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From data to farm decisions: Developing grain-oilseed cost and return guide for Bangladesh

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FROM DATA TO FARM DECISIONS: DEVELOPING GRAIN-OILSEED COST AND RETURN GUIDE FOR BANGLADESH

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EXECUTIVE SUMMARY

Smallholder farmers have been confronted with persistent difficulties to precisely estimate the costs and returns of arable farming due to the unavailability of farm planning guidelines and handy tools. Crop budgets in countries like the United States, the United Kingdom, the European Union and Canada, have been systematically updated over time and made available publicly to support informed decision-making. Regional peers like India and China also initiated crop budgets for farming decisions. Despite global track records, Bangladesh has lacked an organized crop budget and crop budget planning tool due to limited national coordinated information for economic analyses.

To overcome the gaps, this study developed nationally representative division-level (first-order administrative unit) crop cost and return guides for Bangladesh's major cereals (*Aman* rice, *Boro* rice, and wheat) and rotational crops (maize, lentil, and mustard). Crop zones were identified using geographic information systems (GIS) based on the spatio-temporal distribution of production and area of production. Crop zone mapping demonstrated clear regional heterogeneity, where Rangpur division emerged as a hotspot for monsoon season *Aman* rice and winter season maize. Rajshahi division was identified as winter season *Boro* rice, wheat, and mustard hotspots with Khulna division as lentil hotspot. These spatial variations reflect differences in agro-ecological conditions and agricultural practices.

Based on the spatio-temporal analysis, results showed clear cost and return trade-offs across four mechanized farm management alternatives and machinery markets. The comparative profitability analysis indicates that per hectare (ha) return over variable costs (gross margin) for major cereals and rotational crops increased with higher levels of mechanization under both farmer owned and custom hired machinery markets. With least mechanized farm operations (e.g., mechanized tillage only system), *Aman* and *Boro* rice gross margins were negative under the custom hired machinery market. With increasing mechanization, gross margins increased across both farmer owned and custom hired machinery markets. This was largely attributable to the high labour costs associated with less mechanized operations. The gross margins were higher under the farmer owned machinery market because machinery service charges were considered in the custom hired machinery market as variable cost.

When evaluated at market prices, the per hectare return over total costs (net returns) were positive for rotational crops maize and lentil, whereas net returns for all other crops found negative returns across all farm management alternatives and machinery markets. The unprofitable rice production is justified because the staple rice production is not driven with profitability rather intensified due to the family subsistence priority to ensure family food self-sufficiency. Conventional whole farm mechanization appeared more feasible among all farm management alternatives under custom hired machinery market than farmer owned machinery market. For example, in maize production, net return was BDT 10,093.79/ha higher for custom hired conventional whole farm mechanization. The added machinery ownership costs challenged farm profitability in farmer owned machinery markets. However, custom hired services may be disrupted by the challenges associated with machinery availability and optimum scheduling of farm operations that would have negative agronomic and farm economic impacts. The economies of size in machinery ownership markets could help farmers to be better-off with increasing production through adding more land under mechanized operations to reduce the financial burdens of machinery ownership costs. Break-even analyses of main grain yield and price of grain identified the situation at which indifferent profit-loss situations occurred. For example, under the farmer owned machinery market, for maize production, break-even analysis over total cost indicates that the break-even price under conventional whole farm mechanization was BDT 19,000.50/t. Similarly, break-even yield was 4.65 t/ha, which was 0.25 t/ha higher than custom hired machinery services.

To enhance accessibility and practical application of crop budgets, this study developed an open-access digital crop budgeting planning tool hosted by the Hub for Smallholders Agri-Tech Economics (HSATE). The platform integrates crop budgets with national datasets, enabling stakeholders to make evidence-based, location-specific production and investment decisions. It supports policymakers in designing targeted price interventions and moving beyond ‘one-size-fits-all’ approaches in farm planning. The GIS based crop zoning is aligned with the National Agriculture Policy (NAP) of Bangladesh. Because the national policy targeted crop planning using modern techniques like GIS and remote sensing (section 3.3.12.1, pg., 9). The crops cost and return guide identified profitable cereals and oilseed which is consistent with the national agriculture policy, where production of profitable farm enterprises (crops) is targeted (section 3.3.8.6, pg., 8). The profitability assessment of farm enterprises under different mechanized farm management alternatives and markets has implications for national agricultural mechanization policy and plan of action. Because both targeted increasing mechanized operations to ensure the transition to efficient, profitable and commercial agriculture through agricultural mechanization and ensuring sustainable food and nutrition security. The comparative assessment of farmer owned machinery sets and custom hire service markets have implications for machinery markets development and upscaling that have public and private sector implications. The national crop cost and return guide can serve as a critical foundation for enhancing stakeholders capability and capacity to make informed production and investment decisions. Integrating national datasets with spatio-temporal mapping allows better understanding of regional production patterns and comparative advantages. Policymakers should use this tool to design targeted crop support programmes and region-specific investment strategies as agriculture is a risky business. The digital crop budget planning tool can be aligned with national agricultural administrative data through digitizing these datasets and facilitating accessibility which would have policy relevance through automated crop budget planning to inform policy programme and investment decisions. Overall, data-driven agricultural decisions are crucial for transitional economies like Bangladesh that are looking to ensure agriculture as an income generating industry to link with a thriving economy. This has implications for Bangladesh's graduation from LDC, where agriculture should be positioned to facilitate economic growth. The implications of crop budgets in the medium to long-term is dependent on the quality and accessibility of data systems and institutional coordination.

1. INTRODUCTION

Crop budgeting is among the most fundamental farm economic tool (Rogers, 2025) that farmers, agribusiness, academics and researchers, extension agents and policymakers can use to make data-driven informed decisions. They act as a key mechanism for translating national-level agricultural statistics such as prices, yields, input use, and production costs into meaningful economic insights at the farm level. Such farm planning is most effective if updated regularly and this addresses the dynamics of prices, costs, and returns. Globally crop budgets are an established decision-support tool in agriculture, characterized by systematic development, periodic updates, and widespread dissemination for both farm-level and policy use. In developed country settings like the United States (USDA, 2025a), the United Kingdom (Agro Business Consultants, 2018; Redman, 2024), Canada (Alberta, 2025; Manitoba, 2026), and the EU member states such as Ireland (Teagasc, 2026), Germany (KTBL, 2026), crop budgets are regularly updated to provide information, guide farm planning and facilitate extension decisions. Across developed countries, annual crop budgets are available online and/or as published books to inform farm and policy decisions.

Historically, Bangladesh did not often need crop budgets to identify cropping practices, technology alternatives and machinery markets. This is because of the dominance of subsistence agriculture that primarily focused on household food security. However, rapid agrarian transformation has caused labour shifts towards manufacturing, garments, and construction (Sen et al., 2021), due to higher wage rates, input price inflation, and absence of well-developed formal credit and insurance facilities. Continuing family farming traditions are no longer a priority in rural Bangladesh (Wood and Mandal, 2025). Many farm families prefer non-farm employment for their children owing to better non-farm income opportunities as well as the perceived low social status associated with farming. The country is in the crossroad of the graduation from the status of the Least Developed Country (LDC) category (MoF, 2025). Every season, farmers face challenges in making critical decisions about which crop to grow and how to manage farms? In the absence of structured decision-making tools, these decisions are often in formally guided by traditional practices, past experiences, peer influence, advice from input dealers, with limited reliance on formal farm economic information. There is a lack of farm economic tools and national information to guide cost and return of farm enterprises, management alternatives and machinery markets in Bangladesh.

Crop zoning, crop budgets and the digital crop budget planning tool are essential to link economic growth and agricultural transformation in support informed agricultural policy and programme design. The crop zoning and farm planning initiatives taken through this research have implications for the 'sustainable, safe, and profitable' agriculture vision and associated policies set by Bangladesh's government (MoA, 2023; NAMP, 2020; NAP, 2018). To guide data-driven policy decisions and programme formulation, this study mapped major cereals (*Aman* rice, *Boro* rice, and wheat) and rotational crops (maize, lentil, and mustard) intensification zones followed by the development of a crop cost and return guide, and an open-access digital crop budget planning tool for Bangladesh. This research is designed as an extension of the IGC project (BGD-24192), addressing fundamental questions of farm productivity and economics which aligns with the IGC's firm, trade, and productivity theme. This study is the first attempt in Bangladesh to examine the economics of profitable crops at national level through the systematic development of crop budgets.

The main objective of this study was to develop divisional level extensive cost and return guides for major cereals and rotational crops. The study combined divisional-level (first-order administrative units) crop budgets by synthesizing fragmented national datasets. It identified the regions (divisions) where selected grains and oilseed are most intensified. This study employed spatial analysis for the development of regional crop plans through Geographic Information System (GIS) techniques, as emphasized in national agricultural policy frameworks. Further, this study constructed detailed crop budgets for the identified regions to quantify the costs and returns associated with grain and oilseed production. Finally, followed by establishing detailed crop budgets, this study developed an open-access digital crop budget planning tool (a web-based application of the crop budgets).

These research objectives are closely linked to national policy priorities, which emphasize both regional crop planning and farm economic analysis. Despite these priorities, Bangladesh still lacks nationally representative crop budgets, which are crucial for farm economic analysis. Existing national datasets predominantly capture physical indicators, such as production, yield, acreage, and input use, primarily for food security planning, rather than for economic decision-making. Although concerns regarding data reliability and completeness remain issues (Haider, 2025; Paul, 2025; The Business Standard, 2021), these datasets still contain essential elements that can be utilized to develop robust crop budgets. By identifying region-specific production patterns and estimating farm-level profitability, the study expected to support evidence-based policy decisions.

2. STATE OF THE KNOWLEDGE

The state of knowledge indicates that there are generalized crop budget guidelines like FAO user manual for crop budget (FAO, 2014) and FAO handbook on agricultural costs of production statistics (FAO, 2016). The United States Department of Agriculture (USDA) (USDA, 2025a) and different US universities annually update state level crop budgets. For instance, the Purdue University's Crop cost and return guide (Langemeier, 2025), the University of Illinois Urbana-Champaign's 2025 crop budget (Paulson et al., 2026), Kansas State University's Agmanager.info (AgManager.info, 2025), University of Georgia's Crop budgets (UGA, 2026), guide farmers, agribusinesses, agricultural extension services and government agencies. Canadian crop budgeting also plays a key role in guiding agriculture including Alberta government's Cropping alternatives: Crop budget planning (Alberta, 2025), Manitoba's Crop production costs (Manitoba, 2026). In Argentina, the farmer organization CREA produces crop budgets and shares them through regular publications (CREA, 2026).

Similarly, the United Kingdom has enterprise cost and return guidelines such as Agro Business Consultants (Agro Business Consultants, 2018) and John Nix Pocketbook (Redman, 2024), and Ireland follows crop production and budgeting guidelines e.g., Teagasc Crop Costs and Returns 2026 (Teagasc, 2026). In Germany, KTBL international offers data on input costs, output prices, and farm budgets (KTBL, 2026). A global network of experts has developed a platform called agri benchmark which compiles and compares national farm enterprise cost and return across the world (Agri Benchmark, 2026). While comparable initiatives exist in Asia, they are fragmented or less likely have long historical track records. For instance, Indian Union Budget 2026-27 to promote the production of high value crops (PIB, 2026). China has comparatively good track records of publishing book series on crop cost and benefit: Book series: China agricultural products cost-benefit compilation of information (China Statistics Press, 2026).

Beyond institutional practices and national-level frameworks, a substantial body of empirical literature has developed around crop-wise budgeting and profitability analysis across different agro-ecological contexts. These studies typically employed detailed cost and return frameworks to estimate input use, production costs, and profitability, enabling comparisons across technologies, regions, and farm types. Within this empirical literature, rice is one of the most extensively studied crops due to its central role in global food systems. Globally, rice is widely cultivated, and well-established crop budgeting practices are observed across major rice-producing countries, including both developed and developing contexts. In the USA, crop budgets for rice are well developed and comprehensively used (USDA, 2025b). Several Asian countries, including China (Chen et al., 2025; Ye et al., 2020), Japan (Bunthan et al., 2018), India (Namdeo et al., 2025), Nepal (Dhakal et al., 2023), Indonesia (Saediman et al., 2019) and Thailand (Suwanmaneepong et al., 2020) also demonstrate the application of crop budgeting for rice. Similarly, African countries such as Nigeria (Ben-Chendo et al., 2017; Nwahia, 2020) have developed and applied crop budgeting frameworks for rice. Comparable crop budgeting frameworks are also widely applied to other major crops such as wheat (Ali, 2002; Dawadi et al., 2023; Gul et al., 2019; Wahidi et al., 2025), and rotational crops, such as, maize (Girei et al., 2018; Jamakhandi et al., 2020; Khan et al., 2023; Tanin and Engindeniz, 2024), lentil (Habib and Rizwan, 2019; Poudel et al., 2022), and mustard (Nondani et al., 2025; Verma et al., 2023), where detailed estimation of input costs and returns is routinely undertaken.

Although a handful of studies have addressed crop-specific profitability in Bangladesh, they have largely been confined to small geographic areas. National-level coordinated, standardized, and regularly updated crop budgets are still unavailable in Bangladesh. The existing literature has primarily focused on the profitability of rice (Chanda et al., 2019; Sarkar et al., 2024; Sujan et al., 2017; Uddin et al., 2022), wheat (Islam et al., 2012; Morris et al., 1996; Rahman and Hasan, 2011), maize (Adnan et al., 2021; Biswas et al., 2022; Hajong et al., 2023), lentil (Miah et al., 2021; Rahman et al., 2013), and mustard (Rayhan et al., 2013; Sarkar et al., 2020; Tithi and Barmon, 2018). A detailed account of the state of knowledge is provided in Appendix A.

3. MATERIALS AND METHODS

3.1 Study Site

This study considered the context of Bangladesh, a South Asian country (Figure 1), characterized by substantial agricultural production and diverse agro-ecological conditions (BBS, 2024). Bangladesh is administratively divided into eight divisions (first-level administrative unit) and 64 districts (second-level administrative unit) (BBS, 2020), which differ in soil type, cropping patterns, and production intensity. The research particularly aims to identify the divisions and districts where the cultivation of major cereals, such as *Aman* rice, *Boro* rice, and wheat, and rotational crops, such as maize, mustard, and lentil, are the most intensified in terms of production and area of production. These regions are expected to reflect variations in cropping patterns, input use, and farm management practices, providing a representative context for analysing crop cost and return, which in turn informs smallholder farming decisions and national policies.

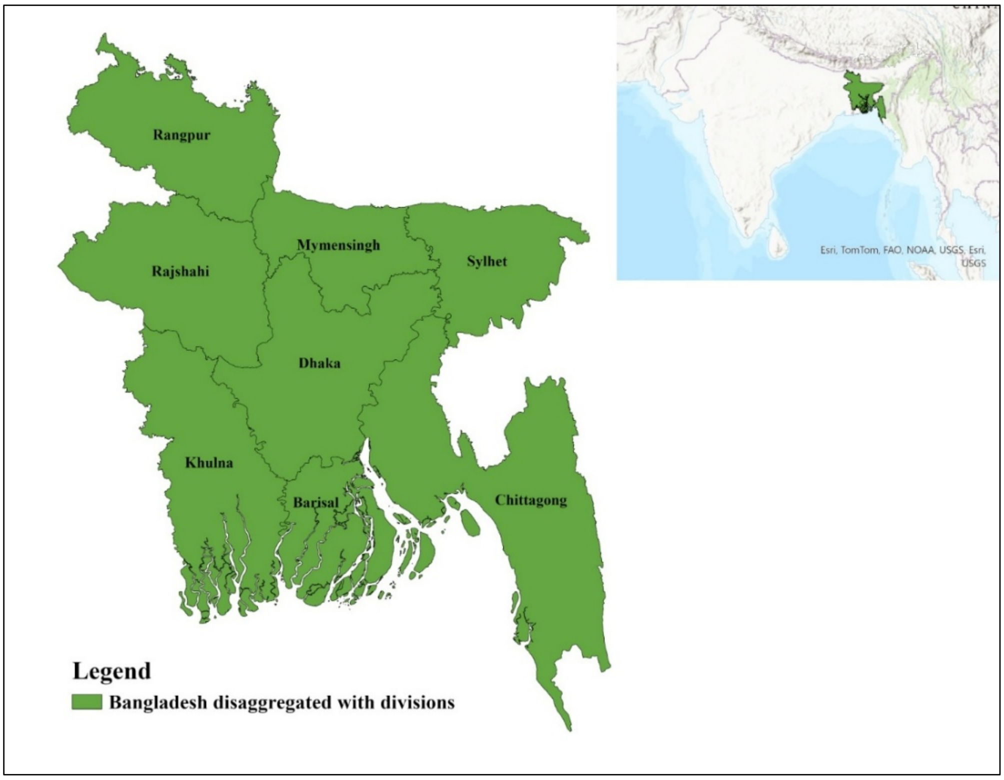

Figure 1. Study area context.
Source: HSATE Team.

3.2 Data

The dataset used to identify division and district-level production and area of production for major cereals (e. g., *Aman* rice, *Boro* rice, and wheat), and rotational crops (e. g., maize, lentil, and mustard) in Bangladesh was based on the Yearbook of Agricultural Statistics, published by the Bangladesh Bureau of Statistics (BBS, 2024). Production and area of production data for major crops were used for the entire period (2007–2024), while data for rotational crops, maize and lentil, were utilized from 2014–2024, and mustard were from 2015–2024. The collected data were first organized in Microsoft Excel and subsequently converted into Geographic Information System (GIS) compatible format for spatio-temporal analysis. Administrative boundary shapefiles of top two administrative unit (division and district) were obtained from Global Administrative Areas (GADM) version 4.1, which were used to visualize the temporal trends into spatial distribution of crop area and production across Bangladesh. Spatial analysis and mapping were conducted using ArcGIS Pro (version 3.3.0), while Microsoft Excel (version 2021) was used for data handling and further validation of the findings (Appendix B).

The inputs specification and cost datasets were based on the empirical techno-economic data collected from secondary, non-proprietary sources, published literature, and KIIs for the production year 2023-2024, which was further validated with experts' consultation (Appendix C). Sporadic national datasets from Bangladesh Bureau of Statistics (BBS), Bangladesh Bank (BB), Department of Agricultural Marketing (DAM), Bangladesh Agricultural Development Corporation (BADC), Department of Agricultural Extension (DAE), were amalgamated to develop crop budgets. KIIs were conducted with subject matter experts, representatives from agri-tech (Appendix D) and agrochemical (Appendix E) companies, and government officials of Bangladesh (Appendix F and Appendix G) to identify the values of operating (e. g., seeds, fertilizers, pesticides, irrigation, labour, machinery fuel and repairs, threshing charge), and fixed (i.e., machinery costs, land rent) costs for the crop budget analyses. Local officials from BADC and DAM were also contacted for specific data.

The quantity of seed was sourced from the Yearbook of Agricultural Statistics (BBS, 2024), while the price data were collected from the BADC (BADC, 2026). Data on pesticides (i.e., herbicides, insecticides, and fungicides) application rate were obtained from the List of Registered Agricultural Pesticides, Bio-Pesticides and Public Health Pesticides in Bangladesh provided by the DAE (DAE, 2024). Due to the unavailability of national price statistics, pesticide price data were gathered from several representative agrochemical companies in Bangladesh. Fertilizer application quantities were obtained from the Fertilizer Recommendation Guide 2024 (FRG, 2024), while fertilizer price data were collected from DAM (2026). Due to the absence of national statistics of the quantity of labour, the labour requirement data was collected through KIIs. The daily wage rates were obtained from the Yearbook of Agricultural Statistics (BBS, 2024). Irrigation charge rates were collected through KIIs as national-level data are not publicly available online. Due to the absence of publicly available national statistics, machinery fuel consumption rates (L/h) were obtained from agri-tech companies in Bangladesh, while work rates (h/ha) were sourced from Al-Amin et al. (2024). Given the volatility of diesel prices, the per litre diesel price was gathered through KIIs, which is consistent with data reported by the Bangladesh Petroleum Corporation (BPC, 2026). Machinery lubricant costs were estimated based on assumptions from North Dakota State University (NDSU, 2025), while machinery repair costs followed the assumptions of John Nix Pocketbook 2024 (Redman, 2024). Information on machinery related indirect cost components (e.g., machinery costs) was compiled from various online machinery marketplaces and supplier websites, consistent with the findings of Al-Amin et al. (2024). Threshing operations were assumed to be conducted through custom hiring services, following the rates reported by Bangladesh Agricultural Research Institute (BARI) (Hossain et al., 2017). Due to the unavailability of national statistics, land rent values were collected through KIIs with Assistant Commissioner (Land), Upazila Agriculture Officer (UAO), and Sub-Assistant Agriculture Officer (SAAO) of the respective divisions (i. e., Rajshahi, Rangpur and Khulna). The monthly agricultural interest rate was obtained from Bangladesh Bank (Bangladesh Bank, 2026a).

The yield of the main product was collected from the Yearbook of Agricultural Statistics published by the Bangladesh Bureau of Statistics (BBS, 2024), while the corresponding price data were obtained from the DAM (2026). As national statistics on by-product yields are currently unavailable, by-product yield and price were compiled through KIIs, consistent with the findings of Al-Amin et al. (2024). All monetary values were expressed in Bangladeshi Taka (BDT). For international comparison, values could be converted using an exchange rate of US$1 = BDT 109.05 for the production year 2023-24 (Bangladesh Bank, 2026b).

To visualize the division specific crop budgets, a web-based open-access digital crop budget planning tool was developed and integrated into the Hub for Smallholders Agri-Tech

Economics (HSATE) website to support the users in estimating the costs and returns associated with various crops. This tool enables users to perform quick budgeting by their own farm-specific cost components and thereby providing an approximate estimate of production costs and returns.

3.3 Analytical Method

3.3.1 Mapping crop zones

This study first compiled the data for the six selected crops in Microsoft Excel and subsequently converted into Geographic Information System (GIS) compatible format for space time cube (STC) construction followed by emerging hotspot analysis (EHSA) to identify region-specific hotspot patterns.

3.3.1.1 Space time cube (STC)

Space, time and attribute are the three core components of spatio-temporal data (Gatalsky et al., 2004.; Peuquet, 1994) (Figure 2). STC is a 3D model or geo-visualization technique which structures the spatio-temporal data in a cube and from the cube the spatio-temporal trends are detected (Kang et al., 2018). Space time bins are the building blocks of this STC cube where x and y are the space dimensions and t are the time dimensions and each of the bins have their own location in these space time coordinate systems while these bins represent the records of attributes in a specific location in a specific time step (Kang et al., 2018; Mo et al., 2020). It is to mention that every horizontal layer of bins or time step is called the 'time slice' representing the spatial distribution of records in a specific point or period in time while every single column of bins is called 'bin time series' representing the time series trend of records for a specific geographic location (ArcGIS Pro, 2026). This study set the time step interval to one year with the alignment of time step to END_TIME. In addition, these bins are the results of aggregation of spatiotemporal dataset and creates a special data structure called Network Common Data Form (NetCDF) which is the prerequisite for emerging hotspot analysis. NetCDF is a special type of file for storing multidimensional variables and it creates a layer to illustrate in a dimension (ArcGIS Pro, 2026).

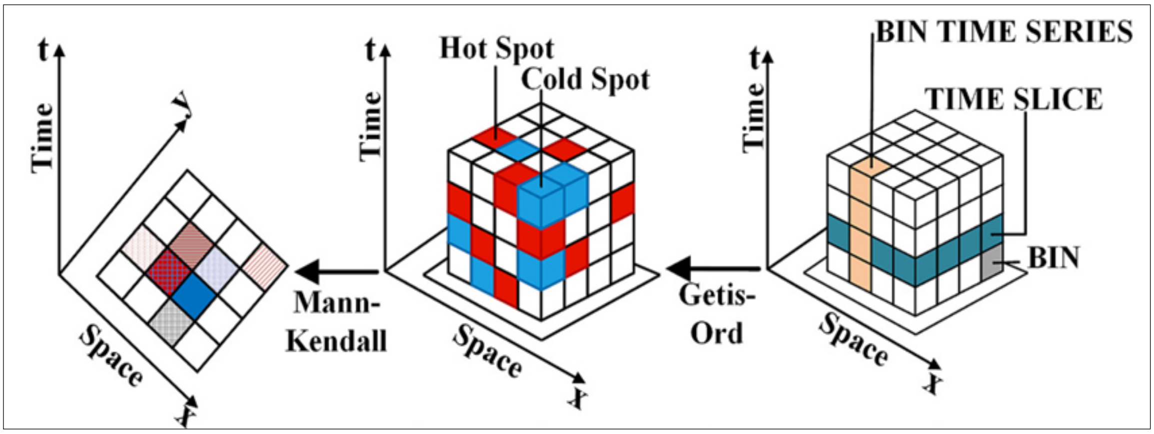

Figure 2. Space time cube (STC).

Source: Cao et al. (2024).

