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Rooftop Garden, A Way for Food and Nutrition Security for The Semi-Urban City of Pabna, Bangladesh

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ABSTRACT

In this study, an examine the benefits of rooftop gardening concerning nutrition & food security, and reducing the burden on urban waste management. The study aims to examine how rooftop gardening positively influences the lives of urban residents, particularly elderly individuals. It also seeks to assess whether rooftop gardening can serve as a supplementary economic activity within urban communities. Relevant information for the study was collected from both primary and secondary sources. Primary data were obtained through a structured questionnaire survey conducted among household owners and rooftop garden owners in Pabna City. The questionnaire was pre-designed and pre-tested to ensure clarity and reliability, and a total of 62 respondents participated in the survey. The most common products grown in the rooftop gardens were fruits, vegetables, leafy vegetables, spices, and plants used for medicinal purposes. These gardens used household biodegradable waste, the residue of the vegetables & shells of eggs, and decomposed them into compost fertilizers and used them in the rooftop gardens, which reduced the average 887.1g of household waste and met 41% of the fertilizers demand per household.

Rooftop gardening is increasingly gaining popularity among elderly individuals as a meaningful way to utilize their leisure time, enhance mental well-being, and foster positive social interactions within the community. The findings indicate that 77.4% of rooftop gardeners experienced an increase in vigor, while 83.9% reported improved psychological well-being as a result of engaging in rooftop gardening activities. In addition to these positive outcomes, negative psychological conditions such as anxiety and depression were either reduced or remained neutral, with no evidence of an increase among participants. Each of the rooftop garden owners' average yearly income from the garden was around 14,750 BDT (taka), from which they met the expenses of the rooftop garden and had very little net income of 1293.5 taka per year. As a bonus, they had 387.5 kg of fruits and vegetables for consumption at the household level. Finally, from an economic perspective, the cost–benefit analysis indicates that rooftop gardening is a profitable activity. Owing to its inherent advantages, such as low initial investment, efficient space utilization, and sustainable production, it holds substantial potential for expansion in urban areas. Rooftop gardening can be made successful through proper training, ensuring the supply of seeds, fertilizers, and pesticides, as well as sensitization and motivation for the use of the roof space by the house owner and tenant. This can lead to reducing food insecurity and ensuring nutritional security in urban society.

Keywords: *Rooftop Garden, Food & Nutrition Security, Mental health, Environmental hazard, Economic income*

1. Introduction

Rooftop agriculture refers to the cultivation of fresh vegetables, herbs, fruits, edible flowers, and, in some cases, small livestock on building rooftops for local consumption. Productive green roofs integrate food production with ecological sustainability by reducing rainwater runoff, moderating urban temperatures, lowering heating and cooling demands (thereby reducing greenhouse gas emissions), enhancing biodiversity, improving aesthetic value, and contributing to better air quality [1,2]. Although rooftop agriculture alone cannot fully ensure food security, it can significantly contribute to urban food systems. Furthermore, its wider adoption can be facilitated through supportive legislation incorporated into town planning schemes, building bylaws, and permit regulations. Green roof systems are broadly categorized into two main types: extensive and intensive systems.

Extensive green roofs are lightweight systems with shallow soil depths ranging from 5–15 cm (2–6 inches). They typically add a weight load of approximately 70–170 kg/m^2 (14–35 lb/sq.ft) and support a limited range of plants such as mosses and herbs. These systems are characterized by relatively low installation costs, minimal maintenance requirements, and limited structural impact, intensive green roofs have deeper soil layers ranging from 20–60 cm (8–24 inches) and can add a saturated weight load of approximately 290–967 kg/m^2 (60–200 lb/sq.ft). These systems support a wider variety of vegetation, including shrubs and small trees, and are often designed for recreational use. Intensive roofs are generally accessible to people and require more substantial structural support, elaborate irrigation and drainage systems, and higher maintenance compared to extensive systems [3].

Various authors define food security as the ability of an individual to obtain an adequate quantity of food on a daily basis [4,5]. It also encompasses access to "safe, nutritious, personally acceptable, and culturally appropriate foods produced in ways that are environmentally sound and socially just" (Nowak, 2004). In contrast, food insecurity refers to a condition in which households lack consistent access to sufficient food due to limited financial resources or other constraints. It remains a significant public health and nutritional concern worldwide [6].
Food security is generally understood to consist of three key dimensions. The first is food availability, which refers to the physical presence of sufficient quantities of food at the city, community, or household level. The second dimension is food access, meaning the ability of individuals to obtain food regularly through economic and physical means. The third dimension is food utilization (or food use), which relates to how food is consumed, including its nutritional quality and the extent to which proper hygiene and sanitation practices are maintained to ensure health and well-being [7], the United States Department of Agriculture (USDA) defines nutrition security as "consistent and equitable access to healthy, safe, and affordable foods that promote optimal health and well-being."

