low	Very Low	Very Low	Medium	Low	Low
19	Lotkon	Very Low	Low	Very Low	Very Low	Medium	Low	Low

#### **4.6 Socio-Environmental impacts of minor fruits on the household**

This study evaluates the perceived impacts of various socio-environmental factors associated with minor fruits, including their influence on income diversification, nutritional security, livelihood opportunities, economic growth, and cultural significance. The analysis aims to understand how these factors intersect and contribute to the overall socio-environmental landscape surrounding minor fruit cultivation. Respondents generally recognize the importance of agriculture in income diversification, enhanced nutritional security, increased livelihood opportunities, and local economic growth. While there is mixed perception regarding cultural significance and agro-tourism, the majority acknowledge the positive impact of agriculture on improved food security, market opportunities, and community resilience. Notably, environmental sustainability and reducing environmental impact emerge as significant concerns, reflecting a shared awareness of the environmental aspects of agricultural practices. The figure illustrates the complex and multifaceted nature of the relationship between agriculture and socioeconomic, cultural, and environmental factors. An additional layer of community perspectives is introduced by the socio-environmental effects analysis, which reveals a mosaic of opinions towards the many of affects that are brought about by the production of more minor fruits. There is a symbiotic relationship between agricultural and socio-economic well-being, and positive acknowledgments of impacts on income diversification, nutritional security, and economic growth resonate with this relationship. Mixed feelings on cultural value and agrotourism are a reflection of the contextual intricacies that shape community perspectives. As a result, individualized approaches to agricultural development are required. Concerns that are held in common regarding the preservation of the environment are indicative of an increasing environmental consciousness within the community, which is in line with the larger conversation around sustainable agriculture.



Notes: 1=Diversification of Income Sources, 2=Enhanced Nutritional Security, 3=Increased Livelihood Opportunities, 4=Local Economic Growth, 5= Cultural Significance, 6=Improved Food Security, 7= Environmental Sustainability, 8=Climate Resilience, 9=Market Opportunities, 10=Reduced Environmental Impact, 11=Enhanced Livestock Feed, 12= Community Resilience, 13= Promotion of Agro-Tourism

**Figure 4: Socio-Environmental impacts of minor fruits on the household**

#### 4.7 Constraint faced by rural household for Minor fruit production

The analysis of constraints affecting tree production reveals a rank order of challenges, with small homestead size as the most significant limitation, holding the highest CFI of 471, indicating that limited space severely impacts tree cultivation. Following closely are pest and disease susceptibility and dependency on pollinators, both ranked second with CFIs of 428, underscoring the need for better pest management and pollinator support. The third-ranked constraint is the lack of fertilizer, with a CFI of 437, reflecting the necessity for improved nutrient management. Water requirements come in fourth with a CFI of 419, emphasizing the importance of efficient water use.

Prone to wind damage, lack of awareness, and lack of quality seeds share the fifth rank, each with a CFI of 401, highlighting the need for protective measures, educational programs, and better seed distribution. Climate sensitivity and competition with other vegetation, both with CFIs of 392, rank last, although they still present significant

challenges. Addressing these issues through targeted interventions will enhance tree production and sustainability.

Table 8. Constraint faced by rural household for Minor fruit production

Sl no.	Major constraints	Very low	Low	Medium	High	Very High	CFI
1	Small homestead	9 (5%)	18 (10%)	45 (25%)	73 (40%)	36 (20%)	471
2	Climate sensitivity	18 (10%)	36 (20%)	55 (30%)	46 (25%)	27 (15%)	392
3	Pest and disease susceptibility	9 (5%)	27 (15%)	64 (35%)	55 (30%)	27 (15%)	428
4	Water requirements	18 (10%)	27 (15%)	55 (30%)	46 (25%)	36 (20%)	419
5	Prone to wind damage	18 (10%)	36 (20%)	46 (25%)	55 (30%)	27 (15%)	401
6	Dependency on pollinators	9 (5%)	27 (15%)	64 (35%)	55 (30%)	27 (15%)	428
7	Competition with other vegetation	18 (10%)	36 (20%)	55 (30%)	46 (25%)	27 (15%)	392
8	Lack of quality seeds	18 (10%)	27 (15%)	64 (35%)	46 (25%)	27 (15%)	401
9	Lack of fertilizer	9 (5%)	27 (15%)	55 (30%)	64 (35%)	27 (15%)	437
10	Lack of awareness	18 (10%)	36 (20%)	46 (25%)	55 (30%)	27 (15%)	401