3.3.1.2 Emerging hotspot analysis (EHSA)

Emerging hotspot analysis (EHSA) was conducted to detect the spatio-temporal trend of production and area of production. EHSA examines the complex attribute data trends across the geographic space over time (Portillo-Quintero and Smith, 2018; Reddy et al., 2020), which in terms helped this study to identify the spatiotemporal changes more easily (Singh and Yan, 2021). After setting the value of 'conceptualization of spatial relationship' parameter which defines the relationship between the spatial and time step neighbours of the bins in the space time cube, the Getis-Ord Gi* or Gi* statistics (Getis and Ord, 1992) was run. This basically identifies a bin as a hotspot or cold spot if the bin attribute value is higher or lower in every year than its neighbours (Bass, 2017; ArcGIS pro, 2026).

$$Gi^* = \frac{\sum_{j=1}^{n} W_{i,j}\, x_j - \bar{X} \sum_{j=1}^{n} W_{i,j}}{S \sqrt{\frac{n \sum_{j=1}^{n} W_{i,j}^2 - (\sum_{j=1}^{n} W_{i,j})^2}{n-1}}} \quad \dots\dots\dots (1)$$

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \quad \dots\dots\dots (2)$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2} \quad \dots\dots\dots (3)$$

where,

x_j = The value of attribute for feature j;

$W_{i,j}$ = Spatial weight between feature *i and j;*

n = Total number of features

This study adopted the 'contiguity edges only' parameter for conceptualizing spatial relationships, which is widely considered suitable for polygon-based shapefiles (ArcGIS Pro, 2026), as it defines neighbours based on shared boundaries. The Getis-Ord Gi* statistic was then utilized to detect spatial clustering, where the resulting z-scores measure the relationship between bins by comparing the mean attribute value of a specific bin to its neighbours (Bass, 2017). In addition, the signs of the z-score indicates increasing (positive sign) or decreasing (negative sign) trends while the Mann-Kendall statistic shows whether the temporal trend is significant or not with small p-value indicating significant trend (Hamed, 2009; Reddy et al., 2019). Emerging hotspot analysis then used this z-scores and p-values for bins and trends, and classified the locations into one of the 17 classes generated by this tool (Zhu and Newsam, 2016). In addition, with the increase of the size of neighbourhood the hotspots became fewer in number resulting increased in the size of these hotspots while the decrease in neighbourhood size results in more localized trends (Harris et al., 2017).

3.3.2 Crop budgeting

A detailed per-hectare (ha) crop budgeting technique was employed to evaluate the costs and returns of major cereals and rotational crops, produced under smaller two-wheel machines (2WMs) mechanized farm management alternatives considering both farmer owned and custom hired machinery service markets. The 2WMs have been widely deployed in Bangladesh for decades. Four mechanized farm management alternatives were considered because agricultural mechanization is evolving from partial conventional mechanization to conventional whole farm mechanization with human machine operators. The first farm management alternative considered mechanized tillage only system (Scenario 1), where all other farm operations were manual labour intensive. This is the typical conventional partial mechanization Bangladesh adopted over the last five decades. The second and third farm management alternatives were mechanized tillage and harvesting only system (Scenario 2), and mechanized tillage, planting & harvesting only system (Scenario 3), with all other farm operations manual labour intensive. These two mechanized farm management alternatives are at the on-farm demonstration stage in Bangladesh. The fourth farm management alternative is conventional whole farm mechanization with human machine operators (Scenario 4), envisioned for wide scale diffusion in the medium to long term. This crop budgeting approach is also relevant for other larger machinery and/or innovative smart precision agriculture technologies, where capital costs and capital associated operating costs would need to be re-estimated.

To assess profitability for smallholder farms, a tabular analytical technique was employed to construct farm budgets covering all operations from land preparation (e. g., tilling) to post-harvest activities (e. g, threshing) for major and rotational grain-oilseeds. The analysis aimed to identify profit-maximizing crop choices and farm management alternatives suitable for resource poor smallholder farms in Bangladesh. In this approach, the study first estimated the total operating costs and subsequently fixed costs were calculated. Gross return was calculated as the total value of main products and by-products, while gross margin was estimated by deducting total variable costs from gross return. Net return was derived by subtracting total production costs from gross return, and the benefit-cost ratio (BCR) was computed to assess profitability as the ratio of gross return and total cost. Break-even analyses of main grain yield and price of grain was conducted to identify the situation at which indifferent profit-loss situations occurred. The analysis accounted for total production costs, including operating costs without interest on variable expenses, total fixed costs, and total costs across different farm management alternatives under both farmer owned and custom hired machinery service markets. Further details regarding the underlying assumptions are provided in Appendix C.

3.3.3 Digital web-based crop budget calculator

To support informed agricultural decision-making among stakeholders, a digital web-based open access crop budget calculator was developed on the HSATE website to estimate production costs and returns for major and rotational crops. The calculator provides a structured framework for users to input farm-specific data, including crop type, area, and operating and fixed input quantities and costs. Operating costs include all input expenses incurred across farm operations from land preparation to post-harvest activities, such as tillage, planting/sowing, seeds, pesticides (herbicides, insecticides, and fungicides), fertilizers, irrigation, machinery fuel, lubricants, repairs, harvesting, and threshing. Fixed costs include land rent and machinery costs. The calculator integrated these inputs to compute total production costs, gross returns, gross margins, net returns, and benefit-cost ratios (BCR) along with percentage share of inventory costs and break-even analyses. By allowing customization based on user-specific data and local management practices, the calculator serves as a flexible analytical tool to systematically quantify the economic performance of crop production.

4. RESULTS

4.1 Spatial Delineation of First-Order Administrative Units in Bangladesh using ArcGIS

Spatial delineation of hotspot categories was based on the frequency and temporal persistence of hotspot identification over the study periods, incorporating trends in attribute values and their occurrence in earlier versus recent time steps (Table B1 in Appendix B). Time steps indicate the unit of time (e.g., one year), while the attribute values refer to the key variable measured, namely production and area of production in this study. This study primarily focused on identifying the divisional (first-order administrative unit) level hotspots of major cereals and rotational crops. The analysis was also conducted at the district level (second-order administrative unit) to capture more robust and localized trends, particularly when no clear patterns emerged at the division level.

Figure 3 to Figure 8 illustrates the hotspot patterns for major and rotational crops. The intensification in production and area of production identified Rangpur division as a hotspot for monsoon season *Aman* rice and maize. The hotspots identified for *Aman* rice and maize is consecutive hotspot suggesting that Rangpur has been hotspot for these crops with a consecutive run in the recent years but in comparison to the total time frame less than 90% of the time it has been a hotspot. Similarly, Rajshahi division was identified as the consecutive hotspot for mustard. However, statistically significant hotspot patterns both for production and area of production were not identified for a few cereals at division level, because the number of hotspots and hotspot patterns depends on the distance and size or area of the neighbourhood. As the neighbourhood size or distance increases, the number of hotspots decreases while their size becomes larger. Conversely, smaller neighbourhoods produce more but smaller hotspots. The results are therefore sensitive to how the neighbourhood is defined. For instance, Rajshahi division was identified as a sporadic hotspot for wheat production, meaning it was significant in less than 90% of the time periods, occurring intermittently and not consecutively over the years, but no significant patterns were evident for wheat area. Similar granular hotspot patterns were detected for winter season *Boro* rice in Rajshahi division and lentil in Khulna division. It showed Rajshahi and Khulna division as intensifying hotspot pattern. To further validate the results, trendline analysis was conducted using Excel spreadsheets (Figure B1 to Figure B6 in Appendix B).

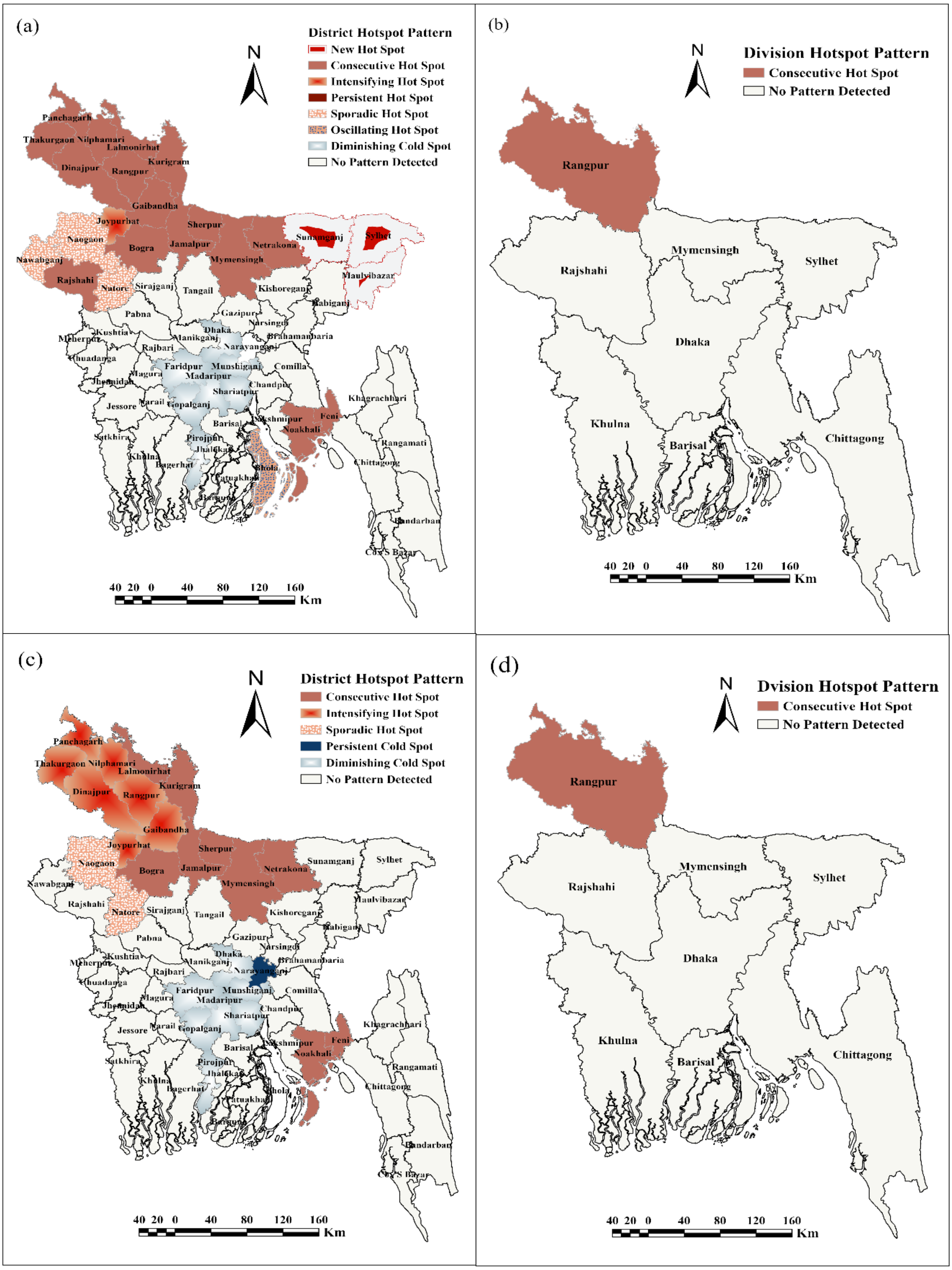

Figure 3. Monsoon season *Aman* rice hotspots subject to production (a, b) and area (c, d).

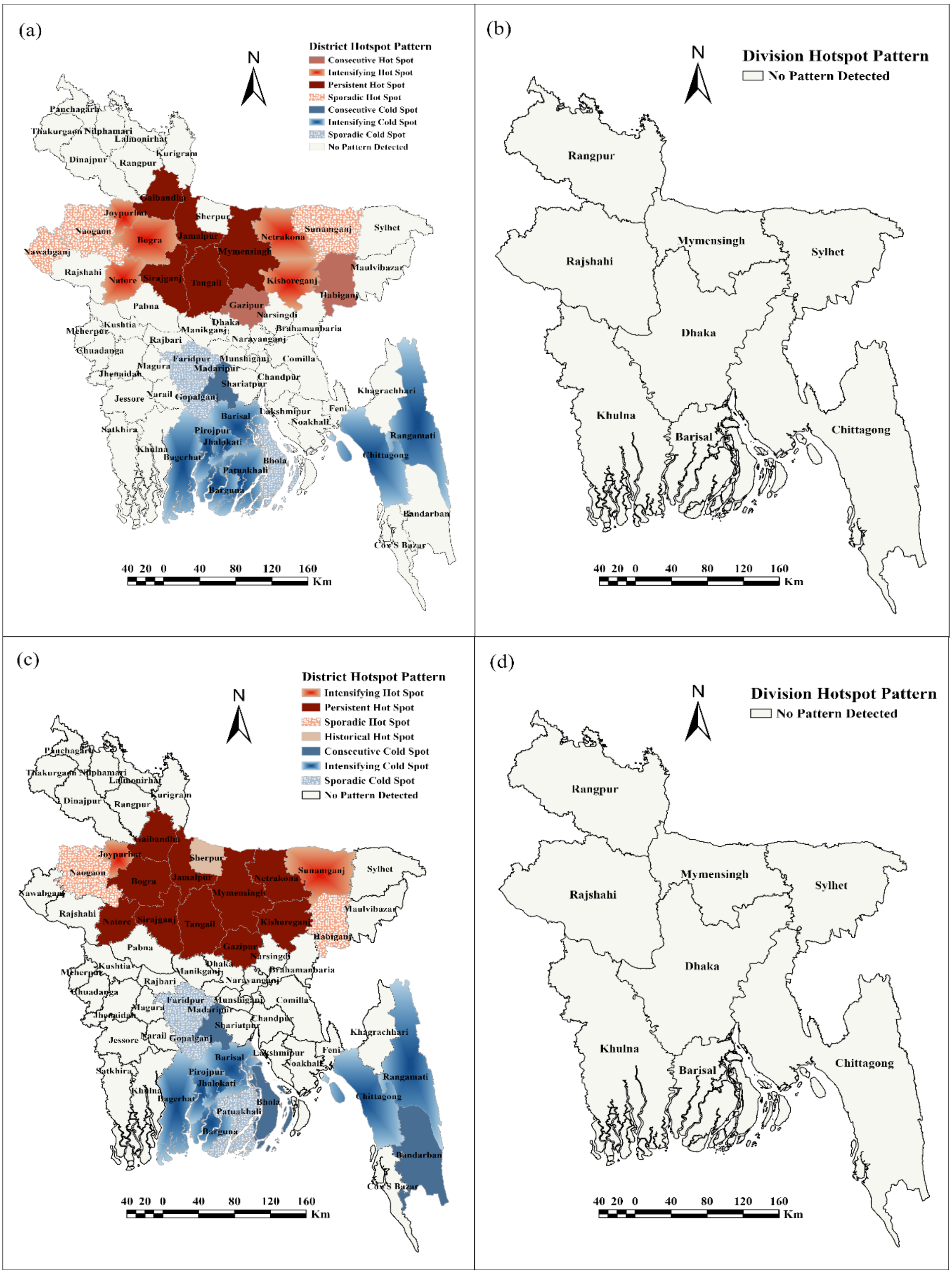

Figure 4. Winter season *Boro* rice hotspots subject to production (a, b) and area (c, d).

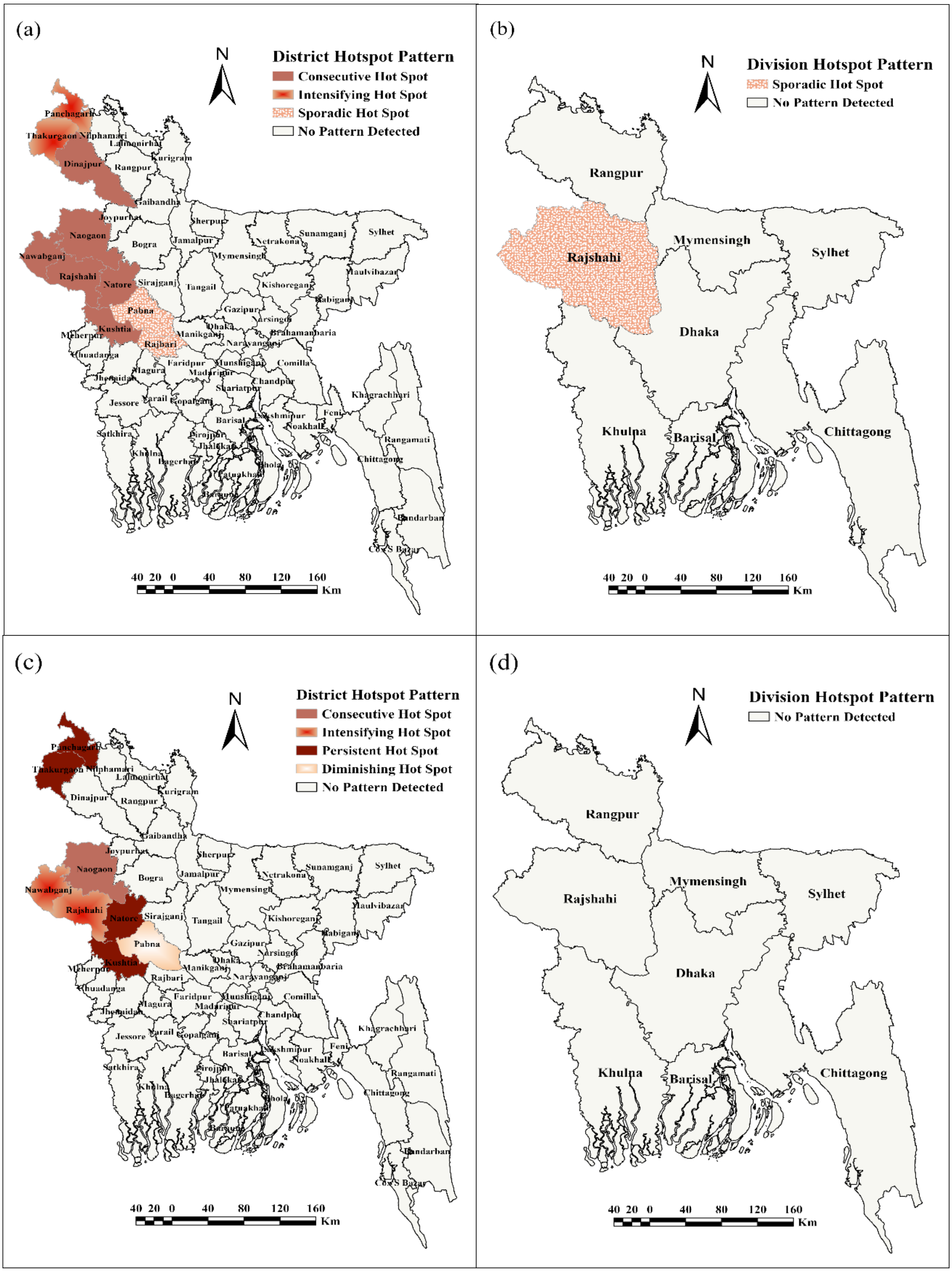

Figure 5. Wheat hotspots subject to production (a, b) and area (c, d).

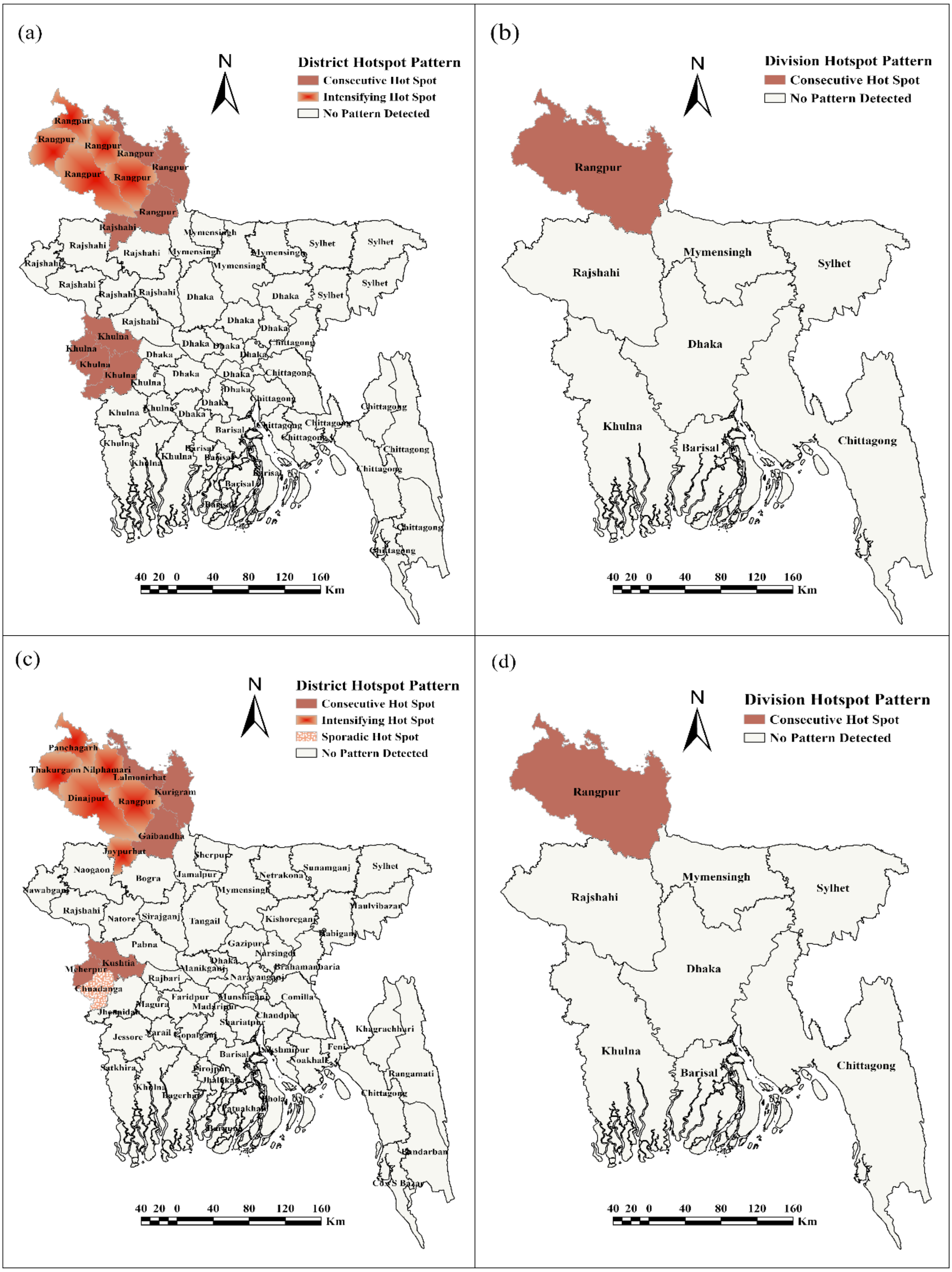

Figure 6. Maize hotspots subject to production (a, b) and area (c, d).

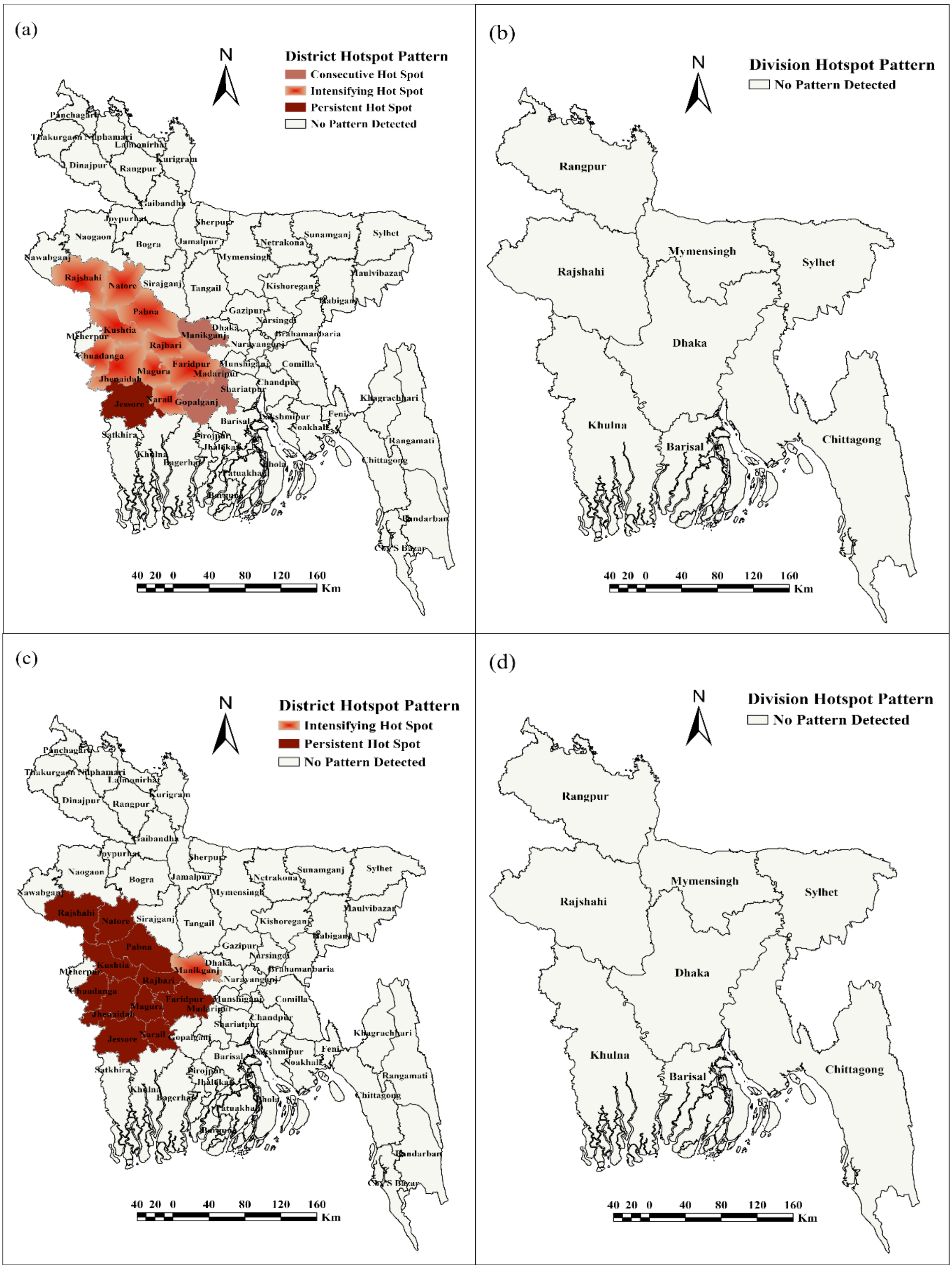

Figure 7. Lentil hotspots subject to production (a, b) and area (c, d).