The Food and Agriculture Organization of the United Nations (FAO) defines nutrition security as "a condition in which all people, at all times, consume food of sufficient quantity and quality—regarding variety, diversity, nutrient content, and safety—to meet their dietary needs and food preferences for an active and healthy life, coupled with a sanitary environment, adequate health services, and proper care" [8,9].
The benefits of rooftop farming can be broadly categorized into three major dimensions: environmental, economic, and social (10). From an environmental perspective, rooftop farms offer multiple advantages. First, vegetation and planting on rooftops replace heat-absorbing surfaces such as glass, concrete, and asphalt, thereby helping to mitigate urban heat island effects. Second, rooftop vegetation contributes to improved air quality by filtering dust and airborne pollutants. Third, it enhances urban biodiversity, as planted areas attract various species, thereby supporting the conservation of both flora and fauna. Fourth, rooftop farms assist in managing stormwater by absorbing and reducing runoff, which helps decrease the burden on urban drainage systems [10,11,12]. From an economic standpoint, rooftop agriculture provides food within urban areas, thereby reducing transportation costs and associated carbon emissions. Additionally, it can lower building operational costs by decreasing the need for artificial heating and cooling, as rooftop vegetation absorbs and reflects solar radiation, improving thermal insulation [10]. From a social perspective, rooftop farms create communal spaces where residents can relax, interact, and engage in community activities. They also enhance urban aesthetics by adding greenery and color to otherwise monotonous cityscapes, contributing to a more calming and visually appealing environment (10). Survey findings indicate that most rooftops (78%) feature pleasure gardens, while fruit gardens account for 12% and vegetable gardens represent 8% [13,14].
In Pabna town, rooftop gardens are mainly classified into two primary categories: extensive and intensive systems. Extensive green roofs are lightweight, designed for low maintenance, and support a limited range of plants. These systems typically have soil depths ranging from 5–15 cm (2–6 inches) and add an approximate load of 70–170 kg/m^2.
They commonly consist of vegetables and herbs and are characterized by relatively low capital investment and minimal maintenance requirements.
In contrast, intensive green roofs have deeper soil profiles, ranging from 20–60 cm (8–24 inches), and impose a higher saturated load of approximately 290–967 kg/m^2. These systems accommodate a wider variety of vegetation, including shrubs and small trees, and are often designed for recreational use. Intensive roofs are generally accessible and require stronger structural support, well-designed irrigation and drainage systems, and higher maintenance (15). However, intensive green roofs are relatively uncommon in Pabna.

Green roofs and rooftop gardening practices in Dhaka can further be categorized into four types based on their use and physical appearance (16):

A. Extensive green roofs
B. Extensive roofs with some intensive plantation
C. Plants in fixed and designed pots
D. Plants in movable pots

In Pabna, Types A, B, and C are usually constructed during the building construction phase and are maintained regularly. In contrast, Type D rooftop gardens—consisting of movable pots—are typically established by residents after construction.
Urban food and nutrition security is an increasing concern in smaller cities such as Pabna, where food supplies are largely dependent on surrounding rural farms. Due to improved transportation and communication systems, much of the agricultural produce is transported to larger cities where higher market prices are available. As a result, both the demand for and practice of rooftop gardening in Pabna have grown to help ensure a steady supply of fresh vegetables and fruits for household consumption. Another contributing factor to the rising popularity of rooftop gardening is concern over the adulteration of vegetables and fruits with harmful chemicals, prompting residents to seek safer and self-produced food alternatives. This study aims to examine the benefits of rooftop gardening in relation to nutrition and food security, as well as its potential role in reducing the burden on urban waste management systems. It seeks to explore how rooftop gardening positively influences the lives of urban residents, particularly elderly individuals, by enhancing their physical, psychological, and social well-being. Furthermore, the study intends to assess whether rooftop gardening can be considered a viable supplementary economic activity within urban society.