## CHAPTER V

### SUMMARY, CONCLUSION AND RECOMMENDATIONS

#### 5.1 Summary

The study provides a comprehensive demographic profile of rural households, highlighting a mean age of 45.87 years with moderate variability (standard deviation = 8.381), which is indicative of a broad age distribution. It is clear that farmers come from a variety of educational backgrounds, as seen by the average age of 6.57 years (standard deviation = 4.951). Within households, the dynamics are highlighted by the diversity of occupations, with a mean of 2.95 (standard deviation = 2.196), and family size, which averages 4.99 people (standard deviation = 1.398). The average size of a homestead was 0.159 hectares, with a standard deviation of 0.09, highlighting the small land holdings. There was a significant amount of variation in annual income, with a mean of 107.897 thousand units (standard deviation = 59.319), which served to illustrate a broad range of income.

The findings of botanical research revealed that the Myrtaceae, Arecaceae, and Sapotaceae families contain a significant number of minor fruit species that are clustered together. Particularly noteworthy is the fact that Boroi, also known as *Spondias pinnata*, emerged as the most abundant species, with a relative prevalence of 1.43, indicating the cultural and ecological significance of this population. According to the results of productivity assessments, the species with the highest production was Tal, which produced an average of 300 units per tree. This was followed by Kamranga, Jam, and Boroi, which highlighted the potential for commercial cultivation of these species.

An examination of the socio-environmental repercussions brought to light the fact that tiny fruits make a substantial contribution to the diversification of income, the improvement of nutritional security, and the expansion of the local economy. On the other hand, important restrictions that have an impact on production and sustainability include things like the size of the homestead (CFI = 471), the susceptibility to pests (CFI = 428), and the amount of water that is required (CFI = 419). These findings are essential for the development of tailored interventions that aim to improve agricultural practices and boost socio-economic resilience in rural communities that are dependent on the cultivation of small fruits.

#### 5.2 Conclusion

This study highlights the significant significance that minor fruit trees play in homestead agroforestry systems, particularly with regard to the enhancement of food and nutritional

security in rural communities who are economically disadvantaged. The broad demographic profile, which includes a mean age of 45.87 years and an average of 6.57 years of education, demonstrates the distinct yet harmonious experiences that are present within the community. While Boroï (*Spondias pinnata*) emerges as a culturally significant species, high-yield species such as Tal, which has an average yield of 300 units per tree, show a considerable potential for enhancing agricultural livelihoods. In July, seasonal productivity reaches its highest point (60 kg), and it reaches its lowest point (2.16 kg) in December, highlighting the importance of strategic resource planning. Despite the fact that diverse attitudes exist regarding the cultural relevance and agrotourism, the socio-environmental repercussions demonstrate that agriculture plays an essential role in the diversification of revenue, the provision of nutritional security, and the expansion of the economy. Concerns about the environment that are widespread represent a growing awareness of environmentally responsible actions. The implementation of focused interventions and educational programs is absolutely necessary in order to address significant restrictions such as the small size of homesteads (CFI 471), the susceptibility of homesteads to pests (CFI 428), and the lack of fertilizers (CFI 437). In general, the incorporation of small fruit trees into agroforestry is supported as a versatile instrument for the improvement of nutrition and sustainable rural development. This is done with the intention of encouraging policymakers and practitioners to acknowledge the potential of these trees to increase holistic well-being.

### **5.3 Recommendations**

By considering the overall aspect of this present study the following points can be recommended:

1. Plantation of more diversified tree species for better eco-friendly management.
2. Long time monitoring programs are recommended to improve socio-economic conditions of the farmers by homestead afforestation.
3. Proper arrangement of different strata of tree species containing herb, shrub, tree will help year-round economic benefit of homestead farmers.
4. Plantation of shade-bearing and fruit tree species can be beneficial for better ecological management.
5. New research should be conducted to improve the design of plantation in homestead areas.