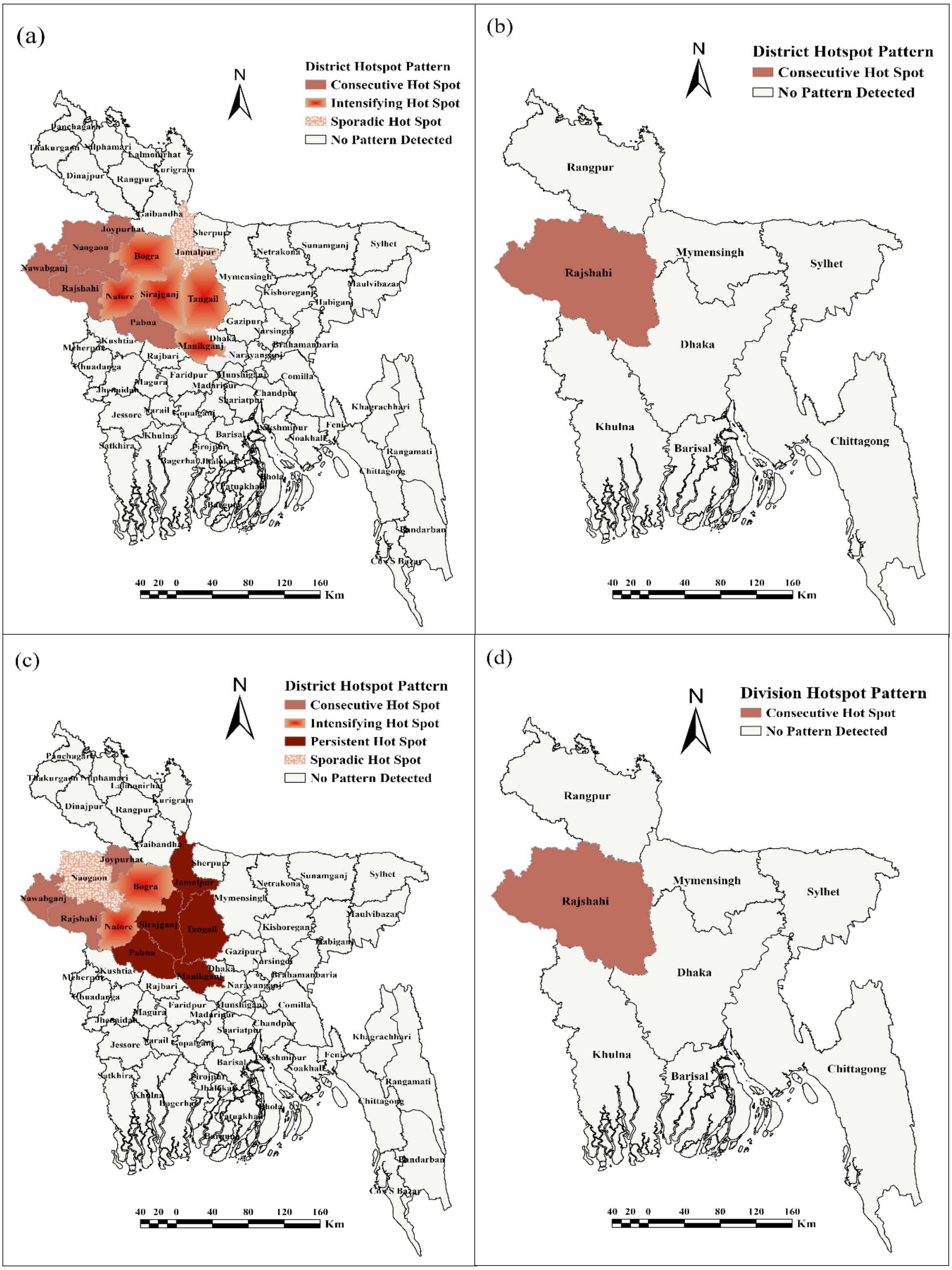

Figure 8. Mustard hotspots subject to production (a, b) and area (c, d).

4.2 Crop Cost and Return Guides

4.2.1 Estimated crop costs and returns under farmer owned machinery market

The comparative cost analyses under farmer owned machinery market indicate that the per hectare (ha) total operating costs (without interest on variable expenses) were highest under the mechanized tillage only system (Scenario 1), for all major crops, i. e., *Aman* rice (Table 1), *Boro* rice (Table 2), and wheat (Table 3), as well as key rotational crops, i. e., maize (Table 4), lentil (Table 5), and mustard (Table 6), followed by mechanized tillage & harvesting only system (Scenario 2), mechanized tillage, planting & harvesting only system (Scenario 3), and conventional whole farm mechanization (Scenario 4). To exemplify, for *Aman* rice, the mechanized tillage only system (Scenario 1) incurred BDT 48,381.28/ha more than the conventional whole farm mechanization (Scenario 4). Likewise, the mechanized tillage only system (Scenario 1) resulted in additional costs of BDT 56,105.17/ha for *Boro* rice, BDT 43,320.64/ha for wheat, BDT 36,032.15/ha for maize, BDT 27,659.94/ha for lentil, and BDT 30,612.00/ha for mustard. Overall, the substantially higher operating costs under less mechanized farm alternatives was largely driven by the high labour costs associated with less mechanized farm operations. *Boro* rice recorded the highest operating costs among all crops due to its greater number of intercultural operations compared to other crops, leading to high labour costs. Similarly, total operating costs (with interest on variable expenses) also resulted the same pattern for all crops across all mechanization alternatives. Total fixed costs (i. e., sum of all fixed expenses) for all crops were highest for the most mechanized farm management alternative, which is conventional whole farm mechanization (Scenario 4). This was due to the added machinery ownership costs. For example, under conventional whole farm mechanization (Scenario 4), *Boro* rice incurred BDT 44,000.88/ha higher fixed cost than mechanized tillage only system (Scenario 1). This increase is attributable to machinery ownership costs, as *Boro* rice involves a higher number of intercultural operations.

Total cost (i. e., sum of all operating and fixed costs) of production varied significantly across the four farm management alternatives. Less mechanized farm management alternative, i.e., mechanized tillage only system (Scenario 1) showed higher total costs for rice (i. e., *Aman* rice and *Boro* rice) followed by mechanized tillage, planting & harvesting only system (Scenario 3), mechanized tillage & harvesting only system (Scenario 2) and conventional whole farm mechanization (Scenario 4). For example, total cost of *Aman* rice was BDT 13,180.58/ha higher under mechanized tillage only system (Scenario 1) than conventional whole farm mechanization (Scenario 4), while for *Boro* rice, it was BDT 12,104.29/ha higher. For non-rice crops (i. e., wheat, maize, and mustard), mechanized tillage only system (Scenario 1) resulted in the highest total costs followed by mechanized tillage & harvesting only system (Scenario 2), mechanized tillage, planting & harvesting only system (Scenario 3), and conventional whole farm mechanization (Scenario 4). An exception was occurred in lentil, where the highest total cost was incurred in mechanized tillage only system (Scenario 1), followed by mechanized tillage & harvesting only system (Scenario 2), conventional whole farm mechanization (Scenario 4), and mechanized tillage, planting & harvesting only system (Scenario 3). Lentil estimated BDT 4,947.33/ha higher under mechanized tillage only system (Scenario 1) than mechanized tillage, planting & harvesting only system (Scenario 3), which recorded the lowest cost across mechanization alternatives.

The per ha profitability analyses reveal that gross returns were identical across all mechanization alternatives for each crop. This is because gross return depends solely on yield and prevailing market prices of main product (grain) and by-product (straw), which were assumed to be constant across all mechanization alternatives. Gross margins (return over variable costs) for all crops increased with higher levels of mechanization. High labour costs associated with less mechanized operations was the primary driver of this outcome. Highest gross margin was observed in maize among all cereals and oilseed under conventional whole farm mechanization (Scenario 4) (i. e., BDT 335,917.49/ha), which was BDT 36,032.15/ha higher than mechanized tillage only system (Scenario 1). Lentil recorded the second-highest gross margin (i. e., BDT 133,046.43/ha) under conventional whole farm mechanization (Scenario 4), while *Aman* rice had the lowest gross margin (i. e., BDT 57,956.94/ha) among all crops.

Net returns (return over total costs) were positive for rotational crops maize and lentil, whereas all other cereals and oilseed found negative returns across all mechanization alternatives. Conventional whole farm mechanization (Scenario 4) appeared more feasible among all farm management alternatives for rice, wheat, maize and mustard. The exception was apparent in lentil, where mechanized tillage, planting & harvesting only system (Scenario 3) emerged as the most feasible alternative, followed by conventional whole farm mechanization (Scenario 4). The higher labour cost in the least mechanized farm management alternative is the main reason for the lower net return under less mechanized systems. For example, maize generated BDT 12,010.43/ha higher return under conventional whole farm mechanization (Scenario 4) than under mechanized tillage only system (Scenario 1). Lentil recorded BDT 4,947.33/ha higher return under mechanized tillage, planting & harvesting only system (Scenario 3) than under mechanized tillage only system (Scenario 1). The benefit-cost ratio (BCR), (i. e., ratio of gross return to total cost) implied a similar pattern consistent with net returns where maize and lentil appeared as feasible enterprises and other cereals and oilseed resulted in negative returns.

Break-even analyses of main grain yield and price of grain were conducted to derive the minimum selling price or minimum yield of each crops require to cover the costs. Break-even analyses were estimated on three cost basis, i. e., total operating cost without interest on variable expenses, total fixed costs, and total costs. For example, for *Aman* rice, to reach the break-even price in terms of total cost, the market main product (grain) selling price should be BDT 22,959.21/ha higher for conventional whole farm mechanization (Scenario 4). Similarly, break-even yield should be 2.19 t/ha higher. The break-even price and yields are sensitive to changes in yields, prices, and cost estimates.

Table 1. Estimated crop costs and returns of monsoon season *Aman* rice across different mechanization alternatives under farmer owned machinery market (BDT/ha).

	Scenario-1: Mechanized tillage only system	Scenario-2: Mechanized tillage & harvesting only system	Scenario-3: Mechanized tillage, planting & harvesting only system	Scenario-4: Conventional whole farm mechanization
A. Operating Costs				
Seed and treatment[1]	1,259.07	1,259.07	2,637.01	2,637.01
Fertilizers[2]				
Urea	5,046.78	5,046.78	5,046.78	5,046.78
Triple super phosphate (TSP)	1,078.65	1,078.65	1,078.65	1,078.65
Muriate of potash (MOP)	1,827.80	1,827.80	1,827.80	1,827.80
Gypsum	375.35	375.35	375.35	375.35
Pesticides[3]				
Herbicides	1,259.17	1,259.17	1,259.17	1,259.17
Insecticides	2,387.02	2,387.02	2,387.02	2,387.02
Fungicides	1,852.75	1,852.75	1,852.75	1,852.75
Labour[4]	84,925.17	68,179.17	44,316.92	26,266.27
Irrigation[5]	8,342.20	8,342.20	8,342.20	8,342.20
Machinery operating expenses[6]				
Fuel	3,156.00	3,632.00	4,178.00	5,777.00
Lubricant	473.40	544.80	626.70	866.55
Repair	2,698.95	3,582.44	7,832.44	8,584.48
Stationary threshing[7]	918.00	918.00	918.00	918.00
Miscellaneous[8]	0.00	0.00	0.00	0.00
Total operating costs without interest on variable expenses	115,600.31	100,285.20	82,678.79	67,219.03
Interest on variable expenses[9]	2,774.41	2,406.84	1,984.29	1,613.26
Total operating costs with interest on variable expenses	118,374.72	102,692.04	84,663.08	68,832.29

B. Fixed Costs				
Land rent[10]	55,471.48	55,471.48	55,471.48	55,471.48
Machinery cost[11]	10,639.93	20,106.32	39,939.66	45,840.64
Miscellaneous	0.00	0.00	0.00	0.00
Total fixed costs	66,111.41	75,577.80	95,411.14	101,312.12
C. Total Costs	181,711.72	175,863.00	178,089.92	168,531.15
D. Estimated Farmgate				
Yield from main product (grain) (t/ha)[12]	3.06	3.06	3.06	3.06
Price of main product (grain) (BDT/t)[13]	32,116.33	32,116.33	32,116.33	32,116.33
Yield from by-product (straw) (t/ha)[14]	5.38	5.38	5.38	5.38
Price of by-product (straw) (BDT/t)[15]	5,000.00	5,000.00	5,000.00	5,000.00
Profitability Analysis Per Hectare				
E. Gross Return	125,175.97	125,175.97	125,175.97	125,175.97
F. Gross Margin	9,575.66	24,890.77	42,497.18	57,956.94
G. Net Return	-56,535.75	-50,687.03	-52,913.95	-43,355.18
H. Benefit Cost Ratio (BCR)	0.69	0.71	0.70	0.74
Break-Even Analysis[16]				
M. Break-Even Price Per Hectare				
Over total operating cost without interest on variable expenses	37,777.88	32,772.94	27,019.21	21,967.00
Over total fixed cost	21,605.04	24,698.63	31,180.11	33,108.53
Over total cost	59,382.92	57,471.57	58,199.32	55,075.54
N. Break-Even Yield Per Hectare				
Over total operating cost without interest on variable expenses	3.60	3.12	2.57	2.09
Over total fixed cost	2.06	2.35	2.97	3.15
Over total cost	5.66	5.48	5.55	5.25

[1]Seeding rates for high-yielding variety (HYV) *Aman* rice were assumed to be 21 kg/ha, following estimates from the Yearbook of Agricultural Statistics published by the Bangladesh Bureau of Statistics (BBS, 2024). Seed price assumptions were derived from average values reported by the Bangladesh Agricultural Development Corporation (BADC). Based on Key Informant Interviews (KIIs), an additional cost was included to account for logistical expenses related to seed preparation and natural germination before sowing in the seedbed for manual planting, while costs associated with mechanized nursery preparation were incorporated for mechanized transplanting; both were based on KIIs. Seed rates may vary depending on soil conditions and input price variations.

[2]Fertilizers included Urea, TSP, MOP, and gypsum. Recommended application rates were based on the Fertilizer Recommendation Guide 2024 (FRG, 2024), namely 195.46 kg/ha for Urea, 39.95 kg/ha for TSP, 91.39 kg/ha for MOP, and 39.72 kg/ha for gypsum. Price data for urea and gypsum were obtained from the Department of Agricultural Marketing (DAM). Due to the unavailability of local price data for TSP and MOP from DAM, their prices were sourced from the Bangladesh Agricultural Development Corporation (BADC). Fertilizer prices were BDT 25.82/kg for Urea, BDT 27.00/kg for TSP, BDT 20.00/kg for MOP, and BDT 9.45/kg for gypsum. Fertilizer doses may vary depending on soil type and product pricing.

[3]Pesticides included herbicides, insecticides, and fungicides. The doses of pesticides were determined based on the List of Registered Agricultural Pesticides, Bio-Pesticides, and Public Health Pesticides in Bangladesh provided by the Department of Agricultural Extension (DAE). Cost estimates were derived from KIIs, using average market prices reported by various agrochemical companies in Bangladesh. Pesticide costs may vary considerably depending on the type of chemicals used, application rates, and prevailing market prices.

[4]Labour requirements (person-days/ha) for *Aman* rice included hired labour, family labour, and machine operator labour. These estimates were derived from KIIs which are consistent with the findings of Al-Amin et al. (2024). The wage rate (BDT/person-day) was sourced from the Yearbook of Agricultural Statistics published by the Bangladesh Bureau of Statistics (BBS, 2024). Labour costs may vary across regions due to differences in local wage rates and labour availability.

[5]Irrigation charges were estimated based on KIIs which are consistent with the findings of Al-Amin et al. (2024).

[6]Machinery operating expenses comprised expenditures on fuel, lubricant, and repair. Fuel consumption rates (L/h) were obtained from agri-tech companies in Bangladesh, while work rates (h/ha) were sourced from Al-Amin et al. (2024). Given the volatility of diesel prices, a rate of BDT 100 per litre was assumed based on KIIs, which is consistent with data reported by the Bangladesh Petroleum Corporation (BPC, 2026). Lubricant cost was estimated at 15% of fuel cost, following the findings of North Dakota State University (NDSU, 2025). Repair costs were calculated based on assumptions reported in the John Nix Pocketbook (Redman, 2024). Machinery operating costs varied across different farm management alternatives and may also differ depending on the type (e. g., smaller or larger) and combination of machinery used.

[7]Threshing charges refer to the cost of threshing using a stationary thresher, which was estimated at BDT 300/t based on the Bangladesh Agricultural Research Institute (BARI) Handbook (Hossain et al., 2017).

[8]Miscellaneous variable and fixed costs are contingent upon farm-level management decisions and may differ across farms due to heterogeneity in management practices, input use structures, and spatial conditions.

[9]Interest on variable expenses for *Aman* rice was calculated at a monthly rate of 0.60% (Bangladesh Bank, 2026a), over a four-month period, corresponding to the monsoon (Kharif-II) season in Bangladesh (Bhuiya et al., 2009), and incorporated for all variable inputs.

[10]Per hectare land rent was estimated based on KIIs conducted with the Assistant Commissioner (Land), Upazila Agriculture Officer (UAO), and Sub-Assistant Agriculture Officer (SAAO) in the Rangpur division.

[11] Machinery costs for different farm management alternatives were obtained from various online machinery marketplaces and supplier websites, consistent with the findings of Al-Amin et al. (2024). These costs varied across management alternatives due to differences in the machinery sets used and may also vary with the scale of machinery employed (e.g., smaller or larger equipment).

[12]*Aman* rice main product (grain) yield in Rangpur division was obtained from the Yearbook of Agricultural Statistics published by the Bangladesh Bureau of Statistics (BBS, 2024).

[13]The wholesale price of *Aman* rice main product (grain) in Rangpur division was based on annual prices reported in the Yearly Average Price List of the Department of Agricultural Marketing (DAM).

[14]*Aman* rice by-product (straw) yield was estimated based on KIIs, which are consistent with the findings of Al-Amin et al. (2024).

[15]*Aman* rice by-product (straw) price was estimated based on KIIs, which are consistent with the findings of Al-Amin et al. (2024).

[16]Break-even analyses of main grain yield and price of grain identified the situation at which indifferent profit-loss situations occurred. The analyses were conducted across three cost categories: Over total operating cost without interest on variable expenses, total fixed cost, and total cost.

Table 2. Estimated crop costs and returns of winter season *Boro* rice across different mechanization alternatives under farmer owned machinery market (BDT/ha).

	Scenario-1: Mechanized tillage only system	Scenario-2: Mechanized tillage & harvesting only system	Scenario-3: Mechanized tillage, planting & harvesting only system	Scenario-4: Conventional whole farm mechanization
A. Operating Costs				
Seed and treatment	1,678.86	1,678.86	2,676.25	2,676.25
Fertilizers				
Urea	8,242.29	8,242.29	8,242.29	8,242.29
Triple super phosphate (TSP)	1,730.70	1,730.70	1,730.70	1,730.70
Muriate of potash (MOP)	2,636.40	2,636.40	2,636.40	2,636.40
Gypsum	657.53	657.53	657.53	657.53
Pesticides				
Herbicides	1,259.17	1,259.17	1,259.17	1,259.17
Insecticides	2,387.02	2,387.02	2,387.02	2,387.02
Fungicides	1,852.75	1,852.75	1,852.75	1,852.75
Labour	124,217.96	105,093.08	78,765.12	56,369.43
Irrigation	12,258.20	12,258.20	12,258.20	12,258.20
Machinery operating expenses				
Fuel	3,156.00	3,632.00	4,178.00	6,103.00
Lubricant	473.40	544.80	626.70	915.45
Repair	3,373.69	4,478.05	9,790.55	10,730.60
Stationary threshing	1,314.00	1,314.00	1,314.00	1,314.00
Miscellaneous	0.00	0.00	0.00	0.00
Total operating costs without interest on variable expenses	165,237.97	147,764.85	128,374.68	109,132.79
Interest on variable expenses	6,279.04	5,615.06	4,878.24	4,147.05
Total operating costs with interest on variable expenses	171,517.01	153,379.92	133,252.92	113,279.84

B. Fixed Costs				
Land rent	77,998.74	77,998.74	77,998.74	77,998.74
Machinery cost	13,299.92	25,132.90	49,924.57	57,300.80
Miscellaneous	0.00	0.00	0.00	0.00
Total fixed costs	91,298.66	103,131.64	127,923.31	135,299.54
C. Total Costs	256,536.62	250,896.50	256,297.99	244,432.33
D. Estimated Farmgate				
Yield from main product (grain) (t/ha)	4.38	4.38	4.38	4.38
Price of main product (grain) (BDT/t)	31,701.85	31,701.85	31,701.85	31,701.85
Yield from by-product (straw) (t/ha)	6.45	6.45	6.45	6.45
Price of by-product (straw) (BDT/t)	5,000.00	5,000.00	5,000.00	5,000.00
Profitability Analysis Per Hectare				
E. Gross Return	171,104.10	171,104.10	171,104.10	171,104.10
F. Gross Margin	5,866.14	23,339.25	42,729.42	61,971.31
G. Net Return	-85,432.52	-79,792.39	-85,193.89	-73,328.23
H. Benefit Cost Ratio (BCR)	0.67	0.68	0.67	0.70
Break-Even Analysis				
M. Break-Even Price Per Hectare				
Over total operating cost without interest on variable expenses	37,725.56	33,736.27	29,309.29	24,916.16
Over total fixed cost	20,844.44	23,546.04	29,206.24	30,890.30
Over total cost	58,570.01	57,282.31	58,515.52	55,806.47
N. Break-Even Yield Per Hectare				
Over total operating cost without interest on variable expenses	5.21	4.66	4.05	3.44
Over total fixed cost	2.88	3.25	4.04	4.27
Over total cost	8.09	7.91	8.08	7.71

Table 3. Estimated crop costs and returns of wheat across different mechanization alternatives under farmer owned machinery market (BDT/ha).

	Scenario-1: Mechanized tillage only system	Scenario-2: Mechanized tillage & harvesting only system	Scenario-3: Mechanized tillage, planting & harvesting only system	Scenario-4: Conventional whole farm mechanization
A. Operating Costs				
Seed	5,965.05	5,965.05	5,965.05	5,965.05
Fertilizers				
Urea	6,500.58	6,500.58	6,500.58	6,500.58
Triple super phosphate (TSP)	3,927.15	3,927.15	3,927.15	3,927.15
Muriate of potash (MOP)	2,620.20	2,620.20	2,620.20	2,620.20
Gypsum	745.98	745.98	745.98	745.98
Pesticides				
Herbicides	1,019.53	1,019.53	1,019.53	1,019.53
Insecticides	1,132.50	1,132.50	1,132.50	1,132.50
Labour	77,103.67	57,978.80	46,671.58	27,978.99
Irrigation	5,526.14	5,526.14	5,526.14	5,526.14
Machinery operating expenses				
Fuel	2,367.00	2,843.00	3,581.00	5,129.00
Lubricant	355.05	426.45	537.15	769.35
Repair	3,373.69	4,478.05	5,061.38	6,001.43
Stationary threshing	7,952.00	7,952.00	7,952.00	7,952.00
Miscellaneous	0.00	0.00	0.00	0.00
Total operating costs without interest on variable expenses	118,588.54	101,115.43	91,240.24	75,267.90
Interest on variable expenses	4,506.36	3,842.39	3,467.13	2,860.18
Total operating costs with interest on variable expenses	123,094.91	104,957.81	94,707.37	78,128.08
B. Fixed Costs				
Land rent	77,998.74	77,998.74	77,998.74	77,998.74

Machinery cost	13,299.92	25,132.90	29,945.40	37,321.63
Miscellaneous	0.00	0.00	0.00	0.00
Total fixed costs	91,298.66	103,131.64	107,944.14	115,320.37
C. Total Costs	209,887.20	204,247.07	199,184.38	190,588.27
D. Estimated Farmgate				
Yield from main product (grain) (t/ha)	3.78	3.78	3.78	3.78
Price of main product (grain) (BDT/t)	44,505.75	44,505.75	44,505.75	44,505.75
Yield from by-product (straw) (t/ha)	4.59	4.59	4.59	4.59
Price of by-product (straw) (BDT/t)	2,566.02	2,566.02	2,566.02	2,566.02
Profitability Analysis Per Hectare				
E. Gross Return	180,009.77	180,009.77	180,009.77	180,009.77
F. Gross Margin	61,421.23	78,894.34	88,769.53	104,741.87
G. Net Return	-29,877.43	-24,237.30	-19,174.62	-10,578.50
H. Benefit Cost Ratio (BCR)	0.86	0.88	0.90	0.94
Break-Even Analysis				
M. Break-Even Price Per Hectare				
Over total operating cost without interest on variable expenses	31,372.63	26,750.11	24,137.63	19,912.14
Over total fixed cost	24,153.08	27,283.50	28,556.65	30,508.03
Over total cost	55,525.71	54,033.62	52,694.28	50,420.18
N. Break-Even Yield Per Hectare				
Over total operating cost without interest on variable expenses	2.66	2.27	2.05	1.69
Over total fixed cost	2.05	2.32	2.43	2.59
Over total cost	4.72	4.59	4.48	4.28

Table 4. Estimated crop costs and returns of maize across different mechanization alternatives under farmer owned machinery market (BDT/ha).