2. Method And Materials

Relevant information for this study was collected from both primary and secondary sources. Primary data were obtained through a structured questionnaire survey conducted among household owners and rooftop garden owners in Pabna City. The questionnaire was pre-designed and pre-tested to ensure clarity and reliability, and a total of 62 respondents participated in the survey, a focus group discussion (FGD) was conducted, where participants were invited to share their views on the opportunities and challenges associated with rooftop gardening in the city. The discussion covered issues such as technical and financial constraints, health and psychological benefits, institutional support from the Department of Agricultural Extension (DAE) and the Municipality, and overall public perception regarding rooftop gardening.

3. Results and Discussion

Food production and consumption in urban areas have become global concerns due to rapid urbanization and the increasing movement of people into cities, which places growing pressure on food security (13). Rooftop agriculture contributes to urban sustainability by promoting efficient resource utilization and enhancing household-level food security. Although green roofs cannot serve as a complete solution to urban food security challenges, they can significantly enhance food diversity and reduce the risk of food insecurity.

Organic gardening practices are generally preferred in rooftop agriculture. However, rooftop gardens are not entirely free from pests and diseases, as these originate from soil and natural environmental conditions. Nevertheless, pest and disease management is often more manageable in rooftop systems, allowing for the use of natural and controlled treatment methods.

In Bangladesh, nearly 60 varieties of fruits and vegetables are cultivated, varying by season and region. Due to limitations such as household food preferences, seed availability, rooftop space, weather conditions, and soil quality, it is not feasible to cultivate all types on rooftops. Therefore, crop selection is typically based on regional suitability and household demand.

Common fruits grown in rooftop gardens include guava, lemon, papaya, pumpkin, and grapes. Frequently cultivated vegetables include cucumber, flat bean, bitter gourd, lady's finger (okra), tomato, and brinjal (eggplant). Leafy vegetables such as spinach, Indian spinach, amaranthus, and red amaranthus are also widely grown, along with spices including green chili, onion, garlic, and coriander leaves. In addition, some households cultivate medicinal plants and aromatic spices for personal use.

A major motivation for rooftop gardening is the desire to obtain fresh and chemical-free fruits and vegetables. Unlike many market products that may contain harmful chemical residues, rooftop-grown produce is generally cultivated using controlled and proportionate amounts of fertilizers and pesticides. As a result, households are able to substitute a portion of their market purchases with produce grown on their own rooftops.

The study findings indicate that rooftop gardens significantly contribute to household fruit consumption. The proportion of fruits supplied from rooftop gardens includes guava (35%), lemon (53%), hog plum (41%), pomegranate (21%), dragon fruit (61%), and papaya (73%), reflecting the substantial role of rooftop agriculture in meeting household nutritional needs.

Table 1: Average food production from the rooftop Garden (Yearly)

Types of Food	Name of The Vegetable	Number of Gardens produced	Average Production/ garden (kg)	Consumption (kg)	Selling Income (taka)
Leafy Vegetables	Indian Spinach	58	52	35	425
	Spinach	43	19	11	320
	Amaranthus	23	30	21	180
	Red Amaranthus	49	36	21	300
Vegetables	Brinjal	57	33	25	448
	Ladies finger	42	26	19	280
	Tomato	62	45	26	1,425
	Cucumber	41	19	12	280
	Flat Bean	19	26	21	400
	Bitter ground	31	15	9	600
	Pumpkin	25	34	34	0
Spices	Green Chili	59	26	13	1,040
	Onion	35	30	30	0
	Garlic	21	15	15	0
	Ginger	49	10	5	1,000
	Coriander leaves	56	5	2.5	312.5
Fruits	Guava	31	5	4	100
	Lemon	57	25	13	960
	Papaya,	43	143	85	3,480
	Hog Plum	27	3	3	0
	Pomegranate	13	3	3	0
	Dragon fruit	46	30	14	3,200
Total Yearly income					**14,750.5**

Rooftop gardeners generally prefer to use organic fertilizers and natural pest control methods in order to minimize the harmful effects associated with chemical fertilizers and synthetic pesticides. Commonly used organic inputs include compost, vermicompost, and other bio-based fertilizers, many gardeners utilize household biodegradable waste as a sustainable nutrient source. Vegetable residues such as leaves, peels of potatoes and other green vegetables, and eggshells are collected and decomposed to produce compost, which is then applied to rooftop gardens. On average, households recycle approximately 500 g to 1,250 g of organic household waste for composting purposes. This practice not only enhances soil fertility and plant growth but also contributes to reducing the volume of organic waste entering the municipal waste management system.