## REFERENCES

- Abdullah, M. R., Rahman, M. M., Hemayet, M. A. and Jalil, M. A. (2020). Diversity of non– conventional vegetables in two ethnic communities of Khagrachari Sadar, Khagrachari, Bangladesh. *International Journal of Forestry, Ecology and Environment*, 02(01), 48-59
- Agatonovic-Kustrin, S., Kustrin, E., & Morton, D. W. (2018). Phenolic acids contribution to antioxidant activities and comparative assessment of phenolic content in mango pulp and peel. *South African journal of botany*, 116, 158-163.
- Akhtar, N., Rahman, M., & Muslim, T. (2020). Comparative study of the content of vitamin c in fresh fruits and different types of food prepared from them. *Dhaka Published Online October*.
- Akhtar, S. (2016). Malnutrition in South Asia—a critical reappraisal. *Critical reviews in food science and nutrition*, 56(14), 2320-2330.
- Akpanyung, E. O. (2005). Proximate and mineral element composition of bouillon cubes produced in Nigeria. *Pakistan journal of nutrition*, 4(5), 327-329.
- Ara, R., Jahan, S., Abdullah, A., Fakhruddin, A., & Saha, B. (2015). Physico-chemical properties and mineral content of selected tropical fruits in Bangladesh. *Bangladesh Journal of Scientific and Industrial Research*, 49(3), 131–136.
- Aworh, O. C. (2015). Promoting food security and enhancing Nigeria's small farmers' income through value-added processing of lesser-known and under-utilized indigenous fruits and vegetables. *Food Research International*, 76, 986-991.
- Baldermann, S., Blagojević, L., Frede, K., Klopsch, R., Neugart, S., Neumann, A., & Schreiner, M. (2016). Are neglected plants the food for the future?. *Critical Reviews in Plant Sciences*, 35(2), 106-119.
- Baul, T. K., Chakraborty, A., Nandi, R., Mohiuddin, M., Kilpeläinen, A., & Sultana, T. (2021a). Effects of tree species diversity and stand structure on carbon stocks of homestead forests in Maheshkhali Island, Southern Bangladesh. *Carbon Balance and Management*, 16(1), 11.

- Baul, T. K., Peuly, T. A., Nandi, R., Kar, S., & Mohiuddin, M. (2021). Composition of homestead forests and their contribution to local livelihoods and environment: a study focused on Bandarban hill district, Bangladesh. *Trees, Forests and People*, 5, 100117.
- BBS. (2016). Bangladesh Household Income and Expenditure Survey 2016. Dhaka: Statistics and Informatics Division, Ministry of Planning.
- BBS. (2022). Yearbook of Agricultural Statistics of Bangladesh 2021. Bangladesh Bureau of Statistics, Dhaka.
- Berdanier, C. D., Dwyer, J. T., & Feldman, E. B. (Eds.). (2007). *Handbook of nutrition and food*.
- Bhuyan, M. A. J. and Uddin, M. N. (2010). Present status and improvement strategy of vegetable crops through regional trials. Paper presented in the regional workshop on Improvement of Vegetables & Adaptive Trials in SAARC Countries, 8-9 September, Dhaka, Bangladesh.
- Bokelmann, W., Huyskens-Keil, S., Ferenczi, Z., & Stöber, S. (2022). The role of indigenous vegetables to improve food and nutrition security: experiences from the project HORTINLEA in Kenya (2014–2018). *Local, Traditional and Indigenous Food Systems in the 21st Century to Combat Obesity, Undernutrition and Climate Change*, 25.
- Brooks, R., Goldson-Barnaby, A., & Bailey, D. (2020). Nutritional and medicinal properties of *Phyllanthus acidus* L. (Jimbilin). *International Journal of Fruit Science*, 20(sup3), S1706-S1710.
- Buttriss, J., and Riley, H. (2013). Sustainable diets: harnessing the nutrition agenda. *Food Chemistry*. 140(3): 402-7
- Chakraborty, R., Biplab, D., Devanna, N., & Sen, S. (2012). Antiinflammatory, antinociceptive and antioxidant activities of *Phyllanthus acidus* L. extracts. *Asian pacific journal of tropical biomedicine*, 2(2), S953-S961.
- Chivenge, P., Mabhaudhi, T., Modi, A. T., & Mafongoya, P. (2015). The potential role of neglected and underutilised crop species as future crops under water scarce