	Scenario-1: Mechanized tillage only system	Scenario-2: Mechanized tillage & harvesting only system	Scenario-3: Mechanized tillage, planting & harvesting only system	Scenario-4: Conventional whole farm mechanization
A. Operating Costs				
Seed	3,952.00	3,952.00	3,952.00	3,952.00
Fertilizers				
Urea	13,450.15	13,450.15	13,450.15	13,450.15
Triple super phosphate (TSP)	6,480.00	6,480.00	6,480.00	6,480.00
Muriate of potash (MOP)	4,200.60	4,200.60	4,200.60	4,200.60
Gypsum	1,904.65	1,904.65	1,904.65	1,904.65
Pesticides				
Herbicides	1,285.80	1,285.80	1,285.80	1,285.80
Insecticides	931.40	931.40	931.40	931.40
Labour	70,939.00	54,193.00	44,284.98	29,477.71
Irrigation	7,505.76	7,505.76	7,505.76	7,505.76
Machinery operating expenses				
Fuel	2,367.00	2,843.00	3,581.00	4,803.00
Lubricant	355.05	426.45	537.15	720.45
Repair	3,373.69	4,478.05	5,061.38	6,001.43
Stationary shelling	1,491.00	1,491.00	1,491.00	1,491.00
Miscellaneous	0.00	0.00	0.00	0.00
Total operating costs without interest on variable expenses	118,236.10	103,141.86	94,665.88	82,203.95
Interest on variable expenses	4,492.97	3,919.39	3,597.30	3,123.75
Total operating costs with interest on variable expenses	122,729.07	107,061.25	98,263.18	85,327.70

B. Fixed Costs				
Land rent	69,339.35	69,339.35	69,339.35	69,339.35
Machinery cost	13,299.92	25,132.90	29,945.40	37,321.63
Miscellaneous	0.00	0.00	0.00	0.00
Total fixed costs	82,639.27	94,472.25	99,284.75	106,660.98
C. Total Costs	200,875.36	197,614.11	193,950.63	188,864.93
D. Estimated Farmgate				
Yield from main product (grain) (t/ha)	9.94	9.94	9.94	9.94
Price of main product (grain) (BDT/t)	40,637.08	40,637.08	40,637.08	40,637.08
Yield from by-product (stover) (t/ha)	10.98	10.98	10.98	10.98
Price of by-product (stover) (BDT/t)	1,292.25	1,292.25	1,292.25	1,292.25
Profitability Analysis Per Hectare				
E. Gross Return	418,121.44	418,121.44	418,121.44	418,121.44
F. Gross Margin	299,885.34	314,979.58	323,455.56	335,917.49
G. Net Return	217,246.07	220,507.32	224,170.80	229,256.51
H. Benefit Cost Ratio (BCR)	2.08	2.12	2.16	2.21
Break-Even Analysis				
M. Break-Even Price Per Hectare				
Over total operating cost without interest on variable expenses	11,894.98	10,376.44	9,523.73	8,270.02
Over total fixed cost	8,313.81	9,504.25	9,988.41	10,730.48
Over total cost	20,208.79	19,880.70	19,512.14	19,000.50
N. Break-Even Yield Per Hectare				
Over total operating cost without interest on variable expenses	2.91	2.54	2.33	2.02
Over total fixed cost	2.03	2.32	2.44	2.62
Over total cost	4.94	4.86	4.77	4.65

Table 5. Estimated crop costs and returns of lentil across different mechanization alternatives under farmer owned machinery market (BDT/ha).

	Scenario-1: Mechanized tillage only system	Scenario-2: Mechanized tillage & harvesting only system	Scenario-3: Mechanized tillage, planting & harvesting only system	Scenario-4: Conventional whole farm mechanization
A. Operating Costs				
Seed	3,921.76	3,921.76	3,921.76	3,921.76
Fertilizers				
Urea	1,136.75	1,136.75	1,136.75	1,136.75
Triple super phosphate (TSP)	2,028.24	2,028.24	2,028.24	2,028.24
Muriate of potash (MOP)	721.60	721.60	721.60	721.60
Gypsum	582.03	582.03	582.03	582.03
Pesticides				
Herbicides	360.00	360.00	360.00	360.00
Insecticides	1,034.00	1,034.00	1,034.00	1,034.00
Fungicides	1,160.83	1,160.83	1,160.83	1,160.83
Labour	53,595.96	39,434.15	28,919.34	20,501.69
Irrigation	4,356.45	4,356.45	4,356.45	4,356.45
Machinery operating expenses				
Fuel	2,367.00	2,843.00	3,581.00	4,937.00
Lubricant	355.05	426.45	537.15	740.55
Repair	3,373.69	4,478.05	5,061.38	5,852.52
Stationary threshing	414.00	414.00	414.00	414.00
Miscellaneous	0.00	0.00	0.00	0.00
Total operating costs without interest on variable expenses	75,407.35	62,897.30	53,814.53	47,747.42
Interest on variable expenses	2,865.48	2,390.10	2,044.95	1,814.40
Total operating costs with interest on variable expenses	78,272.83	65,287.40	55,859.49	49,561.82

B. Fixed Costs				
Land rent	87,358.58	87,358.58	87,358.58	87,358.58
Machinery cost	13,299.92	25,132.90	29,945.40	36,130.34
Miscellaneous	0.00	0.00	0.00	0.00
Total fixed costs	100,658.50	112,491.48	117,303.98	123,488.92
C. Total Costs	176,065.85	175,388.79	171,118.52	171,236.34
D. Estimated Farmgate				
Yield from main product (grain) (t/ha)	1.38	1.38	1.38	1.38
Price of main product (grain) (BDT/t)	126,074.38	126,074.38	126,074.38	126,074.38
Yield from by-product (straw) (t/ha)	1.72	1.72	1.72	1.72
Price of by-product (straw) (BDT/t)	3,960.00	3,960.00	3,960.00	3,960.00
Profitability Analysis Per Hectare				
E. Gross Return	180,793.84	180,793.84	180,793.84	180,793.84
F. Gross Margin	105,386.49	117,896.54	126,979.31	133,046.43
G. Net Return	4,728.00	5,405.06	9,675.33	9,557.51
H. Benefit Cost Ratio (BCR)	1.03	1.03	1.06	1.06
Break-Even Analysis				
M. Break-Even Price Per Hectare				
Over total operating cost without interest on variable expenses	54,643.01	45,577.76	38,996.04	34,599.58
Over total fixed cost	72,940.94	81,515.57	85,002.89	89,484.73
Over total cost	127,583.95	127,093.32	123,998.93	124,084.30
N. Break-Even Yield Per Hectare				
Over total operating cost without interest on variable expenses	0.60	0.50	0.43	0.38
Over total fixed cost	0.80	0.89	0.93	0.98
Over total cost	1.40	1.39	1.36	1.36

Table 6. Estimated crop costs and returns of mustard across different mechanization alternatives under farmer owned machinery market (BDT/ha).

	Scenario-1: Mechanized tillage only system	Scenario-2: Mechanized tillage & harvesting only system	Scenario-3: Mechanized tillage, planting & harvesting only system	Scenario-4: Conventional whole farm mechanization
A. Operating Costs				
Seed	1,176.40	1,176.40	1,176.40	1,176.40
Fertilizers				
Urea	4,878.68	4,878.68	4,878.68	4,878.68
Triple super phosphate (TSP)	3,144.15	3,144.15	3,144.15	3,144.15
Muriate of potash (MOP)	1,780.00	1,780.00	1,780.00	1,780.00
Gypsum	831.32	831.32	831.32	831.32
Pesticides				
Herbicides	1,098.25	1,098.25	1,098.25	1,098.25
Insecticides	893.33	893.33	893.33	893.33
Fungicides	1,530.00	1,530.00	1,530.00	1,530.00
Labour	59,582.95	44,353.88	33,046.66	23,854.01
Irrigation	4,671.78	4,671.78	4,671.78	4,671.78
Machinery operating expenses				
Fuel	2,367.00	2,843.00	3,581.00	4,661.00
Lubricant	355.05	426.45	537.15	699.15
Repair	3,373.69	4,478.05	5,061.38	5,852.52
Stationary threshing	456.00	456.00	456.00	456.00
Miscellaneous	0.00	0.00	0.00	0.00
Total operating costs without interest on variable expenses	86,138.60	72,561.29	62,686.11	55,526.60
Interest on variable expenses	3,273.27	2,757.33	2,382.07	2,110.01
Total operating costs with interest on variable expenses	89,411.87	75,318.62	65,068.18	57,636.61

B. Fixed Costs				
Land rent	77,998.74	77,998.74	77,998.74	77,998.74
Machinery cost	13,299.92	25,132.90	29,945.40	36,130.34
Miscellaneous	0.00	0.00	0.00	0.00
Total fixed costs	91,298.66	103,131.64	107,944.14	114,129.08
C. Total Costs	177,437.26	175,692.94	170,630.25	169,655.68
D. Estimated Farmgate				
Yield from main product (grain) (t/ha)	1.52	1.52	1.52	1.52
Price of main product (grain) (BDT/t)	85,718.64	85,718.64	85,718.64	85,718.64
Yield from by-product (stover) (t/ha)	1.70	1.70	1.70	1.70
Price of by-product (stover) (BDT/t)	1,893.67	1,893.67	1,893.67	1,893.67
Profitability Analysis Per Hectare				
E. Gross Return	133,511.57	133,511.57	133,511.57	133,511.57
F. Gross Margin	47,372.97	60,950.28	70,825.46	77,984.98
G. Net Return	-43,925.69	-42,181.37	-37,118.68	-36,144.11
H. Benefit Cost Ratio (BCR)	0.75	0.76	0.78	0.79
Break-Even Analysis				
M. Break-Even Price Per Hectare				
Over total operating cost without interest on variable expenses	56,670.13	47,737.69	41,240.86	36,530.66
Over total fixed cost	60,064.91	67,849.77	71,015.88	75,084.92
Over total cost	116,735.04	115,587.46	112,256.75	111,615.58
N. Break-Even Yield Per Hectare				
Over total operating cost without interest on variable expenses	1.00	0.85	0.73	0.65
Over total fixed cost	1.07	1.20	1.26	1.33
Over total cost	2.07	2.05	1.99	1.98

4.2.2 Estimated crop costs and returns under custom hired machinery market

The estimated crop costs and returns under custom hired machinery market helps to understand how farmer owned machinery versus custom hired machinery affects the farm level costs and returns. Total operating costs (without interest on variable expenses) in custom hired machinery market exhibited a similar pattern across all crops and mechanization alternatives as in the farmer owned machinery market. Operating costs across all crops were higher in the custom hired machinery market than farmer owned machinery market due to machinery service charges being included as operating expenses. The increases were BDT 26,787.84/ha for *Aman* rice (Table 7) and *Boro* rice, BDT 27,227.84/ha (Table 8) for wheat (Table 9) and maize (Table 10), and BDT 25,379.84/ha for lentil (Table 11) and mustard (Table 12). Fixed costs in custom hired machinery market remained unchanged for each crop (i. e., *Aman* rice, *Boro* rice, wheat, maize, lentil, and mustard), as it was just incurred the land rent while eliminated the costs associated with machinery ownership. However, the inclusion of fixed miscellaneous costs could introduce variation in the overall fixed cost structure. Fixed costs under custom hired machinery market are lower than farmer owned machinery market. For instance, the cost reduction under conventional whole farm mechanized custom hired machinery market were BDT 45,840.64/ha for *Aman* rice, BDT 57,300.80/ha for *Boro* rice, BDT 37,321.63/ha for wheat and maize, and BDT 36,130.34/ha for lentil and mustard compared to farmer owned machinery market.

Gross returns remained identical across all mechanization alternatives for each crop, consistent with the farmer owned machinery market. Gross margin was highest under conventional whole farm mechanization (Scenario 4), indicating that margins increase with higher levels of mechanization. However, with least mechanized farm operations, e.g., mechanized tillage only system (Scenario 1), *Aman* and *Boro* rice gross margins were negative under custom hired machinery market. This was primarily a result of high labour costs associated with less mechanized operations. The gross margins were lower under custom hired machinery market than farmer owned machinery market, because machinery service charges were considered as variable costs, while owned machinery fixed costs were not deducted from gross margins. To illustrate, gross margins under conventional whole farm mechanized custom hired machinery market were BDT 26,787.84/ha for *Aman* and *Boro* rice, BDT 27,227.84/ha for wheat and maize, and BDT 25,379.84/ha for lentil and mustard lower than farmer owned machinery market. When evaluated at market prices, the per hectare net returns were positive for rotational crops maize and lentil, whereas net returns for all other cereals and oilseeds were negative across all farm management alternatives. Conventional whole farm mechanization (Scenario 4) appeared more feasible among all farm management alternatives under custom hired machinery market than farmer owned machinery. For example, in maize production, net return was BDT 10,093.79/ha higher for conventional whole farm mechanized custom hired machinery market. Similarly, in lentil production, net return was BDT 10,750.50/ha higher. The BCR of all crops exhibited a trend consistent with net returns.

Break-even analyses of main grain yield and price were higher for mechanized tillage only system (Scenario 1) in custom hired machinery market, while lower for conventional whole farm mechanization (Scenario 4). Notably, break-even price and yield under farmer owned machinery market were higher than custom hired machinery market for all crops under all farm management alternatives. An exception was observed for *Aman* rice under the mechanized tillage only system (Scenario 1), where the break-even price in the custom hired machinery market exceeded that of the farmer owned machinery market by BDT 649.64/ha, along with a yield difference of 0.06 t/ha.

Table 7. Estimated crop costs and returns of monsoon season *Aman* rice across different mechanization alternatives under custom hired machinery market (BDT/ha).

	Scenario-1: Mechanized tillage only system	Scenario-2: Mechanized tillage & harvesting only system	Scenario-3: Mechanized tillage, planting & harvesting only system	Scenario-4: Conventional whole farm mechanization
A. Operating Costs				
Seed and treatment	1,259.07	1,259.07	2,637.01	2,637.01
Fertilizers				
Urea	5,046.78	5,046.78	5,046.78	5,046.78
Triple super phosphate (TSP)	1,078.65	1,078.65	1,078.65	1,078.65
Muriate of potash (MOP)	1,827.80	1,827.80	1,827.80	1,827.80
Gypsum	375.35	375.35	375.35	375.35
Pesticides				
Herbicides	1,259.17	1,259.17	1,259.17	1,259.17
Insecticides	2,387.02	2,387.02	2,387.02	2,387.02
Fungicides	1,852.75	1,852.75	1,852.75	1,852.75
Labour	84,925.17	68,179.17	44,316.92	26,266.27
Irrigation	8,342.20	8,342.20	8,342.20	8,342.20
Machinery operating expenses				
Fuel	3,156.00	3,632.00	4,178.00	5,777.00
Lubricant	473.40	544.80	626.70	866.55
Repair	2,698.95	3,582.44	7,832.44	8,584.48
Machinery service charge	12,627.84	14,683.84	21,243.84	26,787.84
Stationary threshing	918.00	918.00	918.00	918.00
Miscellaneous	0.00	0.00	0.00	0.00
Total operating costs without interest on variable expenses	128,228.15	114,969.04	103,922.63	94,006.87
Interest on variable expenses	3,077.48	2,759.26	2,494.14	2,256.16

Total operating costs with interest on variable expenses	131,305.63	117,728.30	106,416.77	96,263.03
B. Fixed Costs				
Land rent[11]	55,471.48	55,471.48	55,471.48	55,471.48
Miscellaneous	0.00	0.00	0.00	0.00
Total fixed costs	55,471.48	55,471.48	55,471.48	55,471.48
C. Total Costs	183,699.63	170,440.52	159,394.11	149,478.35
D. Estimated Farmgate				
Yield from main product (grain) (t/ha)	3.06	3.06	3.06	3.06
Price of main product (grain) (BDT/t)	32,116.33	32,116.33	32,116.33	32,116.33
Yield from by-product (straw) (t/ha)	5.38	5.38	5.38	5.38
Price of by-product (straw) (BDT/t)	5,000.00	5,000.00	5,000.00	5,000.00
Profitability Analysis Per Hectare				
E. Gross Return	125,175.97	125,175.97	125,175.97	125,175.97
F. Gross Margin	-3,052.18	10,206.93	21,253.34	31,169.10
G. Net Return	-58,523.66	-45,264.55	-34,218.14	-24,302.38
H. Benefit Cost Ratio (BCR)	0.68	0.73	0.79	0.84
Break-Even Analysis				
M. Break-Even Price Per Hectare				
Over total operating cost without interest on variable expenses	41,904.62	37,571.58	33,961.64	30,721.20
Over total fixed cost	18,127.93	18,127.93	18,127.93	18,127.93
Over total cost	60,032.56	55,699.52	52,089.58	48,849.13
N. Break-Even Yield Per Hectare				
Over total operating cost without interest on variable expenses	3.99	3.58	3.24	2.93
Over total fixed cost	1.73	1.73	1.73	1.73
Over total cost	5.72	5.31	4.96	4.65

Table 8. Estimated crop costs and returns of winter season *Boro* rice across different mechanization alternatives under custom hired machinery market (BDT/ha).

	Scenario-1: Mechanized tillage only system	Scenario-2: Mechanized tillage & harvesting only system	Scenario-3: Mechanized tillage, planting & harvesting only system	Scenario-4: Conventional whole farm mechanization
A. Operating Costs				
Seed and treatment	1,678.86	1,678.86	2,676.25	2,676.25
Fertilizers				
Urea	8,242.29	8,242.29	8,242.29	8,242.29
Triple super phosphate (TSP)	1,730.70	1,730.70	1,730.70	1,730.70
Muriate of potash (MOP)	2,636.40	2,636.40	2,636.40	2,636.40
Gypsum	657.53	657.53	657.53	657.53
Pesticides				
Herbicides	1,259.17	1,259.17	1,259.17	1,259.17
Insecticides	2,387.02	2,387.02	2,387.02	2,387.02
Fungicides	1,852.75	1,852.75	1,852.75	1,852.75
Labour	124,217.96	105,093.08	78,765.12	56,369.43
Irrigation	12,258.20	12,258.20	12,258.20	12,258.20
Machinery operating expenses				
Fuel	3,156.00	3,632.00	4,178.00	6,103.00
Lubricant	473.40	544.80	626.70	915.45
Repair	3,373.69	4,478.05	9,790.55	10,730.60
Machinery service charge	12,627.84	14,683.84	21,243.84	26,787.84
Stationary threshing	1,314.00	1,314.00	1,314.00	1,314.00
Miscellaneous	0.00	0.00	0.00	0.00
Total operating costs without interest on variable expenses	177,865.81	162,448.69	149,618.52	135,920.63
Interest on variable expenses	6,758.90	6,173.05	5,685.50	5,164.98

Total operating costs with interest on variable expenses	184,624.71	168,621.74	155,304.03	141,085.62
B. Fixed Costs				
Land rent[11]	77,998.74	77,998.74	77,998.74	77,998.74
Miscellaneous	0.00	0.00	0.00	0.00
Total fixed costs	77,998.74	77,998.74	77,998.74	77,998.74
C. Total Costs	255,864.55	240,447.43	227,617.26	213,919.37
D. Estimated Farmgate				
Yield from main product (grain) (t/ha)	4.38	4.38	4.38	4.38
Price of main product (grain) (BDT/t)	31,701.85	31,701.85	31,701.85	31,701.85
Yield from by-product (straw) (t/ha)	6.45	6.45	6.45	6.45
Price of by-product (straw) (BDT/t)	5,000.00	5,000.00	5,000.00	5,000.00
Profitability Analysis Per Hectare				
E. Gross Return	171,104.10	171,104.10	171,104.10	171,104.10
F. Gross Margin	-6,761.70	8,655.41	21,485.58	35,183.47
G. Net Return	-84,760.44	-69,343.33	-56,513.16	-42,815.27
H. Benefit Cost Ratio (BCR)	0.67	0.71	0.75	0.80
Break-Even Analysis				
M. Break-Even Price Per Hectare				
Over total operating cost without interest on variable expenses	40,608.63	37,088.74	34,159.48	31,032.11
Over total fixed cost	17,807.93	17,807.93	17,807.93	17,807.93
Over total cost	58,416.56	54,896.67	51,967.41	48,840.04
N. Break-Even Yield Per Hectare				
Over total operating cost without interest on variable expenses	5.61	5.12	4.72	4.29
Over total fixed cost	2.46	2.46	2.46	2.46
Over total cost	8.07	7.58	7.18	6.75

Table 9. Estimated crop costs and returns of wheat across different mechanization alternatives under custom hired machinery market (BDT/ha).

	Scenario-1: Mechanized tillage only system	Scenario-2: Mechanized tillage & harvesting only system	Scenario-3: Mechanized tillage, planting & harvesting only system	Scenario-4: Conventional whole farm mechanization
A. Operating Costs				
Seed	5,965.05	5,965.05	5,965.05	5,965.05
Fertilizers				
Urea	6,500.58	6,500.58	6,500.58	6,500.58
Triple super phosphate (TSP)	3,927.15	3,927.15	3,927.15	3,927.15
Muriate of potash (MOP)	2,620.20	2,620.20	2,620.20	2,620.20
Gypsum	745.98	745.98	745.98	745.98
Pesticides				
Herbicides	1,019.53	1,019.53	1,019.53	1,019.53
Insecticides	1,132.50	1,132.50	1,132.50	1,132.50
Labour	77,103.67	57,978.80	46,671.58	27,978.99
Irrigation	5,526.14	5,526.14	5,526.14	5,526.14
Machinery operating expenses				
Fuel	2,367.00	2,843.00	3,581.00	5,129.00
Lubricant	355.05	426.45	537.15	769.35
Repair	3,373.69	4,478.05	5,061.38	6,001.43
Machinery service charge	12,627.84	14,683.84	21,683.84	27,227.84
Stationary threshing	7,952.00	7,952.00	7,952.00	7,952.00
Miscellaneous	0.00	0.00	0.00	0.00
Total operating costs without interest on variable expenses	131,216.38	115,799.27	112,924.08	102,495.74
Interest on variable expenses	4,986.22	4,400.37	4,291.12	3,894.84
Total operating costs with interest on variable expenses	136,202.60	120,199.64	117,215.20	106,390.58
B. Fixed Costs				

Land rent	77,998.74	77,998.74	77,998.74	77,998.74
Miscellaneous	0.00	0.00	0.00	0.00
Total fixed costs	77,998.74	77,998.74	77,998.74	77,998.74
C. Total Costs	209,215.12	193,798.01	190,922.82	180,494.48
D. Estimated Farmgate				
Yield from main product (grain) (t/ha)	3.78	3.78	3.78	3.78
Price of main product (grain) (BDT/t)	44,505.75	44,505.75	44,505.75	44,505.75
Yield from by-product (straw) (t/ha)	4.59	4.59	4.59	4.59
Price of by-product (straw) (BDT/t)	2,566.02	2,566.02	2,566.02	2,566.02
Profitability Analysis Per Hectare				
E. Gross Return	180,009.77	180,009.77	180,009.77	180,009.77
F. Gross Margin	48,793.39	64,210.50	67,085.69	77,514.03
G. Net Return	-29,205.35	-13,788.24	-10,913.05	-484.71
H. Benefit Cost Ratio (BCR)	0.86	0.93	0.94	1.00
Break-Even Analysis				
M. Break-Even Price Per Hectare				
Over total operating cost without interest on variable expenses	34,713.33	30,634.73	29,874.10	27,115.28
Over total fixed cost	20,634.59	20,634.59	20,634.59	20,634.59
Over total cost	55,347.92	51,269.31	50,508.68	47,749.86
N. Break-Even Yield Per Hectare				
Over total operating cost without interest on variable expenses	2.95	2.60	2.54	2.30
Over total fixed cost	1.75	1.75	1.75	1.75
Over total cost	4.70	4.35	4.29	4.06

Table 10. Estimated crop costs and returns of maize across different mechanization alternatives under custom hired machinery market (BDT/ha).