Table 2: Average household biodegradable waste used in the Rooftop Garden/week

Amount of organic waste	Number of gardens	Percentage of the gardens	Percentage of total fertilizers
500-750 g	14	22.6%	30%
750-1000g	31	50.0%	41%
1000=1250g	17	27.4%	50%
Average	887.10 g		41.0%

In small towns such as district and sub-district centers, the proportion of elderly residents—particularly parents—has been steadily increasing, as younger family members migrate to capital and major cities for employment, income generation, and educational opportunities. This demographic shift often leaves older adults living alone, which can lead to loneliness and difficulties in utilizing leisure time effectively. Such social isolation may contribute to mental health challenges, including stress, anxiety, anger, and depression, rooftop gardening has emerged as a meaningful and beneficial activity for elderly individuals. It provides a constructive way to spend leisure time, promotes physical engagement, and supports mental well-being. Moreover, rooftop gardens facilitate social interaction, as they often become a shared topic of conversation and community engagement among neighbors. Through these interactions, elderly residents can strengthen communal bonds and reduce feelings of isolation, thereby improving their overall quality of life.

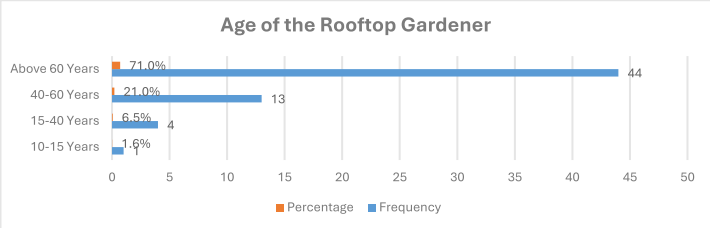

Figure 1: Age of the Rooftop Garden Owners

The survey findings indicate that a majority of rooftop garden owners (44 respondents, representing 71%) are above 60 years of age. This highlights the significant involvement of elderly individuals in rooftop gardening practices. To better understand their motivation, six primary purposes for practicing rooftop gardening were identified: passing leisure time, improving psychological health, enhancing aesthetic value, contributing to environmental amelioration, achieving financial gain, and fulfilling luxury interests. The bar diagram illustrating these purposes provides a clearer representation of the relative importance assigned to each motivation by the respondents.

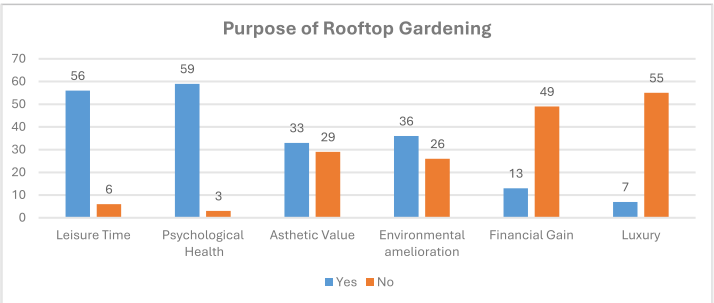

Figure 2: Purposes of the Rooftop Gardening

Recreation and meaningful engagement during leisure time play an important role in maintaining and improving mental health. Individuals require recreational activities to achieve peace of mind and effectively manage anger, stress, and anxiety. Key indicators of psychological well-being include life satisfaction, vigor, a sense of community, and reduced levels of anxiety, stress, anger, and depression. Rooftop gardening has been found to positively influence these dimensions of mental health. The activity contributes to enhanced life satisfaction, increased vitality, improved psychological well-being, and a stronger sense of community among participants.

The survey results reveal that approximately 68% of rooftop garden owners reported an increase in life satisfaction as a result of their engagement in rooftop gardening. Similarly, 77.4% indicated improved vigor, while 83.9% reported enhanced psychological well-being, negative psychological conditions such as anxiety and depression were reported to have either decreased or remained neutral among participants, with no respondents indicating an increase in such conditions. These findings suggest that rooftop gardening serves as a valuable recreational and therapeutic activity, particularly for urban residents.