- conditions in Sub-Saharan Africa. *International journal of environmental research and public health*, 12(6), 5685-5711.
- Dash, P. K., Zohra, F. T., & Mannan, M. A. (2015). Evaluation of some indigenous leafy vegetables of Bangladesh by physico-chemical characterization. *South Asian J. Agric. 2013-2015*, 6 (1&2): 177-185.
- FAO (2004). Policy brief, incorporating nutrition considerations into development policies and programs. Rome, Italy.
- FAO (2012). Neglected crops need a rethink - can help world face the food security challenges of the future. Rome, Italy.
- Fentahun, M. T., & Hager, H. (2009). Exploiting locally available resources for food and nutritional security enhancement: wild fruits diversity, potential and state of exploitation in the Amhara region of Ethiopia. *Food security*, 1, 207-219.
- Goenster, S., Wiehle, M., Kehlenbeck, K., Jamnadass, R., Gebauer, J., & Buerkert, A. (2009, August). Indigenous fruit trees in homegardens of the Nuba Mountains, Central Sudan: tree diversity and potential for improving the nutrition and income of rural communities. In *I All Africa Horticultural Congress 911* (pp. 355-364).
- Hasanuzzaman, M., Ali, M. R., Hossain, M., Kuri, S., & Islam, M. S. (2013). Evaluation of total phenolic content, free radical scavenging activity and phytochemical screening of different extracts of *Averrhoa bilimbi* (fruits). *International Current Pharmaceutical Journal*, 2(4), 92-96.
- Hazra, S. K., Sarkar, T., Salauddin, M., Sheikh, H. I., Pati, S., & Chakraborty, R. (2020). Characterization of phytochemicals, minerals and in vitro medicinal activities of bael (*Aegle marmelos* L.) pulp and differently dried edible leathers. *Heliyon*, 6(10), e05382.
- Hossain, M. A., & Hasan, S. S. (2018). Potentiality of underutilized vegetables for contribution to Sustainable Development Goals (SDGs) in Bangladesh. *Asian Journal of Agricultural Extension, Economics & Sociology*, 26(2), 1-9.
- Hossain, M. F., Islam, M. A., Akhtar, S., & Anwar, M. (2017). Nutritional value and medicinal uses of minor fruits: Burmese grape (*Baccaurea ramiflora* Lour.). *International Journal of Nutrition and Food Sciences*, 6(5), 211-214.

- Hossain, M. M., Rahim, M. A., & Haque, M. R. (2021). Biochemical properties of some important underutilized minor fruits. *Journal of Agriculture and Food Research*, 5, 100148.
- Hossain, S. J., Tsujiyama, I., Takasugi, M., Islam, M. A., Biswas, R. S., & Aoshima, H. (2008). Total phenolic content, antioxidative, anti-amylase, anti-glucosidase, and antihistamine release activities of Bangladeshi fruits. *Food Science and Technology Research*, 14(3), 261-268.
- Hossain, S., Chowdhury, P. B., Biswas, R. K., & Hossain, M. A. (2020). Malnutrition status of children under 5 years in Bangladesh: A sociodemographic assessment. *Children and Youth Services Review*, 117, 105291.
- Hunter, D., Borelli, T., Beltrame, D. M., Oliveira, C. N., Coradin, L., Wasike, V. W., ... & Tartanac, F. (2019). The potential of neglected and underutilized species for improving diets and nutrition. *Planta*, 250, 709-729.
- Islam, M. M., Hossain, M. A., & Sanjowal, R. K. (2022). Bangladesh at Fifty: Changes and Challenges on Population and Development. *Journal of Governance Security & Development*.
- Jamnadass, R. H., Dawson, I. K., Franzel, S., Leakey, R. R. B., Mithöfer, D., Akinnifesi, F. K., & Tchoundjeu, Z. (2011). Improving livelihoods and nutrition in sub-Saharan Africa through the promotion of indigenous and exotic fruit production in smallholders' agroforestry systems: a review. *International forestry review*, 13(3), 338-354.
- Jena, A. K., Deuri, R., Sharma, P., & Singh, S. P. (2018). Underutilized vegetable crops and their importance. *Journal of Pharmacognosy and Phytochemistry*, 7(5), 402-407.
- Kumar, G. V., Kumar, A., Raghu, K., Patel, G. R., & Manjappa, S. (2013). Determination of vitamin C in some fruits and vegetables in Davanagere city, (Karnataka)- India. *International Journal of Pharmacy & Life Sciences*, 4(3), 2489-2491.
- Li, X., & Siddique, K. H. (2020). Future smart food: harnessing the potential of neglected and underutilized species for zero hunger. *Maternal & child nutrition*,

16, e13008.