	Scenario-1: Mechanized tillage only system	Scenario-2: Mechanized tillage & harvesting only system	Scenario-3: Mechanized tillage, planting & harvesting only system	Scenario-4: Conventional whole farm mechanization
A. Operating Costs				
Seed	3,952.00	3,952.00	3,952.00	3,952.00
Fertilizers				
Urea	13,450.15	13,450.15	13,450.15	13,450.15
Triple super phosphate (TSP)	6,480.00	6,480.00	6,480.00	6,480.00
Muriate of potash (MOP)	4,200.60	4,200.60	4,200.60	4,200.60
Gypsum	1,904.65	1,904.65	1,904.65	1,904.65
Pesticides				
Herbicides	1,285.80	1,285.80	1,285.80	1,285.80
Insecticides	931.40	931.40	931.40	931.40
Labour	70,939.00	54,193.00	44,284.98	29,477.71
Irrigation	7,505.76	7,505.76	7,505.76	7,505.76
Machinery operating expenses				
Fuel	2,367.00	2,843.00	3,581.00	4,803.00
Lubricant	355.05	426.45	537.15	720.45
Repair	3,373.69	4,478.05	5,061.38	6,001.43
Machinery service charge	12,627.84	14,683.84	21,683.84	27,227.84
Stationary shelling	1,491.00	1,491.00	1,491.00	1,491.00
Miscellaneous	0.00	0.00	0.00	0.00
Total operating costs without interest on variable expenses	130,863.94	117,825.70	116,349.72	109,431.79
Interest on variable expenses	4,972.83	4,477.38	4,421.29	4,158.41
Total operating costs with interest on variable expenses	135,836.77	122,303.07	120,771.01	113,590.20
B. Fixed Costs				

Land rent[11]	69,339.35	69,339.35	69,339.35	69,339.35
Miscellaneous	0.00	0.00	0.00	0.00
Total fixed costs	69,339.35	69,339.35	69,339.35	69,339.35
C. Total Costs	200,203.29	187,165.05	185,689.07	178,771.14
D. Estimated Farmgate				
Yield from main product (grain) (t/ha)	9.94	9.94	9.94	9.94
Price of main product (grain) (BDT/t)	40,637.08	40,637.08	40,637.08	40,637.08
Yield from by-product (stover) (t/ha)	10.98	10.98	10.98	10.98
Price of by-product (stover) (BDT/t)	1,292.25	1,292.25	1,292.25	1,292.25
Profitability Analysis Per Hectare				
E. Gross Return	418,121.44	418,121.44	418,121.44	418,121.44
F. Gross Margin	287,257.50	300,295.74	301,771.72	308,689.65
G. Net Return	217,918.15	230,956.39	232,432.37	239,350.30
H. Benefit Cost Ratio (BCR)	2.09	2.23	2.25	2.34
Break-Even Analysis				
M. Break-Even Price Per Hectare				
Over total operating cost without interest on variable expenses	13,165.39	11,853.69	11,705.20	11,009.23
Over total fixed cost	6,975.79	6,975.79	6,975.79	6,975.79
Over total cost	20,141.18	18,829.48	18,680.99	17,985.02
N. Break-Even Yield Per Hectare				
Over total operating cost without interest on variable expenses	3.22	2.90	2.86	2.69
Over total fixed cost	1.71	1.71	1.71	1.71
Over total cost	4.93	4.61	4.57	4.40

Table 11. Estimated crop costs and returns of lentil across different mechanization alternatives under custom hired machinery market (BDT/ha).

	Scenario-1: Mechanized tillage only system	Scenario-2: Mechanized tillage & harvesting only system	Scenario-3: Mechanized tillage, planting & harvesting only system	Scenario-4: Conventional whole farm mechanization
A. Operating Costs				
Seed	3,921.76	3,921.76	3,921.76	3,921.76
Fertilizers				
Urea	1,136.75	1,136.75	1,136.75	1,136.75
Triple super phosphate (TSP)	2,028.24	2,028.24	2,028.24	2,028.24
Muriate of potash (MOP)	721.60	721.60	721.60	721.60
Gypsum	582.03	582.03	582.03	582.03
Pesticides				
Herbicides	360.00	360.00	360.00	360.00
Insecticides	1,034.00	1,034.00	1,034.00	1,034.00
Fungicides	1,160.83	1,160.83	1,160.83	1,160.83
Labour	53,595.96	39,434.15	28,919.34	20,501.69
Irrigation	4,356.45	4,356.45	4,356.45	4,356.45
Machinery operating expenses				
Fuel	2,367.00	2,843.00	3,581.00	4,937.00
Lubricant	355.05	426.45	537.15	740.55
Repair	3,373.69	4,478.05	5,061.38	5,852.52
Machinery service charge	12,627.84	14,683.84	21,683.84	25,379.84
Stationary threshing	414.00	414.00	414.00	414.00
Miscellaneous	0.00	0.00	0.00	0.00
Total operating costs without interest on variable expenses	88,035.19	77,581.14	75,498.37	73,127.26
Interest on variable expenses	3,345.34	2,948.08	2,868.94	2,778.84
Total operating costs with interest on variable expenses	91,380.53	80,529.23	78,367.31	75,906.09

B. Fixed Costs				
Land rent	87,358.58	87,358.58	87,358.58	87,358.58
Miscellaneous	0.00	0.00	0.00	0.00
Total fixed costs	87,358.58	87,358.58	87,358.58	87,358.58
C. Total Costs	175,393.77	164,939.72	162,856.95	160,485.84
D. Estimated Farmgate				
Yield from main product (grain) (t/ha)	1.38	1.38	1.38	1.38
Price of main product (grain) (BDT/t)	126,074.38	126,074.38	126,074.38	126,074.38
Yield from by-product (straw) (t/ha)	1.72	1.72	1.72	1.72
Price of by-product (straw) (BDT/t)	3,960.00	3,960.00	3,960.00	3,960.00
Profitability Analysis Per Hectare				
E. Gross Return	180,793.84	180,793.84	180,793.84	180,793.84
F. Gross Margin	92,758.65	103,212.70	105,295.47	107,666.59
G. Net Return	5,400.07	15,854.12	17,936.89	20,308.01
H. Benefit Cost Ratio (BCR)	1.03	1.10	1.11	1.13
Break-Even Analysis				
M. Break-Even Price Per Hectare				
Over total operating cost without interest on variable expenses	63,793.62	56,218.22	54,708.97	52,990.76
Over total fixed cost	63,303.32	63,303.32	63,303.32	63,303.32
Over total cost	127,096.94	119,521.54	118,012.28	116,294.08
N. Break-Even Yield Per Hectare				
Over total operating cost without interest on variable expenses	0.70	0.62	0.60	0.58
Over total fixed cost	0.69	0.69	0.69	0.69
Over total cost	1.39	1.31	1.29	1.27

Table 12. Estimated crop costs and returns of mustard across different mechanization alternatives under custom hired machinery market (BDT/ha).

	Scenario-1: Mechanized tillage only system	Scenario-2: Mechanized tillage & harvesting only system	Scenario-3: Mechanized tillage, planting & harvesting only system	Scenario-4: Conventional whole farm mechanization
A. Operating Costs				
Seed	1,176.40	1,176.40	1,176.40	1,176.40
Fertilizers				
Urea	4,878.68	4,878.68	4,878.68	4,878.68
Triple super phosphate (TSP)	3,144.15	3,144.15	3,144.15	3,144.15
Muriate of potash (MOP)	1,780.00	1,780.00	1,780.00	1,780.00
Gypsum	831.32	831.32	831.32	831.32
Pesticides				
Herbicides	1,098.25	1,098.25	1,098.25	1,098.25
Insecticides	893.33	893.33	893.33	893.33
Fungicides	1,530.00	1,530.00	1,530.00	1,530.00
Labour	59,582.95	44,353.88	33,046.66	23,854.01
Irrigation	4,671.78	4,671.78	4,671.78	4,671.78
Machinery operating expenses				
Fuel	2,367.00	2,843.00	3,581.00	4,661.00
Lubricant	355.05	426.45	537.15	699.15
Repair	3,373.69	4,478.05	5,061.38	5,852.52
Machinery service charge	12,627.84	14,683.84	21,683.84	25,379.84
Stationary threshing	456.00	456.00	456.00	456.00
Miscellaneous	0.00	0.00	0.00	0.00
Total operating costs without interest on variable expenses	98,766.44	87,245.13	84,369.95	80,906.44
Interest on variable expenses	3,753.12	3,315.32	3,206.06	3,074.44
Total operating costs with interest on variable expenses	102,519.57	90,560.45	87,576.01	83,980.88

B. Fixed Costs				
Land rent	77,998.74	77,998.74	77,998.74	77,998.74
Miscellaneous	0.00	0.00	0.00	0.00
Total fixed costs	77,998.74	77,998.74	77,998.74	77,998.74
C. Total Costs	176,765.18	165,243.87	162,368.69	158,905.18
D. Estimated Farmgate				
Yield from main product (grain) (t/ha)	1.52	1.52	1.52	1.52
Price of main product (grain) (BDT/t)	85,718.64	85,718.64	85,718.64	85,718.64
Yield from by-product (stover) (t/ha)	1.70	1.70	1.70	1.70
Price of by-product (stover) (BDT/t)	1,893.67	1,893.67	1,893.67	1,893.67
Profitability Analysis Per Hectare				
E. Gross Return	133,511.57	133,511.57	133,511.57	133,511.57
F. Gross Margin	34,745.13	46,266.44	49,141.62	52,605.14
G. Net Return	-43,253.61	-31,732.30	-28,857.12	-25,393.60
H. Benefit Cost Ratio (BCR)	0.76	0.81	0.82	0.84
Break-Even Analysis				
M. Break-Even Price Per Hectare				
Over total operating cost without interest on variable expenses	64,977.92	57,398.11	55,506.54	53,227.92
Over total fixed cost	51,314.96	51,314.96	51,314.96	51,314.96
Over total cost	116,292.88	108,713.08	106,821.51	104,542.88
N. Break-Even Yield Per Hectare				
Over total operating cost without interest on variable expenses	1.15	1.02	0.98	0.94
Over total fixed cost	0.91	0.91	0.91	0.91
Over total cost	2.06	1.93	1.89	1.85

4.3 Interactive tool for evidence-based farming decisions

The open-access digital crop budget planning tool available at Hub for Smallholders Agri-Tech Economics (HSATE) website was developed to help all stakeholders including farmers, agribusinesses and policymakers to identify profitable cropping, farm management alternatives and machinery markets. Users could estimate farmgate level total revenues, farm operating expenses, capital and all associated fixed costs, percentage share of inventory costs and break-even analyses. This farm planning tool allows profitability analysis of different cropping, and technology alternatives and markets that would support farming and policy decisions. This digital crop budget planning tool could easily automate farm planning decisions subject to accessible digitized national administrative agricultural datasets and coordination of administrative entities. This could facilitate informed farm management and crop production decisions and help formulate national policy and programme design.

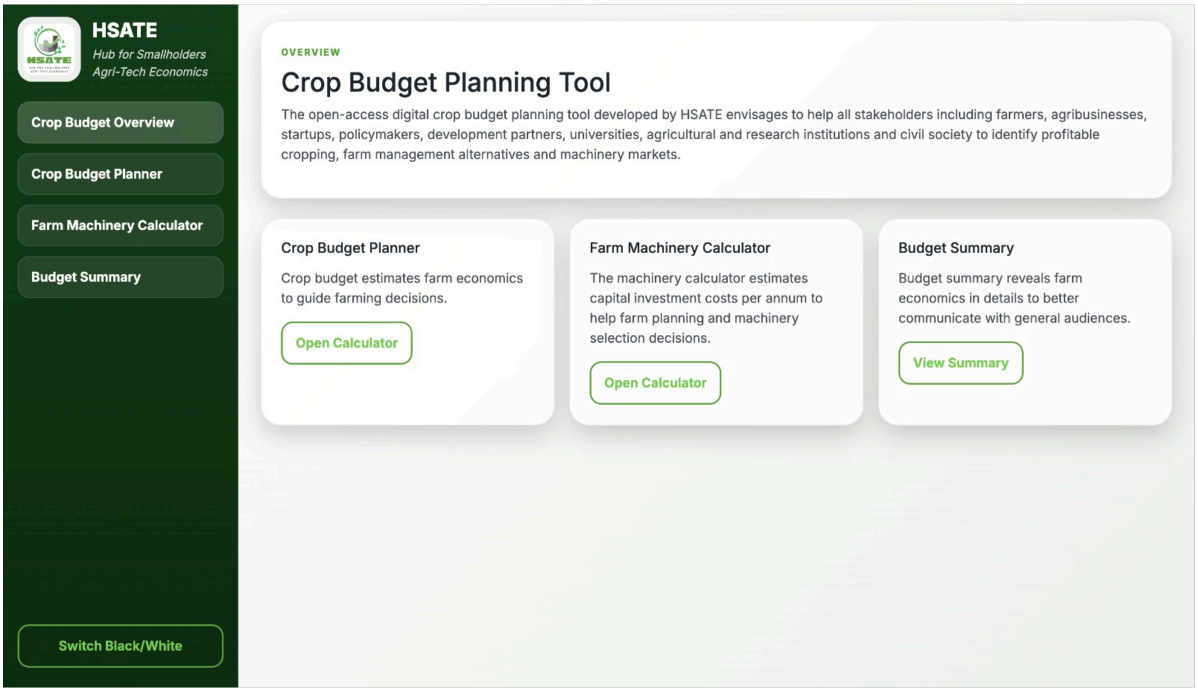

Figure 9. Overview of web-based open access digital calculator.

5. DISCUSSION

This study overcomes the long-standing crop budgeting gaps of Bangladesh through developing nationally representative budgets for different mechanized farm management alternatives under farmers owned and custom hire machinery markets. The division level crop hotspot zoning found that Rangpur division emerged as a key hotspot for monsoon season *Aman* rice and winter season maize. Rajshahi division was specialized in winter season *Boro* rice, wheat, and mustard, while Khulna division was identified as lentil production hotspots. These spatio-temporal variations reflect differences in agro-ecological conditions indicating 'one size fits all' intensification approach not a feasible strategy. This crop zoning approach is aligned with the targets envisaged in the National Agriculture Policy (NAP, 2018), especially prioritized as GIS-based crop planning.

Following the spatial understanding of crop zones, this study developed major and rotational crop budgets across mechanized farm management alternatives and machinery markets. The comparative profitability analysis indicates that per hectare return over variable costs (gross margin) for all crops increased with higher levels of mechanization under both farmer owned and custom hired machinery markets. This was primarily attributed to the high labour costs associated with less mechanized farm operations. The gross margins were higher under farmer owned machinery market because in custom hired machinery market, machinery service charges were added burdens to farms. The per hectare return over total costs (net return) found positive for rotational crops maize and lentil, while other grain-oilseed assessed found negative returns across all farm management alternatives and machinery markets. The performance of custom hired machinery services was more favourable in terms of net returns under highly mechanized farm management alternatives, particularly when compared with farmer owned machinery.

The break-even analyses of main grain price and yield underscore the importance of cost structure in determining farm-level viability across crops and farm management alternatives. For example, under farmer owned machinery market, for maize production, break-even analysis over total cost indicates that the break-even price under conventional whole farm mechanization was BDT 19,000.50/t. Similarly, break-even yield was 4.65 t/ha, which was 0.25 t/ha higher than custom hired machinery services. The current arable farming system in Bangladesh is not strongly profit-oriented, as only two out of six major farm enterprises generate positive returns. For instance, maize has emerged as a widely cultivated rotational crop, largely driven by its comparatively higher profitability as demand for growing animal feed. Achieving profitability in rice cultivation remains challenging, as substantially higher yields are required to offset production costs. As a common policy approach, the Government of Bangladesh provides price support for major crops (FPMS, 2026), which helps farmers to achieve at least break-even price level. However, it is increasingly important for agronomists to also focus on break-even yield, as ensuring price support alone may not guarantee profitability when yield gaps persist significantly. Evidence from this study shows that actual yields fall short of break-even yields under conventional whole farm mechanization (all farm operations as mechanized except field to farmstead transportation) when total costs are considered. For example, although rice is the staple food in Bangladesh, the actual yield of *Aman* rice is lower than the break-even yield by 2.19 t/ha and 1.59 t/ha under farmer owned and custom hired machinery markets, respectively. Similarly, for *Boro* rice, the yield gaps are even more pronounced, at 3.33 t/ha and 2.37 t/ha under the respective machinery markets. These findings highlight significance of improving yield performance. Besides, if the land is owned by the farmers, production of cereals and oilseeds is closer to break-even at current price and sometimes profitable.

Alongside price support and increased yield, it is further reinforced that the adoption of more cost-effective and economically viable mechanization alternatives which is essential for achieving sustainable farm profitability. Relying solely on price support policies and productivity gains is not sufficient, as existing partial conventional mechanization systems, in their current form, fail to consistently ensure profitability across crops and management alternatives. Therefore, identifying and promoting more efficient mechanization alternatives is critical for improving overall farm feasibility. The results of this study indicate that conventional whole farm mechanization performs best in terms of profitability. However, its practical adoption remains constrained by the lack of mechanized field-to-farmstead transportation, which results in higher labour requirements that consequently, increased operating costs. If field-to-farmstead transportation could be mechanized, it would substantially reduce labour requirements and operating costs, thereby enabling farmers to fully realize the economic benefits of whole farm mechanization. The findings are in line with the vision of the National Agriculture Policy (NAP, 2018), which emphasizes the promotion of economically profitable crop production (3.3.8.6). Furthermore, this study contributes to achieving the goals of the National Agricultural Mechanization Policy (NAMP, 2020) and plan of action (MoA, 2023) by supporting the 'transition to efficient and commercial agriculture through agricultural mechanization and ensuring sustainable food and nutrition security' through informed, data-driven farm-level decision-making.

Furthermore, to improve accessibility, this study also developed an open-access digital platform where crop budgets and a published cost and return guide are available online, hosted by HSATE. The developed national crops cost and return guide can serve as a critical foundation for enhancing stakeholders' ability to make informed production and investment decisions. Integrating national datasets with spatio-temporal analyses allow for a better understanding of regional production patterns and comparative advantages. Policymakers should use this tool to design targeted crop support programmes and region-specific investment strategies instead of proposing 'one size fits all' approach for agriculture, well known as a risky business. Further alignment with the national data repository, this platform could bridge the gap between datasets and practical applications, allowing stakeholders to make timely, evidence-based decisions. The developed national autonomous crop budgeting systems can serve as a critical foundation for enhancing farmers' ability to make informed production and investment decisions. Tertiary level of education will benefit with such attempt which could be used for hands-on training material for graduate and postgraduate students. This crops budget planning tool could be easily converted to handy user-friendly mobile apps.

The findings also highlight key challenges that must be addressed. The sensitivity of input and output cost and price inflation would inform the impact on farm economic performances. The effectiveness of crop budgets depends on regular updates, data accuracy, and institutional coordination among actors like BBS, BADC, DAE, and DAM. The digital platform would help capacity building of the key stakeholders. This crop budget planning tool could be used for impact assessment with treatment and control groups through randomized controlled trials (RCTs). Overall, data-driven agricultural decisions are crucial for transitional countries like Bangladesh that are looking to ensure agriculture as an income generating industry to link with economic growth. This is relevant with Bangladesh's graduation from LDC (MoF, 2025). The transitional agriculture of Bangladesh needs such evidence-based decisions. But the medium to long-term implications is subject to quality and digital data systems, access, and institutional coordination.

6. CONCLUSIONS

Crop budgets are among the most widely used farm economic tools, supporting farmers, agribusinesses, academics, researchers, and policymakers in making data-informed decisions. Bangladesh has experienced a prolonged absence of structured crop budgeting systems, lacking a coordinated, regularly updated framework to support cost and return guide for major and rotational grain-oilseeds. This shortfall has hindered farmers' ability to make informed farm-level decisions. This study contributes to nationally represented division level crop budgets for major cereals (*Aman* rice, *Boro* rice, and wheat) and rotational crops (maize, lentil, and mustard). Firstly, crop zoning analysis was based on production and area of production intensification, identified Rangpur division as a hotspot for *Aman* rice and maize, and Rajshahi for mustard. Rajshahi was also identified as a hotspot for wheat production, although no statistically significant hotspot patterns were observed for wheat area at the divisional level. However, district level analysis confirmed Rajshahi division as a wheat hotspot. Similar localized patterns were observed for *Boro* rice in Rajshahi and lentil in Khulna. Across all crops and machinery markets, conventional whole farm mechanization emerged as the most profitable farm management alternative. Maize and lentil remained profitable under all farm management alternatives and machinery markets, while most other crops failed to cover variable costs. Nevertheless, custom hiring services played a key role in reducing costs and moving production closer to break-even. To ensure easy communication and automate crop budgeting, an open-access digital crop budget planning tool has been developed by the Hub for Smallholders Agri-Tech Economics (HSATE). This provides stakeholders with the ability to assess crop choices, farm management strategies, and machinery market options, thereby supporting evidence-based decision-making and policy formulation. If national agricultural administrative datasets are digitized and accessible, this crop budget planning tool could generate automated farming planning decisions. Overall, the findings strongly support crop zoning and region-specific crop budgeting as effective approaches to address spatial, agroclimatic and economic heterogeneity, with important implications for agricultural transformation in Bangladesh. These initiatives can strengthen stakeholders' capacity, facilitate impact evaluation through randomized controlled trials, and enable automated decision-making in smallholder farming systems. This study provides critical evidence for data-driven agricultural transformation in Bangladesh. The insights generated can guide targeted policy interventions, improve efficiency in resource allocation, and enhance farm-level profitability.

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Appendices

The appendices include:

- Appendix A: Supporting evidence of state of the knowledge.
- Appendix B: Conceptual classification of emerging hotspots and time-series analysis of crop production and area.
- Appendix C: Assumptions underpinning crop cost and return calculations.
- Appendix D: Checklist for Key Informant Interview (KII) of agri-tech companies in Bangladesh.
- Appendix E: Checklist for Key Informant Interview (KII) of agro-chemical companies in Bangladesh.
- Appendix F: Checklist for Key Informant Interview (KII) of Bangladesh Agricultural Development Corporation (BADC).
- Appendix G: Checklist for Key Informant Interview (KII) of Department of Agricultural Marketing (DAM).

Appendix A

Appendix A: Supporting evidence of state of the knowledge

Appendix A presents a structured summary of the reviewed literature. It includes key information on cost and return studies, such as data categories, data sources, types of economic analysis, and main economic outcomes. This format helps organize the evidence base and provides a clear overview of the existing state of knowledge.

Table A1. Review of literature on rice.

Author and year	Region	Data category		Data source	Economic analysis	Economic outcome
		Variable cost	Fixed cost			
Alam et al. (2021)	Gaibandha, Bangladesh	Seed, land preparation, human labour, cow dung, fertilizers (urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum, zinc, boron), irrigation, fungicides, insecticides	Interest on operating capital (IOC), land rent	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. Benefit cost ratio (BCR) (Undiscounted)	Positive
Ahmed et al. (2025)	Sunamganj, Bangladesh	Human labour, seed, power tiller, fertilizers (urea, TSP, MOP), insecticides, irrigation, weeding	IOC, land use cost	Primary data: Field survey	i. Total return ii. Net return iii. Average rate of return (ARR) iv. BCR	Positive
Chanda et al. (2019)	Sirajganj, Bangladesh	Fertilizer, seedling, ploughing, transplanting, irrigation, weeding, pesticides, harvesting, processing	Land charge, bank interest	Primary data: Field survey	i. Gross returns ii. Net returns iii. Production cost iv. BCR	Positive

Fatema et al. (2014)	Khulna, Bangladesh	Hired labour, power tiller, seedlings, fertilizers (urea, TSP, MOP, gypsum), insecticides	Family labour, IOC	Primary data: Field survey	i. Gross margin ii. Net return iii. Undiscounted BCR	Positive
Lucky et al. (2018)	Cumilla, Bangladesh	Human labour, tillage, seed, fertilizers, irrigation, pesticides		Primary data: Field survey	i. Gross return ii. Gross margin	Positive
Kamruzz-aman and Uddin (2020)	Kishoreganj, Bangladesh	Seed, power tiller, labour, fertilizers (chemical and organic), herbicides, insecticides, irrigation	Land use cost, IOC	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR	Positive
Khan (2020)	Cumilla, Bangladesh	Seedlings, irrigation, power tiller/mechanical cost, hired labour, fertilizers (urea, TSP, MOP, gypsum, zinc sulphur), manure, insecticides	Land use, family labour, IOC	Primary data: Field survey Secondary data: BBS, Ministry of Agriculture (MoA)	i. Gross return ii. Gross margin iii. Net return iv. Undiscounted BCR	Positive
Moon et al. (2020)	Rangpur, Bangladesh	Labour, seed, tractor, irrigation, fertilizer (urea, TSP, MOP, gypsum), manure, insecticides	Land use cost	Primary data: Field survey	i. Total return ii. Net return iii. BCR	Positive
Nasrin and Uddin (2011)	Mymensingh, Bangladesh	Seedlings, power tiller, human labour, inorganic fertilizers (urea, TSP, MOP, $ZnSO_4$), organic fertilizer (cow dung), irrigation, insecticides	IOC, land rent, depreciation of farm	Primary data: Field survey	i. Net return	Positive

Rahaman et al. (2022)	Habiganj, Sunamganj, Maulavibazar, and Sylhet districts of Bangladesh	Seedling development, human labour (daily wage basis and contract basis), tillage, fertilizers (urea, MOP, DAP, gypsum, $ZnSO_4$, $MgSO_4$), manure, irrigation, herbicides, insecticides, power thresher	Family labour, IOC	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. Unit price of grain v. Unit cost of production vi. BCR on full cost basis	Positive
Rasha et al. (2018)	Mymensingh, Bangladesh	Seed, animal labour/power tiller, human labour, fertilizers (urea, TSP, MOP, gypsum, zinc sulphate), manure, irrigation, pesticides	IOC, rental value of land	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR (undiscounted)	Positive
Roy et al. (2019)	Satkhira, Bangladesh	Seed, fertilizers (urea, TSP, MOP, gypsum, DAP, zinc), insecticides, power tiller, hired labour	Family labour, land use cost	Primary data: Field survey Secondary data: Existing publications, Bangladesh Bureau of Statistics (BBS), research reports, etc.	i. Total return ii. Gross margin iii. Net return iv. Undiscounted BCR	Positive
Sarkar et al. (2021)	Sunamganj, Rangpur, Gopalganj, Pabna, and Magura districts of Bangladesh	Hired labour, power tiller, seed, fertilizers (urea, TSP, MOP, gypsum, zinc), cow dung, pesticides, irrigation	Family labour, IOC, land use cost	Primary data: Field survey	i. Total return ii. Gross margin iii. Net return iv. BCR on full cost v. BCR on variable cost	Positive

Sarkar et al. (2022)	Mymensingh, Rangpur, Cumilla and Magura districts of Bangladesh	Hired labour, power tiller, seed, fertilizers (urea, TSP, MOP), cow dung, pesticides, irrigation, IOC	Family labour, land use cost	Primary data: Field survey	i. Total return ii. Gross margin iii. Net return iv. BCR on full cost v. BCR on variable cost	Positive
Sarkar et al. (2023)	Mymensingh, Jamalpur and Rangpur districts of Bangladesh	Hired labour, power tiller, seed, fertilizers (urea, TSP, MOP, gypsum, zinc sulphate), cow dung, pesticides, irrigation, IOC	Family labour, land use cost	Primary data: Field survey	i. Total return ii. Gross margin iii. Net return iv. BCR on full cost v. BCR on variable cost	Positive
Sarkar et al. (2024)	Mymensingh, Bogura, Naogaon and Rangpur districts of Bangladesh	Hired labour, power tiller, seed, fertilizers (urea, TSP, MOP, gypsum, zinc), cow dung, pesticides, irrigation, IOC	Family labour, land use cost	Primary data: Field survey	i. Total return ii. Gross margin iii. Net return iv. BCR on full cost v. BCR on variable cost	Positive
Sultana et al. (2024)	Mymensingh, Netrokona and Rangpur districts of Bangladesh	Hired labour, power tiller, seed, fertilizers (urea, TSP, DAP, MOP, gypsum), cow dung, insecticides, irrigation, IOC	Family labour, land use cost	Primary data: Field survey	i. Total return ii. Gross margin iii. Net return iv. BCR on full cost	Positive
Sujan et al. (2017)	Bogura, Bangladesh	Human labour (family & hired labour), power tiller, seed, organic manure, chemical fertilizers (urea, TSP, gypsum), insecticides, irrigation	Land use cost, IOC	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR on full cost basis v. BCR on variable cost basis	Positive

Uddin et al. (2022)	Tangail, Bangladesh	Human labour, power tiller, seed/seedlings, fertilizers, irrigation, insecticides and herbicides	Land use cost, IOC	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. Benefit cost ratio (BCR)	Positive
Zaman et al. (2022)	Mymensingh, Bangladesh	Ploughing, labour, seed, fertilizers (urea, MOP, TSP, gypsum, zinc, boron), cow dung, pesticides, herbicides, harvesting, threshing and drying, IOC	Land cost	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR	Positive
Ben-Chendo et al. (2017)	Nigeria	Seed, fertilizer, agro-chemicals, bags, labour	Depreciation (rent on land, interest on loan, depreciation on implement/machines used)	Primary data: Field survey	i. Total revenue ii. Gross margin iii. Net return iv. Benefit cost ratio (BCR) v. Gross margin ratio	Positive
Dhakal et al. (2023)	Nepal	Seed, chemical fertilizer, farmyard manure (FYM), tractor/ thresher, bullocks, labour, pesticides, transportation		Primary data: Field survey	i. Gross return ii. Gross profit iii. BCR	Positive
Nwahia (2020)	Nigeria	Labour, fertilizer, seed, herbicides, interest on loan	Depreciation, land rent	Primary data: Field survey	i. Total revenue ii. Net farming income (NFI) iii. Returns/US dollar invested (RUSDI)	Positive

Saediman et al. (2019)	Indonesia	Seed, fertilizer, pesticides, herbicides, paid labour	Depreciation, tax	Primary data: Field survey	i. Revenue ii. Net return iii. Return-cost ratio (R/C ratio)	Positive
Suwanma-neepong et al. (2020)	Thailand	Labour, seed, green manure, fuel, biofertilizers	Land tax, land rent, opportunity cost, depreciation cost	Primary data: Field survey	i. Total revenue ii. Gross margin iii. Break-even quantity iv. Break-even price v. BCR	Positive
USDA (2025b)	USA	Seed, fertilizer, chemicals, custom services, fuel, lube, and electricity, repairs, commercial drying, purchased irrigation water, IOC	Hired labour, opportunity cost of unpaid labour, capital recovery of machinery and equipment, opportunity cost of land, taxes and insurance, general farm overhead	Secondary data: U.S. Department of Agriculture (USDA), Economic Research Service (ERS), National Agricultural Statistics Service's Agricultural Resource Management Survey (ARMS) data	i. Gross value of production ii. Net value	Positive

Table A2. Review of literature on wheat.