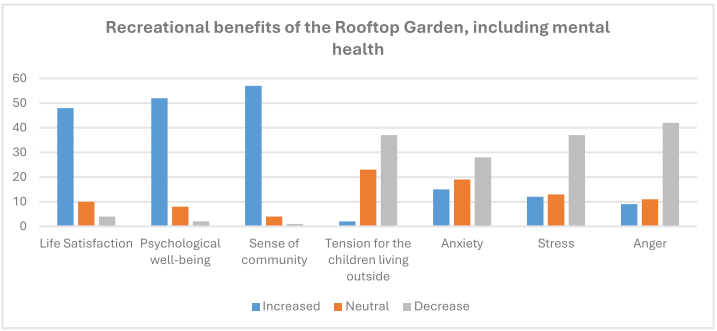

Figure 3: Recreational benefits of Rooftop Gardening, including the mental health

In the study area, rooftop garden owners utilized both purchased and home-supplied inputs for cultivation. All inputs were valued either at the prevailing market price during the survey period or at the actual purchase price paid by the respondents. Similarly, the output from rooftop gardens was assessed based on the current market value of the produce. Purchased inputs—such as seeds, fertilizers, containers, and other gardening materials—involved direct monetary expenditures, making their valuation relatively straightforward. In contrast, home-supplied inputs did not involve direct cash payments. Therefore, their costs were estimated using the opportunity cost principle, assigning value based on the potential earnings or market price that could have been obtained had those resources been used elsewhere.

Table 3: The average cost-return per household garden calculation

Items	Cost (Tk.)	Percentage
Construction & Repairing cost per year	523.0	3.89%
Container replacement cost per year	623.0	4.63%
Soil cost per year	3691.0	27.43%
Material cost per year	123.0	0.91%
Seed collection, planting, and maintenance costs	645.0	4.79%
Irrigation/Watering cost	5052.0	37.54%
Fertilizer cost	1100.0	8.17%
Insecticide cost	350.0	2.60%
Laborer cost per year	1350.0	10.03%
Gross cost per year	13457.0	
Gross return per year	14750.5	
Net return per year	1293.5	

3. Challenges

Rooftop garden owners in the study area face several challenges. Many gardeners reported limited access to quality seeds, fertilizers, pesticides, and technical support from government and non-government organizations. Insufficient institutional assistance restricts the effective expansion and management of rooftop gardens. An additional challenge involves the complex relationship between birds and crops. While birds often act as natural predators by controlling garden pests, they can also cause damage by feeding on young vegetable plants and fruits. Moreover, fallen leaves and plant debris can accumulate on rooftops, requiring periodic cleaning and maintenance.

Access to high-quality planting materials is another concern. Most gardeners purchase seedlings and plants from local nurseries; however, inconsistent quality sometimes results in poor crop performance and lower yields. In some cases, gardeners become discouraged after investing in low-quality planting materials that fail to produce desirable outputs. Tenants are generally less interested in establishing rooftop gardens due to concerns raised by homeowners, who fear potential structural damage to buildings. Furthermore, the lack of formal training is considered a major constraint. Many rooftop gardeners rely primarily on inherited agricultural knowledge and personal experience rather than scientific or technical guidance, these constraints, rooftop gardening is not perceived as a zero-benefit activity by most participants. Gardeners continue the practice to meet household consumption needs, gain recreational satisfaction, and improve both physical and mental well-being.

4. Conclusion

Rapid urban population growth, particularly the increasing proportion of elderly residents in small towns such as Pabna, has intensified the demand for food and household food expenditure. At the same time, agricultural land is steadily being converted into residential, commercial, and industrial uses, thereby reducing the capacity for conventional food production. Additionally, concerns regarding food contamination—such as the excessive use of harmful chemicals, inorganic fertilizers, and pesticides—have heightened public awareness about food safety. Under these circumstances, rooftop farming emerges as a practical and promising solution to address issues related to food security, nutrition, and environmental sustainability.

In the context of urban life in Pabna, rooftop gardening provides significant recreational and psychological benefits. Garden owners experience stress relief and improved mental well-being through cultivating and nurturing plants. Indicators such as life satisfaction and psychological health have shown positive improvement, while negative conditions including anxiety, stress, and depression have declined due to meaningful engagement in rooftop gardening activities.

Despite these benefits, rooftop gardeners face challenges in accessing quality seeds, fertilizers, and essential nutrients. The study findings indicate that the expansion of rooftop garden size positively influences profitability, and experience plays a crucial role in improving economic returns. However, managing a wide variety of fruit and vegetable crops requires careful planning, effort, and technical knowledge.

From an economic perspective, the cost–benefit analysis demonstrates that rooftop gardening is a profitable activity with substantial potential for expansion due to its inherent characteristics, such as low space requirements, resource recycling capacity, and contribution to household consumption.