- Madhu, C., Krishna, K. M., Reddy, K. R., Lakshmi, P. J., & Kelari, E. K. (2017). Estimation of crude fibre content from natural food stuffs and its laxative activity induced in rats. *Int J Pharma Res Health Sci*, 5(3), 1703-1706.
- Mazumdar, B. C. (2004). *Minor fruit crops of India: Tropical and subtropical*. Daya Books.
- Melo, V., Vargas, N., Quirino, T., & Calvo, C. M. C. (2013). Moringa oleifera L. An underutilized tree with macronutrients for human health. *Emirates Journal of Food and Agriculture*, 785-789.
- Molla, M. M., Sabuz, A. A., Chowdhury, M. G. F., Khan, M. H. H., Alam, M., Nasrin, T. A. A., & Islam, M. M. (2021). Bioactive compounds and biochemical and antioxidant properties of selected minor indigenous fruits in Bangladesh. *Asian Journal of Agriculture and Rural Development*, 11(1), 35-46.
- Molla, M. M., Sabuz, A. A., Chowdhury, M. G. F., Khan, M. H. H., Alam, M., Nasrin, T. A. A.,
- Monirul Alam, G. M., Alam, K., & Mushtaq, S. (2018). Drivers of food security of vulnerable rural households in Bangladesh: implications for policy and development. *South Asia Economic Journal*, 19(1), 43-63.
- Nasim, M., Shahidullah, S. M., Saha, A., Muttaleb, M. A., Aditya, T. L., Ali, M. A., & Kabir, M. S. (2017). Distribution of crops and cropping patterns in Bangladesh. *Bangladesh rice journal*, 21(2), 1-55.
- Nimse, S. B., & More, D. R. (2018). Evaluation of physical and nutritional properties of Aonla. *Journal of Pharmacognosy and Phytochemistry*, 7(2), 3733-3735.
- Oladunjoye, A. O., Adeboyejo, F. O., Okekunbi, T. A., & Aderibigbe, O. R. (2021). Effect of thermosonication on quality attributes of hog plum (*Spondias mombin* L.) juice. *Ultrasonics sonochemistry*, 70, 105316.
- Omotayo, A. O., & Aremu, A. O. (2020). Underutilized African indigenous fruit trees and food–nutrition security: Opportunities, challenges, and prospects. *Food and Energy Security*, 9(3), e220.

- Pasha, M. K., & Uddin, S. B. (2019). Minor edible fruits of Bangladesh. *Bangladesh Journal of Plant Taxonomy*, 26(2), 299-313.
- Pearson, A. L., Winter, P. R., McBreen, B., Stewart, G., Roets, R., Nutsford, D., ... & Wilson, N. (2014). Obtaining fruit and vegetables for the lowest prices: pricing survey of different outlets and geographical analysis of competition effects. *PLoS one*, 9(3), e89775.
- Punchay, K., Inta, A., Tiansawat, P., Balslev, H., & Wangpakapattanawong, P. (2020). Nutrient and mineral compositions of wild leafy vegetables of the Karen and Lawa communities in Thailand. *Foods*, 9(12), 1748.
- Quamruzzaman, A. K. M., Khatun, A., & Islam, F. (2020). Morphological and nutritional properties of popular eggplant cultivars in Bangladesh. *J. Bio. Life Sci*, 11(2), 155-167.
- Rabbani, G., Rahman, A., & Mainuddin, K. (2013). Salinity-induced loss and damage to farming households in coastal Bangladesh. *International Journal of Global Warming*, 5(4), 400- 415.
- Rahman, M. M., Khan, F. E., Das, R., & Hossain, M. A. (2016). Antioxidant activity and total phenolic content of some indigenous fruits of Bangladesh. *International Food Research Journal*, 23(6).
- Rahman, M. N., Alam, S. S., Mohsin, F. M., Hasan, M. M., & Islam, K. (2022). Dietary habits, food consumption, energy and nutrients intake of adults of selected areas of Bangladesh. *Indian Journal of Public Health Research & Development*, 13(1), 188-197.
- Rahman, M., & Rahman, J. (2014). Medicinal value and nutrient status of indigenous fruits in Bangladesh. *Nova Journal of Medical and Biological Sciences*, 2(6), 1-19.
- Roy, A., & Bauri, F. K. (2015, August). Scope of minor fruit production in India. In *III International Symposium on Underutilized Plant Species 1241* (pp. 43-50).
- Roy, D., Sarker Dev, D., & Sheheli, S. (2019). Food security in Bangladesh: insight from available literature. *Journal of Nutrition and Food Security*, 4(1), 66-75.