Author and year	Region	Data category		Data source	Economic analysis	Economic outcome
		Variable cost	Fixed cost			
Islam et al. (2012)	Dinajpur, Bangladesh	Human labour, seed, fertilizers (urea, TSP, MOP, power tiller, irrigation, miscellaneous, IOC	Land rent	Primary data: Field survey	i. Gross return ii. Gross cost iii. Gross margin iv. Net return vi. BCR (Undiscounted)	Positive
Kamruzz-aman et al. (2006)	Khulna, Bangladesh	Human labour, land mortgage/rented, hired bullock labour, tractor/power tiller, seed purchased, fertilizers (urea, TSP, MOP, others), irrigation, fuel, machine charge, pesticides, working capital, IOC, miscellaneous	Land tax, family human labour, family bullock labour, seed (family supplied), farm manure (family supplied), depreciation and repairing of machinery and buildings, interest on land improvement, interest on fixed capital, miscellaneous	Primary data: Field survey Secondary data: BBS, journals, reports, official records, and documents of the fourth and the fifth five-year plan, and ministry of planning of Bangladesh	i. Gross return ii. Gross margin iii. Profit iv. BCR over variable cost v. BCR over fixed cost vi. BCR over total cost	Positive
Rahman and Hasan (2011)	Dinajpur, Rajshahi and Jamalpur, Bangladesh	Human labour, animal power, mechanical power, seed, fertilizers, manures, irrigation	IOC, land rent	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR	Positive
Sarkar (2012)	Dinajpur, Bangladesh	Human labour (Family labour and hired labour), animal power cost, mechanical power cost, seeds, organic fertilizers, inorganic	Depreciation of farm implements, Land rental value, IOC	Primary data: Field survey Secondary data: Handouts, reports, published and unpublished	i. Gross return ii. Gross margin iii. Net return v. Gross margin per ton vi. Net return per ton	Positive

		fertilizers, pesticides, vitamin, irrigation charges		documents of the Government of Bangladesh (GOB), different government organizations and agencies such as Statistical Yearbook of Bangladesh, Bangladesh Economic Review, various journals, newspaper, notifications, etc.	vii. Net return over total cost viii. BCR (Undiscounted)	
Morris et al. (1996)	Five wheat production zones (Northwest, North Central, South Central, Southwest, Northeast) of Bangladesh	Seed, fertilizers (urea, TSP, MOP), manure, pesticides, irrigation (repair and maintenance, and fuel), labour (family labour, attached farm labour, casual labour), working capital	Irrigation, animal traction	Primary data: Field survey	i. Gross return ii. Net return	Positive
Ali (2002)	USA	Seed, fertilizers, chemicals, custom operations, fuel, lube, and electricity, repairs, purchased irrigation water and baling, interest on operating capital, hired labour	Capital recovery (machinery and equipment), taxes and insurance	Secondary data: 1998 USDA Agricultural Resource Management Study	i. Returns above: a) Operating costs b) Operating and ownership costs C) Total costs	Positive for return above operating costs and operating-plus-ownership costs, but negative for return

						above total costs.
Dawadi et al. (2023)	Nepal	Seed, land preparation, marketing and storage, labour, FYM/organic manure, chemical, fertilizers (Urea, MOP, and Diammonium Phosphate (DAP)), micronutrient, plant protection measure, irrigation, harvesting and threshing, other variable cost		Primary data: Household surveys, focus group discussions (FGD), and Key Informant Interviews (KII). Secondary data: Agricultural Knowledge Center (AKC), Prime Minister Agriculture Modernization Project (PMAMP) reports, newsletters, relevant articles, and the websites of respected national and international organizations.	i. Total return ii. Gross margin iii. BCR	Positive
Gul et al. (2019)	Pakistan	Land Preparation (Tractor, labour in land preparation), seed, fertilizers (urea, DAP), FYM, transportation, labour, irrigation, harvesting, threshing marketing	Land rent	Primary data: Field survey	i. Gross return ii. Net return	Positive
Iqbal et al. (2014)	Pakistan	Land preparation, seed, labour, fertilizers (urea, DAP, nitrophos), FYM,	Land rent	Primary data: Field survey	i. Total revenue ii. Net Revenue	Positive

		irrigation, pesticides and weeding				
Wahidi et al. (2025)	Afghanistan	Tractor operation, seed, fertilizers (urea, DAP), FYM, labour, irrigation, weedicides, threshing	Land rent	Primary data: Field survey	i. Total revenue ii. Total cost iii. Net revenue	Positive
Kumar et al. (2016)	India	Seed, manures and fertilizers, hired labour, bullock labour, tractor power, irrigation, plant protection chemicals, miscellaneous expenditure, interest on working capital, rent paid for leased – in land	Interest on fixed capital, rental value of owned land	Primary data: Field survey	i. Gross return ii. Net return iii. Cost benefit ratio (CBR)	Positive
Hiary (2014)	Jordan	Mechanical ploughing, weeding, herbicides, pesticides, spraying Machine, fertilizer (urea), spreading, harvesting (by combine), bags, transportation, labour, IOC	Seeds, depreciation, land rent, interest on capital cost	Primary data: Field survey	i. Total return ii. Net return	Positive
Alberta (2025)	Canada	Seed, cleaning and treatment, fertilizers (NPKS blend), chemical, hail/crop insurance, trucking and marketing, fuel, oil and lube, machinery repairs, building repairs, custom	Crop share/cash rent, licenses and insurance, depreciation, paid capital interest	Primary data: Crop specialists' recommendations, irrigation specialists' recommendations, seed suppliers. Secondary data: Forecasts for the 2022	i. Contribution margin ii. Break-even yield	Positive

		work, labour (paid and unpaid), utilities and miscellaneous, operating interest		crop year, price outlook sources, Agriculture Financial Services Corporation (AFSC), the Alberta Farm Input Prices Survey (AIMS), the Alberta Farm Fertilizer Information and Recommendation Manager (AFFIRM), the AgriProfit$ program, and last year's estimates indexed for the 2022 crop year.		
Manitoba (2026)	Canada	Seed and treatment, fertilizers, crop protection, fuel, machinery operating and lease, hired labour, crop insurance, hail insurance, drying and other costs, land taxes, storage cost, interest on operating	Land costs, machinery costs		i. Gross revenue ii. Operating expense ratio iii. Marginal returns over operating costs iv. Marginal returns over total costs (Net profit) v. Return on operating (ROO) vi. Return on asset (ROA)	Positive
Ontario (2025)	Canada	Seed, fertilizers, herbicides, fungicides, plant growth regulator, tractor and machine	Machinery, land, other costs	Primary data: Field survey	i. Total operating expenses ii. Overhead expenses	

		expenses, production insurance, risk management program, marketing board and grain financial protection fees, custom work, trucking, land rent, operator labour (self or hired), interest on operating				
Saskatch-ewan (2025)	Canada	Seed, fertilizers (nitrogen, phosphorus, sulphur and other), plant protection (herbicides, insecticides, fungicides), machinery operating (fuel and repair), custom work and hired labour, crop insurance premium, hail insurance premium, utilities and miscellaneous, interest on variable expenses	Building repair, property taxes, business overhead, machinery depreciation, building depreciation, machinery investment, building investment, land investment	Primary data: Regional crop specialists' recommendations, producer-reported farm practices, local grain buyers, agro-input dealers, machinery and irrigation specialists. Secondary data: Agriculture and agri-Food Canada, Saskatchewan crop insurance corporation (SCIC), MoA, Custom rate and rental guide (2024–25), Statistics Canada census of agriculture and farm input price indices, provincial utility providers, and historical insurance	i. Gross revenue ii. Return over variable expenses iii. Return over total expenses	Return over variable expenses is positive while return over total expenses is negative.

				and market data indexed to the current crop year.		
[NDSU (2025)]()	USA	Seed, herbicides, fungicides, insecticides, fertilizers, crop insurance, fuel and lubrication, repairs, drying, miscellaneous, operating interest	Machinery depreciation, machinery investment, land charge, miscellaneous overhead cost	Secondary data: North Dakota State University (NDSU) extension economists' price estimates, NDSU Extension agronomists' yield recommendations, farm management specialists' cost assumptions, regional crop specialists' input use recommendations, and industry sources for specialty crops.	i. Market income ii. Return to labour and management	Negative
[Langemeier (2025)]()	USA	Fertilizers, seed, pesticides, dryer fuel, machinery fuel, machinery repairs, hauling, interest, insurance/miscellaneous	Machinery ownership, family and hired labour, land	Secondary data: Purdue University Extension, Purdue University Department of Agronomy, Tri-state fertilizer recommendations (Purdue Extension Bulletin AY-9-32), Indiana office of the national agricultural statistics Service (NASS), CME group futures market, Purdue	i. Market revenue ii. Crop contribution margin iii. Total contribution margin iv. Earnings or (losses)	Negative

				extension crop budgets, Revenue Protection (RP) crop insurance program, and U.S. farm input price estimates.		

Table A3. Review of literature on maize.

Author and year	Region	Data category		Data source	Economic analysis	Economic outcome
		Variable cost	Fixed cost			
Adnan et al. (2021)	Manikgonj, Dinajpur, Bogura and Cumilla districts of Bangladesh	Labour, land preparation, seed, fertilizers, manure/cow dung, irrigation, insecticides, shelling		Primary data: Field survey	i. Total return ii. Net return iii. BCR	Positive
Alam et al. (2016)	Lalmonirhat, Bangladesh	Labour, power tiller, seed, fertilizers, cow dung, pesticides, irrigation	IOC, land use cost	Primary data: Field survey	i. Total return ii. Net return iii. BCR (Undiscounted)	Positive
Biswas et al. (2022)	Chuadanga, Bangladesh	Hired labour, land preparation, seed, fertilizers (urea, TSP, MOP, zinc sulphate, gypsum), manure, irrigation, pesticides	Lease value, family labour, IOC	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR (Total cost basis) v. BCR (Variable cost basis)	Positive
Ferdausi et al. (2014)	Bogura, Bangladesh	Labour, power tiller, manure, fertilizers, insecticides, irrigation	IOC, land use cost	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return	Positive

					iii. BCR (Undiscounted)	
Hajong et al. (2023)	Meherpur, Kushtia, Chuadanga, and Jhenaidah districts of Bangladesh	Land preparation cost, seed, hired labour, shelling cost, fertilizers, manure, pesticides, irrigation, IOC	Family labour, land use cost	Primary data: Field survey	i. Gross margin ii. Net margin iii. BCR (Cash cost basis) iv. BCR (Total cost basis)	Positive
Hasan (2008)	Dinajpur and Panchagarh districts of Bangladesh	Seed, manure, fertilizers (urea, TSP, MOP, gypsum), irrigation, human labour, animal power cost, power tiller cost	IOC, land use cost	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR (Considering variable cost) v. BCR (Considering total cost)	Positive
Karim et al. (2010)	Rangpur, Dinajpur, Bogura, and Kushtia districts of Bangladesh	Human labour (family and hired labour), land preparation cost, seed cost, fertilizers (urea, TSP, MOP, zinc, borax, gypsum), manure (owned and purchased), irrigation cost, insecticides, shelling cost		Primary data: Field survey	i. Gross return ii. Gross margin iii. BCR	Positive
Khandok-er et al. (2018)	Rajshahi, Chuadanga, Cumilla and Rangpur districts of Bangladesh	Land preparation, hired labour, seed, manures, chemical fertilizers (Urea, TSP, MOP, zinc, gypsum, DAP, boron), irrigation, insecticides, IOC	Family labour, land use cost	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net Return iv. BCR on full cost basis v. BCR on cash cost basis	Positive

					vi. Production cost	
Mohiudd-in et al. (2007)	Kishoreganj, Bangladesh	Human labour (family labour and hired labour), power tiller, seeds, manures (cow dung (own and purchase), ash (own and purchase)), fertilizers (urea, TSP, MOP), irrigation, IOC, land use cost		Primary data: Field survey Secondary data	i. Total return ii. Gross margin (Full cost basis) iii. Gross margin (Cash cost basis) iv. Net return (Full cost basis) v. Net return (Cash cost basis) vi. Net return (Variable cost basis) vii. Returns to labour (Full cost basis) viii. Returns to labour (Cash cost basis) ix. Returns to labour (Variable cost basis) x. BCR (Full cost basis) xi. BCR (Cash cost basis) xii. BCR (Variable cost basis)	Positive
Moniru-zzaman et al. (2009)	Chuadanga, Dinajpur, Bogura and Lalmonirhat districts of Bangladesh	Human labour (own and hired), mechanical cost (own and hired), seed (purchased), cow dung (own), fertilizers (urea, TSP, MOP, mixed, gypsum, zinc, borax, lime),	IOC, land use cost	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR (Total cost basis) v. BCR (Variable cost basis)	Positive

		insecticides, irrigation (own and hired), machine cost			vi. BCR (Cash cost basis) vii. Returns to labour (Total cost basis)	
Rahman and Rahman (2014)	Kushtia, Bogura and Dinajpur districts of Bangladesh	Human labour, mechanical power, seed, manure, chemical fertilizers (MOP, urea, zinc sulphate, gypsum, borax, TSP, mixed), pesticides	IOC, land rent	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR	Positive
Rahman et al. (2013)	Natore, Bangladesh	Power tiller, labour, seed, fertilizers (urea, tsp, mop, gypsum), weeding, cow dung, insecticides, irrigation charge	IOC, land use cost	Primary data: Field survey	i. Total return ii. Net return iii. BCR (Undiscounted)	Positive
Sampa et al. (2022)	Manikganj and Rajshahi districts of Bangladesh	Land preparation, human labour, seed, fertilizers (urea, TSP, MOP), insecticides, irrigation, IOC	Land rent	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR (Undiscounted)	Positive
Babura-ja and Pichaipi-llai (2025)	India	Seed, land preparation, farm yard manure, neem cake, fertilizers (urea, potassium, phosphorous, complex, DAP), pesticides, weedicide, diesel, weeding, human labour		Primary data: Field survey	i. Total yield return ii. Net return iii. CBR	Positive
Girei et al. (2018)	Nigeria	Seed, labour, transportation,	Land rent, interest on loans, farm tools	Primary data: Field survey	i. Revenue ii. Gross income	Positive

		herbicides, insecticides, fertilizers			iii. Gross margin iv. Net farm income	
Jamakh-andi et al. (2020)	India	Seed, farm yard manure, fertilizer, plant protection chemicals, human labour, bullock labour, machine labour, interest on working capital	Land revenue, depreciation, rental value on land, interest on fixed capital	Primary data: Field survey	i. Gross return ii. Net return iii. BCR	Positive
Khan et al. (2023)	Pakistan	Preparation of land (fertilizer, tractor plough and levelling), tilling (seed and manual sowing), irrigation (labour cost and water charges), plough (manual plough and plough with bullock), fertilizers (*sona* urea, DAP, super nitrate), harvesting (cutting of maize, collection, separation), threshing, transport, miscellaneous	Land rent	Primary data: Field survey	i. Total revenue ii. Net revenue	Positive
Kibirige (2014)	South Africa	Seeds (modified and recycled/local), fertilizer, herbicides, pesticides, irrigation pump, labour, transport, marketing		Primary data: Field survey Secondary data: Eastern Cape Department of Agriculture	i. Gross margin	Positive

Siagian et al. (2021)	Indonesia	Seed, fertilizers (urea, SP-36, KCL, NPK ponska, manure, others fluid fertilizer, fluid leaf fertilizer), pesticides (solid and fluid), herbicides (fluid), others (tax of building and land (PBB) and land rent), cost of labour rent (rent labour and family labour, wage of tractor service)		Primary data: Field survey	i. Return ii. Income iii. Revenue cost ratio (R/C) iv. BCR	Positive
Tanin and Engind-eniz (2024)	Turkey	Material costs (seed, fertilizer (N, P_2O_5, K_2O), pesticides (herbicides, insecticides), electric diesel and others), labour and machine costs (soil preparation, planting, fertilization, hoeing, irrigation, pesticides application, harvest and transportation), interest on variable costs		Primary data: Field survey	i. Gross return ii. Net return	Positive

Table A4. Review of literature on lentil.

Author and year	Region	Data category		Data source	Economic analysis	Economic outcome
		Variable cost	Fixed cost			
Hajong et al. (2020)	Jashore, Jhenaidah and Kushtia districts of Bangladesh	Land preparation, seed, hired labour, fertilizer, manure, pesticides, IOC	Land use cost, family labour	Primary data: Field survey	i. Gross return ii. Net return iii. BCR	Positive
Islam et al. (2020)	Magura, Pabna, Jashore, Kushtia and Faridpur districts of Bangladesh	Labour (family and hired), power tiller (owned and hired), seed (owned and purchased), fertilizer, organic manure, pesticides, insecticides, irrigation (owned and hired), IOC		Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR on full cost basis v. BCR on cash cost basis	Positive
Miah et al. (2021)	Faridpur, Magura, Kushtia, Jhenaidah, Manikganj, and Sirajganj districts of Bangladesh	Land preparation, hired labour, seed, manure (cow dung), fertilizer (urea, TSP, MOP, boron, $ZNSO_4$, DAP), irrigation, pesticides, IOC	Land use cost, family labour	Primary data: Field survey	i. Total return ii. Gross margin iii. Net return iv. BCR on VC v. BCR on TC	Positive
Rahman et al. (2013)	Jhenaidah and Jashore districts of Bangladesh	Labour, mechanical power cost, seed, fertilizers (urea, TSP, MOP, gypsum), insecticides	Land use cost, IOC	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR (undiscounted)	Positive
Sultana et al. (2024)	Madaripur, Faridpur, and	Land preparation, human labour,	Land use cost, IOC	Primary data: Field survey	i. Gross return ii. Gross margin	Positive

	Magura districts of Bangladesh	machinery inputs, seed, fertilizers (urea, TSP, MOP, others), insecticides and pesticides		Secondary data: FAOSTAT, Bangladesh Bank, several literatures	iii. Net return iv. BCR	
Poudel et al. (2022)	Nepal	Seed cost, land preparation, seed sowing cost, fertilizers (urea, DAP, potash), irrigation, weeding, harvesting, threshing		Primary data: Field survey	i. Total revenue ii. BCR	Positive
Habib and Rizwan (2019)	Pakistan	Cost of ploughing and sowing, seed, fertilizer, weeding cost, harvesting, threshing		Primary data: Field survey	i. Gross benefit ii. Net benefit iii. CBR	Positive
Zeb et al. (2022)	India	Hired labour, preparatory tillage, seed, sowing, FYM, fertilizer nutrients (nitrogenous, phosphatic, potassic, zinc sulphate), irrigation, hoeing/weeding, plant protection, harvesting, threshing/winnowing, miscellaneous, interest on working capital	Depreciation on fixed capital, land revenue paid to government, rental value of owned land, interest on fixed capital, imputed value of family labour	Primary data: Field survey	i. Gross return ii. Net return iii. BCR	Positive

Table A5. Review of literature on mustard.

Author and year	Region	Data category		Data source	Economic analysis	Economic outcome
		Variable cost	Fixed cost			
Chaity (2021)	Pabna, Bangladesh	Seed, fertilizers (urea, TSP, MOP), insecticides, irrigation, machinery inputs (land preparation), human labour, IOC	Land use cost	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR	Positive
Huq et al. (2007)	Jamalpur, Bangladesh	Power tiller, human labour, seed, fertilizers (urea, TSP, MOP, gypsum, DAP), IOC	Rental value of land	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR on full cost basis v. BCR on variable cost basis	Positive
Rayhan et al. (2013)	Sirajganj, Bangladesh	Human labour, power tiller, seed, manure, urea, TSP, MOP, insecticides, IOC	Land use cost	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR (undiscounted)	Positive
Sampa et al. (2021)	Manikganj, Bangladesh	Land preparation, human labour, seed, fertilizers (urea, TSP, MOP), insecticides, irrigation, IOC	Rental value of land	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR (undiscounted)	Positive
Sarkar et al. (2020)	Jashore, Kushtia, Magura and Faridpur	Hired labour, power tiller, seed, fertilizers (urea, TSP, MOP, gypsum, zinc oxide, boric acid), cow dung,	Family labour, land use cost	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. BCR on full cost	Positive

	districts of Bangladesh	pesticides, irrigation, IOC			v. BCR on variable cost	
Tithi and Barmon (2018)	Meherpur, Bangladesh	Seed, irrigation, fertilizers, manure, pesticides, land preparation, hired labour, IOC	Family labour, land use cost	Primary data: Field survey	i. Gross return ii. Gross margin iii. Net return iv. Rate of return (RoR) on variable cost v. RoR on total cost	Positive
Verma et al. (2023)	Uttar Pradesh, India	Hired labour, machinery charges, seed, manure and fertilizer, irrigation, plant protection, total working capital, interest on working capital	Family labour, rental value of land, interest on fixed capital	Primary data: Field survey	i. Gross income ii. Net return iii. Family income iv. Farm business income v. Farm investment income vi. Cost of production vii. Input- output ratio	Positive
Nondani et al. (2025)	Mirpurkhas, Sindh province, Pakistan	Tractor plough, seed, fertilizers (urea, DAP), labour, transportation, loading/unloading, commission	Land tax, rent of land	Primary data: Field survey	i. Total revenue ii. Net profit iii. Input-output ratio iv. Cost-benefit ratio	Positive

Appendix B

Appendix B: Conceptual classification of emerging hotspots and time-series analysis of crop production and area

This appendix presents the classification of emerging hotspot categories (Table B1) and the production and area of production trendline of major (*Aman* rice, *Boro* rice, wheat) and rotational crops (maize, lentil, mustard) (Figure B1 to Figure B6).

Table B1. Emerging hotspot categories and their definitions (Harris et al., 2017).