Recommendations

To promote sustainable rooftop gardening in the study area, the following recommendations are proposed:

- Unused rooftop spaces should be effectively utilized for gardening, ensuring proper drainage systems to maintain building safety and hygiene.
- Regular training programs should be organized to provide basic knowledge on container preparation, fertilizer application, irrigation methods, and overall garden management.
- Specialized training on insect and pest management should be provided to ensure safe and high-quality production of fruits and vegetables.
- Marketing opportunities should be developed to enable rooftop gardeners to consider the activity as a viable supplementary economic option.
- High-yielding and suitable varieties of fruits and vegetables should be made accessible to rooftop gardeners to enhance productivity.
- Rooftop gardens should be maintained in a clean and organized manner to ensure their sustainability and longevity.
- Tenants should be encouraged to engage in rooftop gardening through mutual agreements with building owners.
- A technically feasible, socially acceptable, economically viable, and environmentally sustainable rooftop gardening model should be developed and gradually scaled up in urban areas.
- Awareness and motivational programs should be implemented to encourage rooftop gardeners to adopt improved technologies and innovative practices.
- A coordinated approach involving institutions such as Bangladesh Agricultural Research Institute (BARI), Department of Agricultural Extension (DAE), and relevant non-governmental organizations (NGOs) should be established to develop and implement a suitable rooftop gardening model.

5. Ethical Considerations

To ensure the protection of participants—particularly vulnerable groups such as children and pregnant or lactating women—the study adhered to fundamental ethical principles, including voluntarism, confidentiality, and anonymity. Participation in the study was strictly voluntary. At the beginning of each interview or discussion, the purpose of the study was clearly explained, and participants were informed that all information provided would be kept confidential. Respondents were given the right to withdraw from the study at any stage or to decline answering any question without facing any negative consequences.

Do No Harm: The data collection instruments were carefully designed to avoid harm, discomfort, or distress to respondents. Questions were framed sensitively, and where necessary, appropriate support or referral information was provided for issues requiring further assistance.

Integrity: All data were reported accurately and transparently. Every effort was made to verify and cross-check the information to ensure that findings were presented correctly and within their appropriate context.

Participant Feedback: Key findings of the study were shared with the community and participants to ensure transparency and to incorporate their perspectives into the final report.

6. Acknowledgement

On behalf of the research team, we sincerely acknowledge all caregivers of children under five, pregnant and lactating women, Majhi (community leaders), religious leaders, and kitchen garden beneficiaries who generously shared their experiences and insights during this study.

- Their valuable contributions will help inform future programs aimed at mitigating the impact of ration reductions on the nutritional status of children under five, pregnant and lactating women, and other vulnerable populations.

We also extend our gratitude to other stakeholders, including nutrition and food security staff who conducted the qualitative components of the study through Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) at the field level, as well as the camp authorities for their support and cooperation.

Author Contributions: Conceptualization: TA and MAKS; Data Curation: SSB, MAH, and MI; Formal Analysis: MI and SSB; Methodology: TA, MAKS, and MI; Project Administration: SSB and MAH; Supervision: SSB, MI, and MAH; Validation: MI; Writing – Original Draft Preparation: TA and MAKS; Writing – Review and Editing: TA, MAKS, SSB, MAH, and MI.

Informed Consent

Prior to the commencement of both quantitative and qualitative data collection, the survey team provided a brief introduction outlining the purpose of the study and the estimated duration of the survey. Participants, including individual respondents and Focus Group Discussion (FGD) members, were informed about the confidentiality and privacy of the information to be collected. It was clearly stated that no personal or family information would be disclosed in the reporting of the findings, and that the rights and dignity of all participants would be fully respected.

Respondents were informed of their right to refuse to answer any question or to withdraw from the survey at any stage without any consequences. The survey proceeded only after obtaining informed consent from individual participants and/or FGD group members. Participants were selected equitably, and voluntary participation was strictly ensured.

7. Ethical Approval

Formal approval to conduct the survey was obtained from the relevant authorities, including the Deputy Commissioner (DC) of Pabna District, the Mayor of Pabna Municipality, and the Department of Agricultural Extension (DAE).

8. Competing Interests

All authors declare that there are no personal or financial conflicts of interest related to this study.

9. Disclaimer (AI)

The authors hereby declare that no generative artificial intelligence technologies, including large language models (such as ChatGPT, Copilot, etc.) or text-to-image generators, were used in the writing or editing of this manuscript.

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