- Sachdeva, S., Sachdev, T. R., & Sachdeva, R. (2013). Increasing fruit and vegetable consumption: challenges and opportunities. *Indian journal of community medicine: official publication of Indian Association of Preventive & Social Medicine*, 38(4), 192.
- Saifullah, M., Goffar, M. A., Ahmad, S., & Bhuyan, M. A. J. (2011). Utilization of indigenous vegetables for sustainable vegetable production in Bangladesh. *International Symposium on Sustainable Vegetable Production in Southeast Asia 958* (pp. 163-170).
- Sarker, M. R., Galdos, M. V., Challinor, A. J., & Hossain, A. (2021). A farming system typology for the adoption of new technology in Bangladesh. *Food and Energy Security*, 10(3), e287.
- Satter, M. M. A., Khan, M. M. R. L., Jabin, S. A., Abedin, N., Islam, M. F., & Shaha, B. (2016). Nutritional quality and safety aspects of wild vegetables consume in Bangladesh. *Asian Pacific Journal of Tropical Biomedicine*, 6(2), 125-131.
- Schreckenber, K., Awono, A., Degrande, A., Mboosso, C., Ndoeye, O., & Tchoundjeu, Z. (2006). Domesticating indigenous fruit trees as a contribution to poverty reduction. *Forests, Trees and Livelihoods*, 16(1), 35-51.
- Shaheen, S., Ahmad, M., Haroon, N., Shaheen, S., Ahmad, M., & Haroon, N. (2017). Edible wild plants: a solution to overcome food insecurity. *Edible Wild Plants: An alternative approach to food security*, 41-57.
- Shajib, M. T. I., Kawser, M., Miah, M. N., Begum, P., Bhattacharjee, L., Hossain, A., ... & Islam, S. N. (2013). Nutritional composition of minor indigenous fruits: Cheapest nutritional source for the rural people of Bangladesh. *Food Chemistry*, 140(3), 466-470.
- Sharma, N., Kumar, M., Zhang, B., Kumari, N., Singh, D., Chandran, D., & Lorenzo, J. M. (2022). *Aegle marmelos* (L.) Correa: An underutilized fruit with high nutraceutical values: A review. *International Journal of Molecular Sciences*, 23(18), 10889.

- Sorifa, A. M. (2018). Nutritional compositions, health promoting phytochemicals and value added products of bitter gourd: a review. *International Food Research Journal*, 25(5).
- South Asia: Bangladesh. *The World Factbook*, Central Intelligence Agency. (28 March, 2023). <https://www.cia.gov/the-world-factbook/countries/bangladesh/>
- Sulaiman, S. F., Sajak, A. A. B., Ooi, K. L., & Seow, E. M. (2011). Effect of solvents in extracting polyphenols and antioxidants of selected raw vegetables. *Journal of Food Composition and analysis*, 24(4-5), 506-515.
- Sultana, R., Shemu, S., Ali, M. A., Ahiduzzaman, M., Rahman, M. M., Rafiquzzaman, S. M., & Haque, M. A. (2022). Burmese grape is an underexploited fruit crop potential to use in phytonutrient enriched yogurt formulation. *European Journal of Applied Sciences– Vol*, 10(1).
- The Business Post. (2021). Five vegetables make up 62% of total production. The Business Post, 6 Oct 2022.
- The Business Post. (2022). The Reign of Five Fruits. The Business Post, 3 June 2022.
- Tiburski, J. H., Rosenthal, A., Deliza, R., de Oliveira Godoy, R. L., & Pacheco, S. (2011). Nutritional properties of yellow mombin (*Spondias Mombin* L.) Pulp. *Food Research International*, 44(7), 2326-2331.
- United Nations Population Division. (2022). *World population prospects 2022*. United Nations Department for Economic and Social Affairs, Population Division.
- World Bank (2019). Bangladesh Poverty Assessment: Facing Old and New Frontiers in Poverty Reduction.
- Yahia, E. M., Maldonado Celis, M. E., & Svendsen, M. (2017). The contribution of fruit and vegetable consumption to human health. *Fruit and Vegetable Phytochemicals: Chemistry and Human Health, 2nd Edition*, 1-52.
- Zihad, S. N. K., Gupt, Y., Uddin, S. J., Islam, M. T., Alam, M. R., Aziz, S., ... & Sarker, S. D. (2019). Nutritional value, micronutrient and antioxidant capacity of some green leafy vegetables commonly used by southern coastal people of Bangladesh. *Heliyon*, 5(11), e02768.