Categories	Definition
New	The location or spatial unit is statistically significant hotspot only in the final time step before the final time step is has never been a hotspot.
Consecutive	The location or spatial unit has never a statistically significant hotspot except the uninterrupted run of hotspots in the final time steps and less than 90% of the bins were statistically significant hotspots.
Intensifying	The location or spatial unit has been statistically significant hotspot for 90%-time steps including the final step and the intensity of the attribute value of each bin for the location is increasing overall which is also statistically significant.
Persistent	The location or spatial unit has been statistically significant hotspot for 90%-time steps but with no detectable trend of increasing or decreasing of the value of the bin attributes.
Diminishing	The location or spatial unit has been statistically significant hotspot for 90%-time steps including the final step and the intensity of the attribute value of each bin for the location is decreasing overall which is also statistically significant.
Sporadic	The location or spatial unit has been on again and off again statistically significant hotspot but for less than 90% of the time steps and has never been statistically significant cold spot.
Oscillating	The location or spatial unit was a statistically significant hotspot for less than 90% of the time steps including the final time step with a history of also being a statistically significant cold spot in the prior time steps.
Historical	The location or spatial unit is not a hotspot in the recent time steps but it has a history of being a hotspot for at least 90% of the prior time steps.

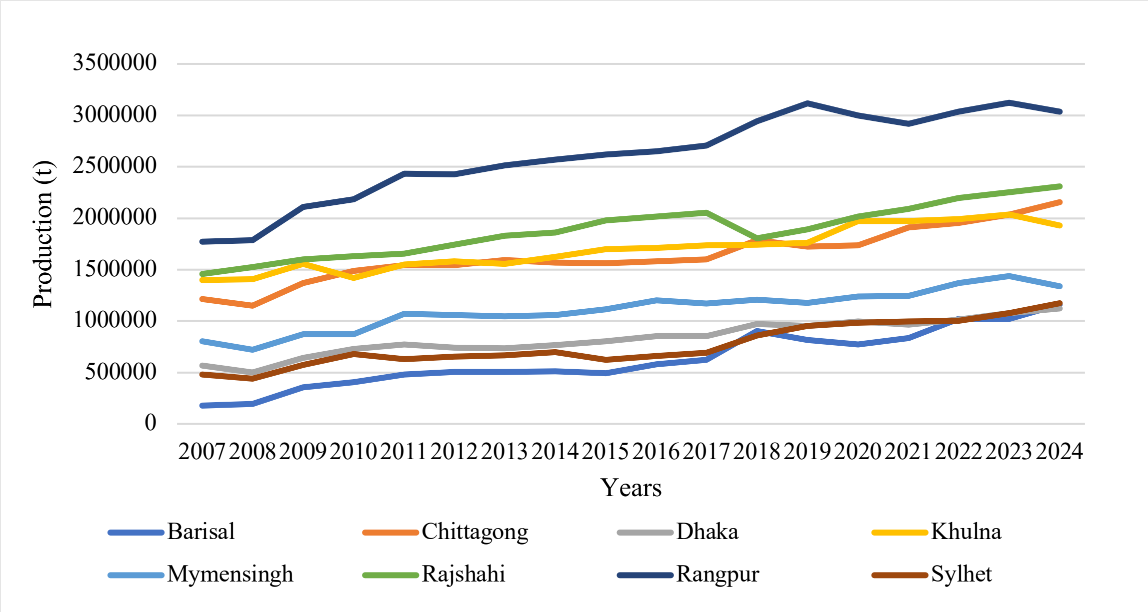

Figure B1(a). *Aman* rice divisional trendline subject to production.

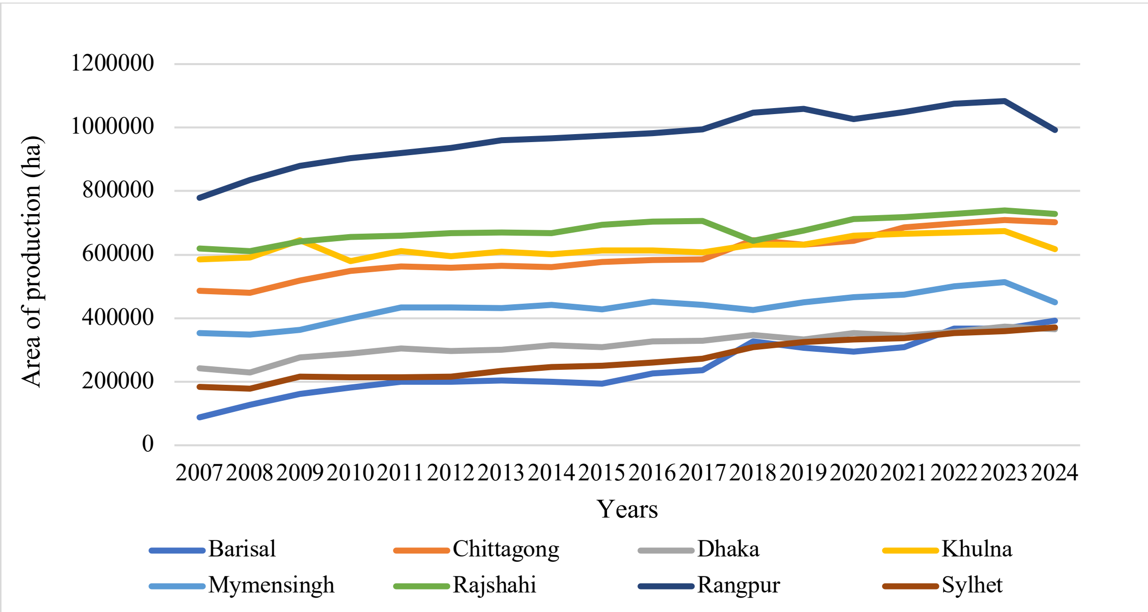

Figure B1(b). *Aman* rice divisional trendline subject to area.

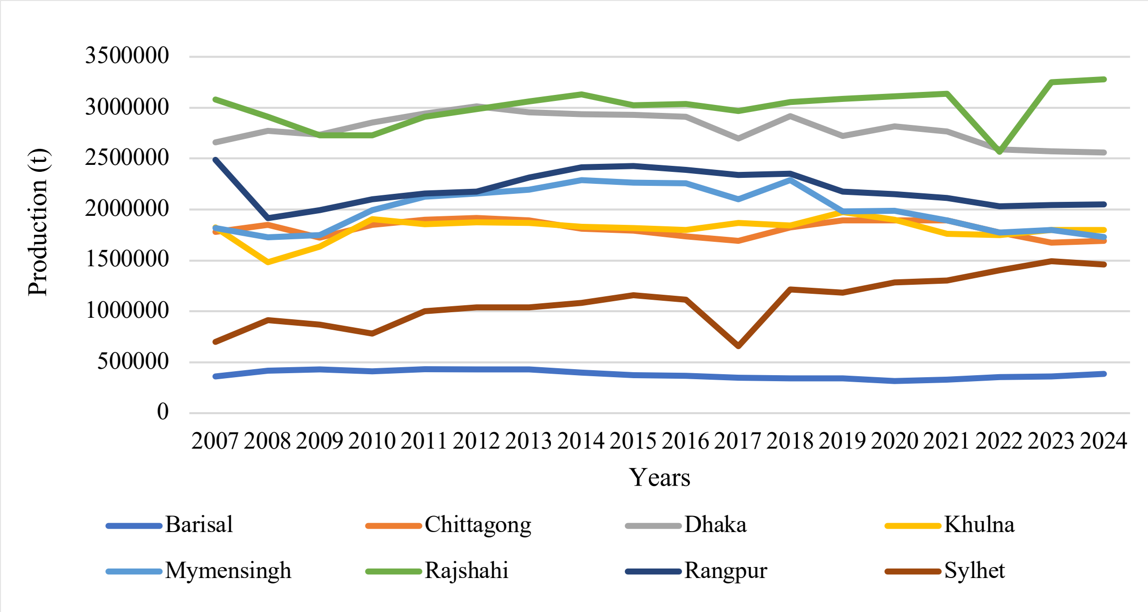

Figure B2 (a). *Boro* rice divisional trendline subject to production.

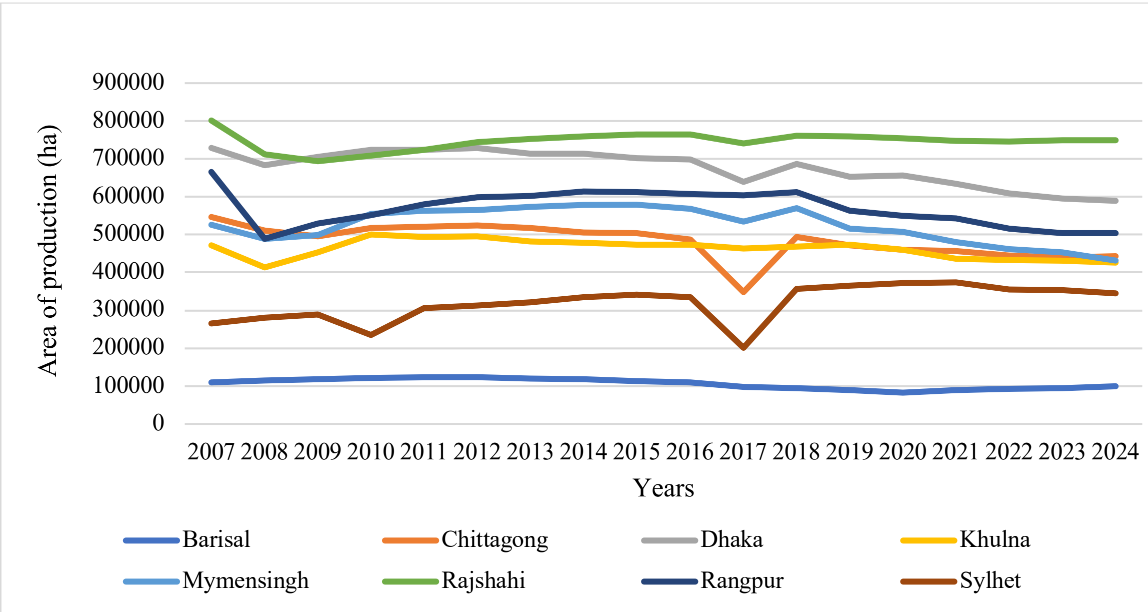

Figure B2 (b). *Boro* rice divisional trendline subject to area.

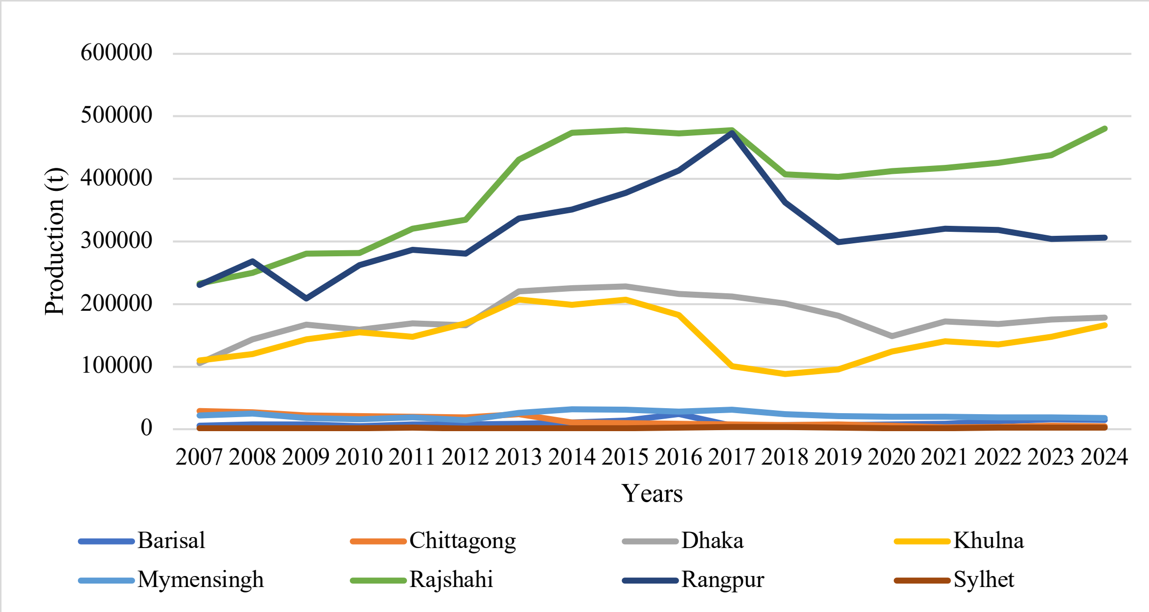

Figure B3 (a). Wheat divisional trendline subject to production.

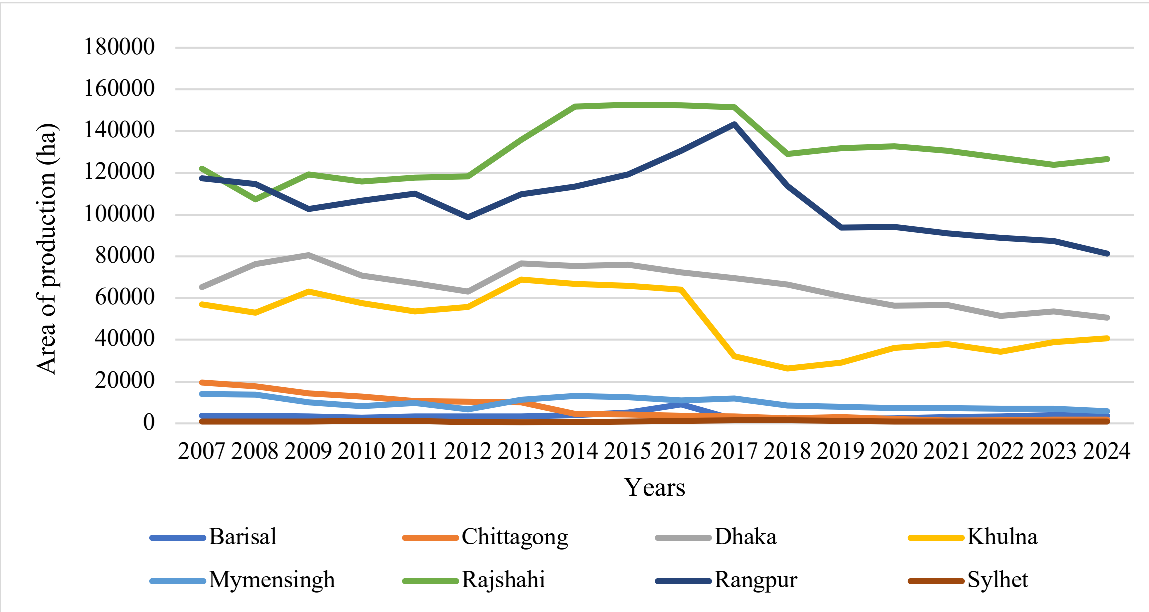

Figure B3 (b). Wheat divisional trendline subject to area.

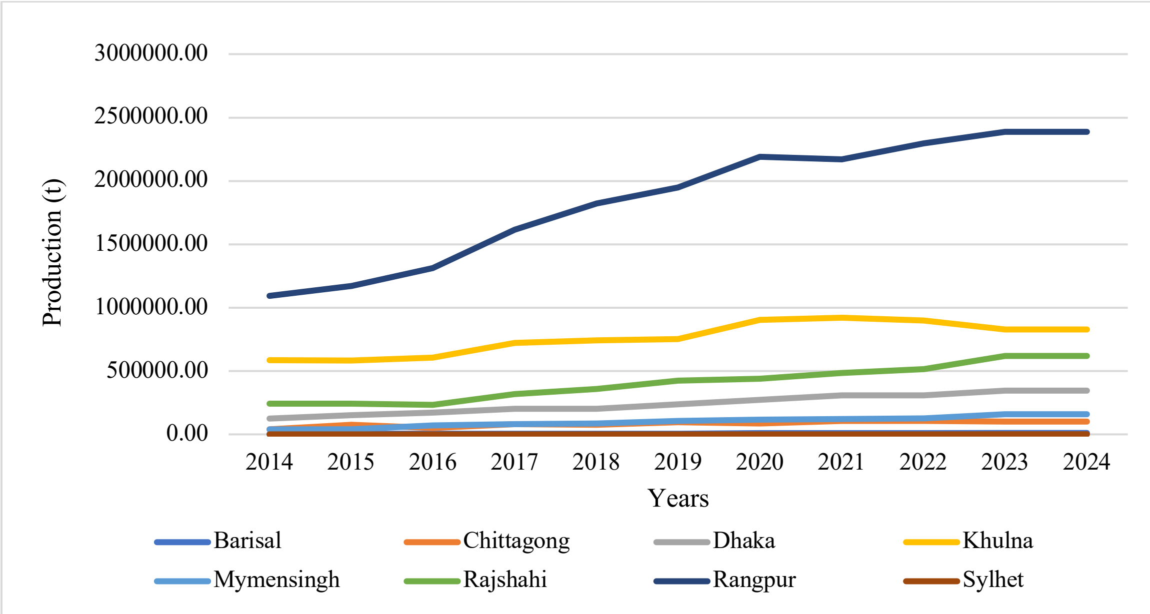

Figure B4(a). Maize divisional trendline subject to production.

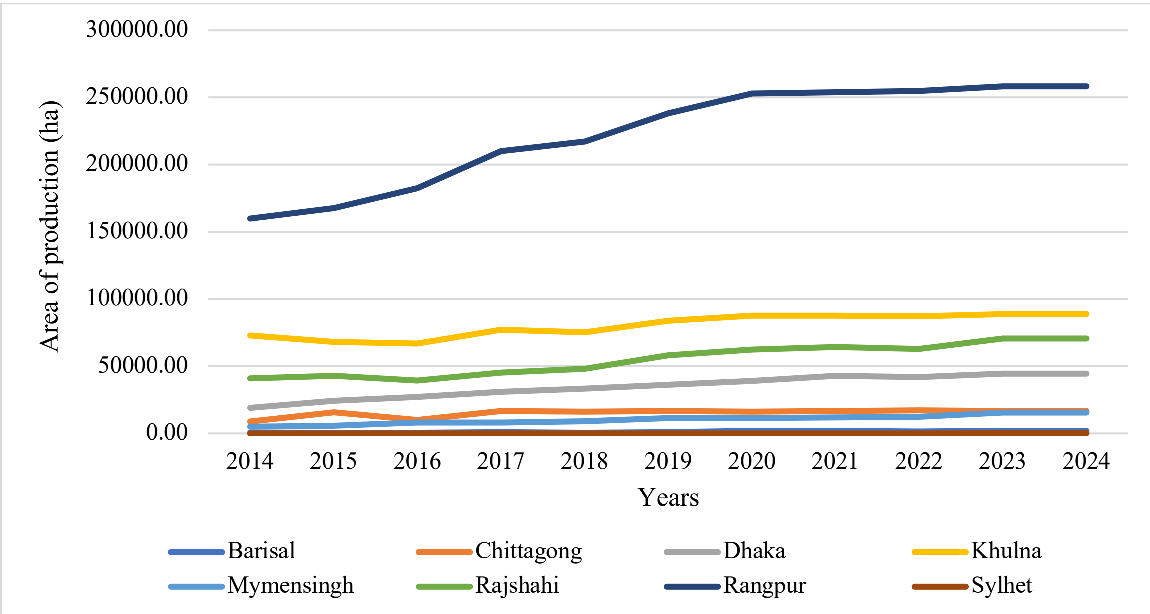

Figure B4 (b). Maize divisional trendline subject to area.

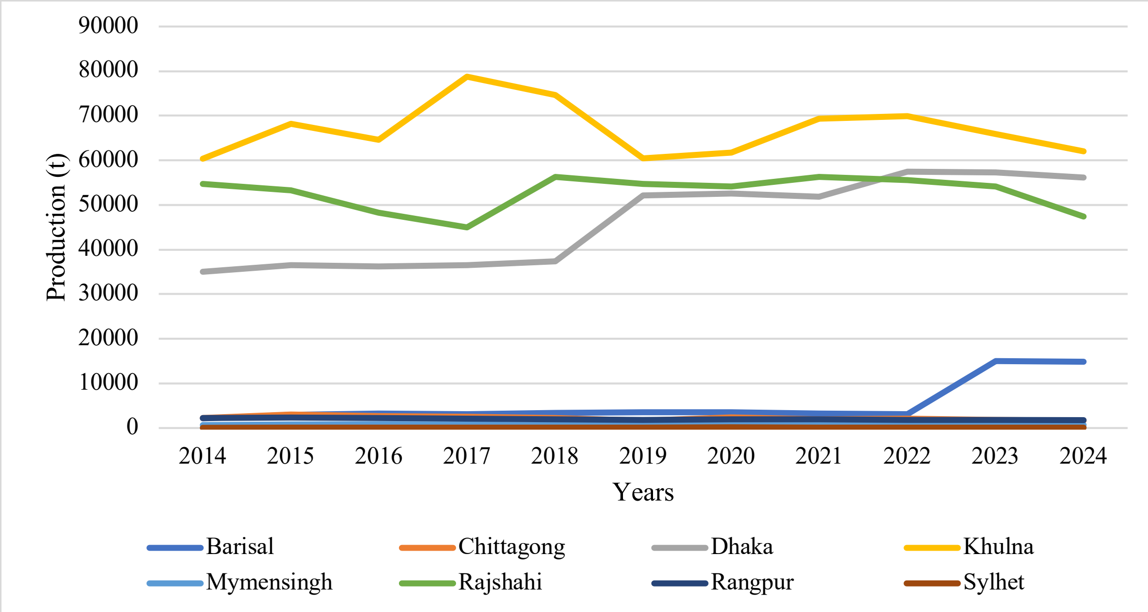

Figure B5(a). Lentil divisional trendline subject to production.

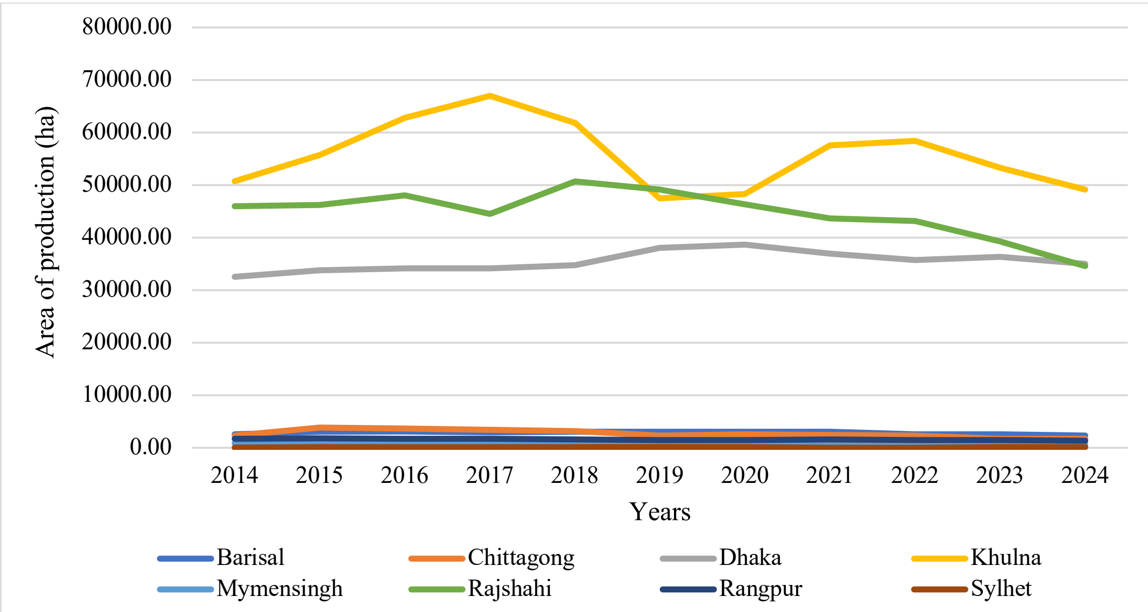

Figure B5(b). Lentil divisional trendline subject to area.

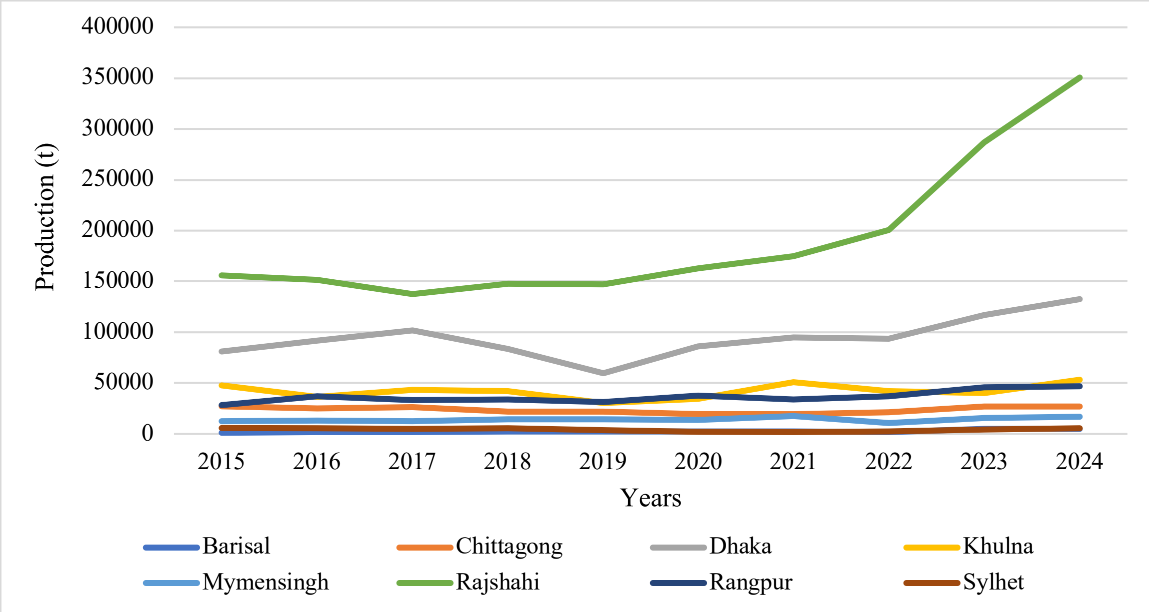

Figure B6(a). Mustard divisional trendline subject to production.