## APPENDICES

### APPENDIX I: Interview schedule used in this study to assess farmer's socioeconomic condition

English version of an interview schedule Department of agroforestry and environmental science

Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200

Interview schedule for data collection for the research on

#### **'MINOR FRUIT TREES IN HOMESTEAD NURTURING FOOD AND NUTRITIONAL SECURITY THROUGH MULTI-FUNCTIONAL BENEFITS: EVIDENCE FROM RURAL POOR**

(The interview schedule is entitled for a research study)

Serial no. :

**Date:**

Upazila:

**Union:**

Village:

**“Please answer the following questions”**

#### **1. Age**

How old are you?..... Years

#### **2. Education**

Please state your level of education

- a. Can read and write ( )
- b. Can sign only ( )
- c. I read upto ..... class
- d. I've passed ..... class

#### **3. Occupation**

- a. Main occupation.....
- b. Others.....

#### 4. Family member

Sl. No.	Sex	Number
1.	Male	
2.	Female	
	Total	

#### 5. Farm Size: Please furnish information on your land ownership

Sl. No.	Pattern of ownership of land	Area	
		Local unit	Hectare
1.	Homestead		
2.	Own land under own cultivation		
3.	Land taken from others on borga		
4.	Land given to others on borga		
5.	Land taken from others on lease		
6.	Others (specify)		
	Total		

#### 6. Homestead Size

Sl. No.	Description	Area	
		Local Unit	Hectare
1.	Housing		
2.	Cowshed/courtyard		
3.	Area under Vegetation		
4.	Area covered with trees		
5.	Fellow		
6.	Pond		
7.	Others(specify)		
	Total		

## 7. Annual Income

Sl. No.	Source of Income	Amount(Tk.)
1.	Agriculture	
2.	Non-agricultural	
3.	Laborer	
4.	Business	
5.	Transport and communication	
6.	Service	
7.	Construction	
8.	Religious Service	
9.	Rent and remittance	
10	Others	
11	Total	

## 8. Tree species in homestead: Please list of tree species in your homestead

Sl. No.	Name of tree species	Amount(No.)	Uses
1.			
2.			
3.			
4.			
5.			

## 9. Product: Please list product u get from tree species in your homestead

Sl. No.	Name of tree species	Product name	Quality
1.			
2.			
3.			
4.			
5.			
6.			

7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			

**10. Seasonality:** Please mention the yield and time of harvesting of different tree species in your homestead

<b>Sl. No.</b>	<b>Name of tree species</b>	<b>Yield</b>	<b>Harvesting time</b>
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			

**11. Constraint faced:** Please mention the constraint faced for minor fruit production in your homestead

<b>Sl no.</b>	<b>Major constraints</b>	<b>Very low</b>	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>Very High</b>
1	Small homestead					
2	Climate sensitivity					
3	Pest and disease susceptibility					
4	Water requirements					
5	Prone to wind damage					
6	Dependency on pollinators					
7	Competition with other vegetation					
8	Lack of quality seeds					
9	Lack of fertilizer					
10	Lack of awareness					

Thank you giving me your valuable time

\_\_\_\_\_  
Signature of the respondents

## APPENDIX II: Photographs of Experimental Site



Plate 1: Discuss with rural people



Plate 2: Discussion and data collection with minor seller



Plate 3: Discussion and data collection with farmer



Plate 4: Data collection



Plate 5: Data collection for minor fruit with seller



Plate 6: Data collection for minor fruit with local peoples