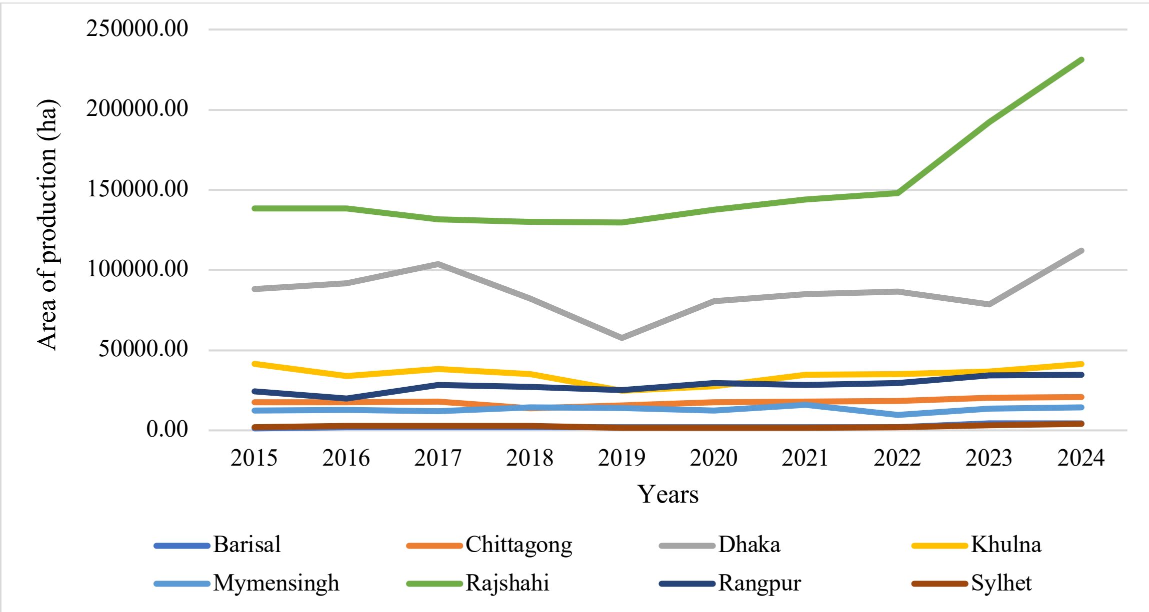

Figure B6(b). Mustard divisional trendline subject to area.

Appendix C

Appendix C: Assumptions underpinning crop cost and return calculations

Appendix C presents the detailed assumptions used to estimate costs, returns, and profitability for major cereals (*Aman* rice, *Boro* rice, wheat) and rotational crops (maize, lentil, mustard) under different mechanized farm management alternatives for both farmer owned and custom hired machinery markets. These assumptions ensure a consistent and standardized approach across all crop budgeting analyses.

Assumptions underlying crop cost and return calculations:

1. **Seed and treatment:**

Seeding rates were assumed to be 21 kg/ha for high-yielding variety (HYV) *Aman* rice, 23.47 kg/ha for HYV *Boro* rice, 86.45 kg/ha for wheat, 19.76 kg/ha for maize, 30.88 kg/ha for lentil, and 8.65 kg/ha for mustard, following estimates from the Yearbook of Agricultural Statistics published by the Bangladesh Bureau of Statistics (BBS, 2024). Seed price assumptions were derived from average values reported by the Bangladesh Agricultural Development Corporation (BADC). Based on Key Informant Interviews (KIIs), an additional cost was incurred in rice to account for logistical expenses related to seed preparation and natural germination before sowing in the seedbed for manual planting, while costs associated with mechanized nursery preparation were incorporated for mechanized transplanting. Seed rates may vary depending on soil conditions and input price variations.

Manual planting:

Seed cost = (Seed rate * Seed price) + Logistical expenses

Mechanized planting:

Seed and treatment cost = Seed cost + Seed treatment cost

2. **Fertilizers:**

Fertilizers included urea, TSP, MOP, and gypsum. Recommended application rates were based on the Fertilizer Recommendation Guide 2024 (FRG, 2024). Price data for urea and gypsum were obtained from the Department of Agricultural Marketing (DAM) (DAM, 2026). Due to the unavailability of local price data for TSP and MOP from DAM, their prices were sourced from the Bangladesh Agricultural Development Corporation (BADC) (BADC, 2026). Fertilizer doses may vary depending on soil type and product pricing.

Table C1. Recommended fertilizer doses (kg/ha) with price estimates (BDT/kg).

Crops	Urea		TSP		MOP		Gypsum	
	Doses	Price	Doses	Price	Doses	Price	Doses	Price
Aman rice	195.46	25.82	39.95	27.00	91.39	20.00	39.72	9.45
Boro rice	330.22	24.96	64.10	27.00	131.82	20.00	69.58	9.45
Wheat	260.44	24.96	145.45	27.00	131.01	20.00	78.94	9.45
Maize	520.92	25.82	240.00	27.00	210.03	20.00	201.55	9.45
Lentil	45.47	25.00	75.12	27.00	36.08	20.00	61.59	9.45
Mustard	195.46	24.96	116.45	27.00	89.00	20.00	87.97	9.45

Fertilizer cost = Cost of urea + Cost of TSP + Cost of MOP + Cost of gypsum

Urea = Doses * Price
TSP = Doses * Price
MOP = Doses * Price
Gypsum = Doses * Price

3. **Pesticides costs:**

Pesticides included herbicides, insecticides, and fungicides. The doses of pesticides were determined based on the List of Registered Agricultural Pesticides, Bio-Pesticides, and Public Health Pesticides in Bangladesh provided by the Department of Agricultural Extension (DAE) (DAE, 2024). Cost estimates were derived from KIIs, using average market prices reported by various agrochemical companies in Bangladesh. Pesticide costs may vary considerably depending on the type of chemicals used, application rates, and prevailing market prices.

Pesticides Costs = Herbicide costs + Insecticide costs + Fungicide costs

4. **Labour:**

Labour requirements (person-days/ha) included hired labour, family labour, and machine operator labour. These estimates were derived from key informant interviews (KIIs) which are consistent with the findings of Al-Amin et al. (2024). The wage rate (BDT/person-day) was sourced from the Yearbook of Agricultural Statistics published by the Bangladesh Bureau of Statistics (BBS, 2024). Labour costs may vary across regions due to differences in local wage rates and labour availability.

Labour cost = Labour requirements * Wage rate

5. **Machinery operating expenses:**

Machinery operating expenses include fuel, lubrication, and repair.

Fuel:

Fuel consumption rates (L/h) were obtained from agri-tech companies in Bangladesh, while work rates (h/ha) were sourced from Al-Amin et al. (2024). Given the volatility of diesel prices, a rate of BDT 100 per litre was assumed based on Key Informant Interviews (KIIs), which is consistent with data reported by the Bangladesh Petroleum Corporation (BPC, 2026).

Fuel cost = Fuel consumption rate * Fuel price

Lubricant:

Lubricant cost was estimated at 15% of fuel cost, following the findings of North Dakota State University (NDSU, 2025).

Lubrication cost = Fuel cost * 15%

Repair:

Repair cost was estimated based on the assumption from John Nix Pocketbook 2024 (Redman, 2024), where repair costs are expressed as a percentage (%) of the initial investment cost.

Repair cost = Initial investment * Repair rate

Repair rates were assumed as a percentage of machinery investment, varying by machine type: power tiller at 4.5%; rice transplanter, fertilizer spreader, knapsack sprayer, boom sprayer, mechanical weeder, and sickle at 3.0%; seed drill at 2.0%; and reaper at 1.5%.

Machinery operating costs varied across different farm management alternatives and may also differ depending on the type (e. g., smaller or larger) and combination of machinery used.

6. **Machinery service charge:**

Machinery service charges were compiled from multiple sources: power tiller from Islam and Kabir (2017), reaper from Hasan et al. (2020), rice transplanter from Sarkar et al. (2020), knapsack sprayer from Ashik-E-Rabbani et al. (2020), and seed drill from Hoque et al. (2025). For machinery not yet widely adopted in Bangladesh, data were drawn from neighbouring countries. For example, the service charge for boom sprayers was obtained from a source in India named Truck1. The service charges for fertilizer spreaders and mechanical weeders were assumed using the boom sprayer rate as a proxy. Machinery service charge was only incurred for custom hired machinery market model.

Machinery service charge = ∑ Service charge of each machine used

7. **Stationary threshing and shelling costs:**

Stationary threshing cost (BDT/t) for rice, wheat, lentil and mustard, and shelling cost (BDT/t) of maize were based on the BARI handbook (Hossain et al., 2017), while the grain yield was adopted from the Yearbook of Agricultural Statistics published by the Bangladesh Bureau of Statistics (BBS, 2024). Threshing charges were estimated at BDT 300/t for rice, lentil, and mustard, and BDT 800/t for wheat, while shelling costs for maize were BDT 150/t using a large power sheller.
Threshing/shelling cost = Grain yield * Custom hire charge

8. Miscellaneous costs:

Miscellaneous variable and fixed costs are contingent upon farm-level management decisions and may differ across farms due to heterogeneity in management practices, input use structures, and spatial conditions.

9. Total operating costs:

Without interest on variable expenses:

Total operating costs = ∑ All variable costs

Interest on variable expenses:

Interest on variable expenses = Total operating costs without interest on variable expenses * Per month interest rate (%) * Months

The monthly interest rate varied by cultivation season. For example, interest rate was 0.60% during the monsoon (Kharif-II) season and 0.76% during the winter (Rabi) season, based on (Bangladesh Bank, (2026).

With Interest on variable expenses:

Total operating costs = Total operating costs without interest on variable expenses + Interest on variable expenses

10. Machinery cost:

Machinery costs for different farm management alternatives were obtained from various online machinery marketplaces and supplier websites, consistent with the findings of Al-Amin et al. (2024). These costs varied across management alternatives due to differences in the machinery sets used and may also vary with the scale of machinery employed (e.g., smaller or larger equipment). Machinery ownership cost was only incurred for farmer owed machinery market model.

Machinery cost = (Opportunity cost of capital + Depreciation) * Months/12

where,

Opportunity cost of capital (BDT) = Initial Investment (BDT) * Annual interest rate

Annual Depreciation (BDT) = Initial Investment without subsidy (BDT) / Useful Life

11. Total fixed costs:

Total fixed costs = ∑ All fixed cost

12. Total costs:

Total costs = Total operating costs without interest on variable expenses + Total fixed costs

13. Gross return:

Gross return comprised the value of both the main product (grain) and the by-product (straw), based on their respective yields and prices. Main product yields were obtained from the Yearbook of Agricultural Statistics published by the Bangladesh Bureau of Statistics (BBS, 2024). Wholesale price was based on annual prices reported in the Yearly Average Price List of the Department of Agricultural Marketing (DAM) DAM (2026). By-product (straw) yield and price were estimated based on Key Informant Interviews (KIIs), which are consistent with the findings of Al-Amin et al. (2024).

Gross return = Main product yield * Main product price + By-product yield * By-product price

14. Gross margin:

Gross margin = Gross Return - Total operating costs without interest on variable expenses

15. Net return:

Net return = Gross Return - Total cost

16. Benefit cost ratio (BCR):

BCR = Gross Return /Total cost

17. Break-even analysis:

Break-even analyses of main grain yield and price of grain were conducted across three cost categories: over total operating cost without interest on variable expenses, total fixed cost, and total cost.

Break-even price over:

Total operating cost without interest on variable expenses = Total operating cost without interest on variable expenses/Grain yield

Total fixed cost = Total fixed cost/Grain yield

Total cost = Total cost/Grain yield

Break-even yield:

Total operating cost without interest on variable expenses = Total operating cost without interest on variable expenses/Grain price

Total fixed cost = Total fixed cost/Grain price
Total cost = Total cost/Grain price

Appendix D

Appendix D: Checklist for Key Informant Interview (KII) of agri-tech companies in Bangladesh.

International Growth Centre

CHECKLIST FOR KEY INFORMANT INTERVIEW (KII)

STRICTLY PRIVATE & CONFIDENTIAL FOR ACADEMIC AND RESEARCH PURPOSES

Research Questionnaire:

"***From data to farm decisions: Developing grain-oilseed cost and return guide for Bangladesh***"

Project Code: BGD-25165

Study background

This research intends to develop comprehensive crop budgets, one of the most extensively used tools in farm economics, needed by farmers, agribusiness, academics and research, and policy makers to make data-driven decisions. In countries such as the United States, the United Kingdom, the European Union, and Canada, crop budgets are updated annually and made publicly available online/printed form to support decision-making. Unfortunately, over the last five decades, Bangladesh has not maintained systematically updated and publicly accessible crop budgets for farm enterprises. In response to the absence of crop budgets, this study seeks to develop costs and return guideline for grain-oilseed farms.

This research contributes to Bangladesh's growing economy and support the 'sustainable, safe and profitable' agriculture vision of the National Agriculture Policy (2018). This study maps the crop zones for major crops (*Aman* rice, *Boro* rice, and wheat) and key rotational crops (maize, lentil, and mustard) followed by development of crop budgets for grain-oilseed for that zone where particular crops are intensified. This research is designed as an extension of the IGC project (BGD-24192), addressing fundamental questions of farm productivity and economics in alignment with the IGC's firm, trade, and productivity theme.

The study is being conducted by the Hub for Smallholders Agri-Tech Economics (HSATE) under the *Department of Agricultural Economics, Faculty of Agricultural Economics and Rural Sociology, Bangladesh Agricultural University (BAU), Mymensingh-2202, Bangladesh*.

This study is funded by the *International Growth Centre (IGC),* which is directed by *The London School of Economics and Political Science (LSE)* and *University of Oxford*.

Who is eligible to take part?

This KII is conducted with the agri-tech importers and manufacturers of Bangladesh.

How long will the study last?

On average, the duration of this survey will be for 30 minutes.

Confidentiality:

Your responses will be kept strictly confidential and will only be used for academic and research purposes envisages in this study. Personal information will not be shared or disclosed to any third parties.

Ethical Approval:

This research and survey are ethically approved by the Bureau of Socioeconomic Research and Training (BSERT) subject to follow the BSERT code of ethics for research in the biological, economic, social and behavioural sciences involving human participants.

Consent:

By participating in this survey, you agree to share your responses for academic and research purposes. You have the right to withdraw from the survey at any time without any consequences. We will be happy to answer any questions you have about this study. For further queries or if you have any other research ideas related to this study, you may contact the Principal Investigator, Dr. A. K. M. Abdullah Al-Amin at Phone: +8801743120000 and/or Email: abdullah.alamin@bau.edu.bd.

Name of the Respondent	
Name of the Institution	
Do you agree to participate in this survey? (Yes=1, No=0)	
Signature	

Thank you in advance for your participation in this study

CHECKLIST FOR KEY INFORMANT INTERVIEW (KII)

Questions	Responses						
	Power tiller (16 hp)	Walking type rice transplanter (3.5 hp)	Reaper (6.5 hp)	Four-wheel tractor (60 hp)	Four-wheel tractor operated rotavator (60 hp)	Riding type rice transplanter (20 hp)	Combine harvester (70 hp)
1. Do you offer these machines for sale? Please tick (✓) the applicable machines.							
2. What is the fuel consumption rate (L/ha) of the respective machine?							
3. What is the working width (m) of the respective machine?							
4. What is the field speed (km/h) of the respective machine?							
5. What is the field efficiency (%) of the respective machine?							
6. What is the overlap percentage (%) of the							

respective machine?							
7. What is the lubricant requirement (L) for the respective machine?							
8. Could you please specify what is the estimated per annum cost (BDT/year) of repair and maintenance of the respective machine?							
9. Could you please explain the reasons for not sharing all these information on your website?							
10. Do you have plans to expand your business into the service market in addition to importing and manufacturing products? (Yes=1, No=2)							

11. If yes, would you be able to declare the custom hire rate for each type of machinery you offer?	
12. If no, why?	
13. Do you offer custom hire threshing services to farmers? (Yes=1, No=2)	
14. If yes, could you please specify the crop-wise (i. e., rice, wheat, maize, lentil, mustard) and location-specific (i. e., Rajshahi, Rangpur, Khulna divisions) threshing rates?	
15. Based on your sales experience , which machinery do farmers use most	

frequently ?	
16. From your experience , which option do you consider more effective for machinery sales to farmers: machinery purchase subsidies or machinery purchase loans?	
17. As we are planning to develop an online cost and return guide tool, how can we establish a direct link or data integration with your website?	
18. If the governme nt wants to link your data directly to their website, how would you handle, organize and	

simplify it?	
*Note: *Further details of the machinery specification are provided in Appendix A.*	

Appendix A

Table A1. Equipment specification from ACI Motors Ltd.

Power tiller (16 hp)					
Power (hp)	Power (kW)	Model	Country of Origin	Width of Rotary Tiller (mm)	Speed (km/h)
16	12	ACI Power Tiller Classic Special 16 HP (18 Blade)	China	600	Forward: 1.39, 2.47, 4.15, 5.14, 9.12, 15.30 Reverse: 1.10, 4.10
16	12	ACI Power Tiller Regular 16 Version 2.0	China	600	Forward: 1.39, 2.47, 4.15, 5.14, 9.12, 15.30 Reverse: 1.10, 4.10
16	12	ACI Power Tiller R24 16 HP	China	680	Forward: 3.03, 5.52, 7.05, 9.27, 12.53, 21.03 Reverse: 2.45, 5.5
16	12	ACI Power Tiller DF 16	China		
16	12	ACI Power Tiller DF 15L (Q690)	China		

Tractor (60 hp)				
Power (hp)	Power (kW)	Model	Speed (km/h)	Maintenance cost
60	44.13	Supreme DI 60 RX	3.15-33.75	1 acre = 5.5 L; 1 trip = 1.25 L

Riding type rice transplanter (20 hp)					
Power (hp)	Power (kW)	Model	Number of rows of planting	Planting row spacing (mm)	Width (m)
20.90	15.37	YANMAR (YR70D)	7	25	1.75

Combine harvester (70 hp)				
Power (hp)	Power (kW)	Model	Header cut width (m)	Speed (km/h)
70.00	51.50	Yanmar Combine Harvester AG600GA	1.4	*Forward (m/s)-* Low: 0 - 1.01 Standard: 0 - 1.65 Travel: 0 - 2.05 *Reverse(m/s)-* Low:0 - 0.83 Standard: 0 - 1.35 Travel: 0 - 1.68

70.02	51.50	Yanmar YH700	1.98	Low speed: 0 to 0.88 Standard: 0 to 1.37 High speed: 0 to 1.85
70.02	51.50	Yanmar YH700GU		
Source: ACI Motors Ltd.				

Table A2. Equipment inventory selection[a] for 2WMs.

Inventory of 2WM	Width of the implement (m)	Overlap (%)	Field speed (Km/h)	Field efficiency (%)	Custom hire rate[b] (BDT)
Rotary tiller (16 hp)	0.60	5%	4.14	70%	
Rice transplanter (3.5 hp)	1.20	5%	2.06	70%	
Reaper (6.5 hp)	1.00	5%	3.28	61%	
Thresher					300 BDT/ton for paddy; 800 BDT/ton for wheat.
Maize sheller					300 BDT/ton by small power sheller; 150 BDT/ton by large power sheller; 1000 BDT/ton by hand maize sheller.
[a]*Al-Amin et al. (2024).* [b]*Hossain et al. (2017).*					

Table A3. Equipment inventory selection[a] for 4WMs.

Inventory of 4WM	Width of the implement (m)	Overlap (%)	Field speed, (Km/h)	Field efficiency (%)
Rotavator (60 hp)	2.02	5%	4.20	76%
Rice transplanter (20 hp)	1.75	5%	5.94	87%
Combine harvester (70 hp)	1.71	5%	7.07	56%
[a]*Al-Amin et al. (2024).*				

Appendix E

Appendix E: Checklist for Key Informant Interview (KII) of agro-chemical companies in Bangladesh.

CHECKLIST FOR KEY INFORMANT INTERVIEW (KII)

STRICTLY PRIVATE & CONFIDENTIAL FOR ACADEMIC AND RESEARCH PURPOSES

Research Questionnaire:

"***From data to farm decisions: Developing grain-oilseed cost and return guide for Bangladesh***"

Project Code: BGD-25165

Study background

This research intends to develop comprehensive crop budgets, one of the most extensively used tools in farm economics, needed by farmers, agribusiness, academics and research, and policy makers to make data-driven decisions. In countries such as the United States, the United Kingdom, the European Union, and Canada, crop budgets are updated annually and made publicly available online/printed form to support decision-making. Unfortunately, over the last five decades, Bangladesh has not maintained systematically updated and publicly accessible crop budgets for farm enterprises. In response to the absence of crop budgets, this study seeks to develop costs and return guideline for grain-oilseed farms.

This research contributes to Bangladesh's growing economy and support the 'sustainable, safe and profitable' agriculture vision of the National Agriculture Policy (2018). This study maps the crop zones for major crops (*Aman* rice, *Boro* rice, and wheat) and key rotational crops (maize, lentil, and mustard) followed by development of crop budgets for grain-oilseed for that zone where particular crops are intensified. This research is designed as an extension of the IGC project (BGD-24192), addressing fundamental questions of farm productivity and economics in alignment with the IGC's firm, trade, and productivity theme.

The study is being conducted by the Hub for Smallholders Agri-Tech Economics (HSATE) under the *Department of Agricultural Economics, Faculty of Agricultural Economics and Rural Sociology, Bangladesh Agricultural University (BAU), Mymensingh-2202, Bangladesh*. This study is funded by the *International Growth Centre (IGC),* which is directed by *The London School of Economics and Political Science (LSE)* and *University of Oxford*.

Who is eligible to take part?

To complement the national statistics of Department of Agricultural Extension (DAE), this KII is conducted among the agrochemical industries of Bangladesh.

How long will the study last?

On average, the duration of this survey will be for 30 minutes.

Confidentiality:

Your responses will be kept strictly confidential and will only be used for academic and research purposes envisages in this study. Personal information will not be shared or disclosed to any third parties.

Ethical Approval:

This research and survey are ethically approved by the Bureau of Socioeconomic Research and Training (BSERT) subject to follow the BSERT code of ethics for research in the biological, economic, social and behavioural sciences involving human participants.

Consent:

By participating in this survey, you agree to share your responses for academic and research purposes. You have the right to withdraw from the survey at any time without any consequences. We will be happy to answer any questions you have about this study. For further queries or if you have any other research ideas related to this study, you may contact the Principal Investigator, Dr. A. K. M. Abdullah Al-Amin at Phone: +8801743120000 and/or Email: abdullah.alamin@bau.edu.bd.

Name of the Respondent	
Name of the Institution	
Do you agree to participate in this survey? (Yes=1, No=0)	
Signature	

Thank you in advance for your participation in this study

CHECKLIST FOR KEY INFORMANT INTERVIEW (KII)

1. Could you please provide the names of the commonly used plant protection inputs* (i. e., insecticides, herbicides, and fungicides) by farmers for each of the respective crops?		
HYV *Aman* rice	Insecticide	
	Fungicide	
	Herbicide	
HYV *Boro* rice	Insecticide	
	Fungicide	
	Herbicide	
Wheat	Insecticide	
	Fungicide	
	Herbicide	
Maize	Insecticide	
	Fungicide	
	Herbicide	
Lentil	Insecticide	
	Fungicide	
	Herbicide	
Mustard	Insecticide	
	Fungicide	
	Herbicide	
*Note: *Further details of the plant protection inputs (i.e., insecticides, fungicides, and herbicides) are provided in Appendix A.*		

2. Relative to the recommended rate, what is the usual percentage (%) of over-application of plant protection inputs observed in the field?

3. Do you have any plans to publish a comprehensive and regularly updated repository of input use recommendations and pricing information on your website? (Yes=1, No=2)

4. Do you have any unpublished or internal documents containing price information for the plant protection inputs your company supplies? (Yes=1, No=2)

5. Do prices vary across divisions (i. e., Rajshahi, Rangpur, Khulna)? If yes, could you please share the current prices in the respective divisions?

6. In practice, do farmers generally follow recommended doses, or is there overuse/underuse?

7. Have you observed any recent changes in farmers' demand for specific agrochemicals? If yes, what factors do you think are driving these changes?

8. What are the major challenges in agrochemical distribution in Bangladesh?

____

9. Are there any government regulations in pesticides supply? If yes, what are those?

____

10. Have there been recent regulatory changes that influenced product availability or pricing?

____

11. What future trends do you foresee in Bangladesh's agrochemical market (e.g., shift to bio-pesticides, integrated pest management)?

____

Appendix

Table A1. List of insecticides for respective crops (i. e., rice, wheat, maize, lentil, mustard).

Common name	Trade name
Rice:	
Abamectin	(1) Abom 1.8EC; (2) Sunmectin 1.8EC; (3) Toptin 1.8EC; (4) Licar 1.8EC; (5) Ambush 1.8EC; (6) Acamite 1.8EC; (7) Alba 1.8EC; (8) Basket 1.8EC; (9) Mectin 1.8EC; (10) Vectin 1.8EC; (11) Segatin 1.8EC; (12) Benten 1.8EC; (13) Killmite Plus 1.8EC; (14) Agree 1.8EC; (15) Choice 1.8EC; (16) Avid 1.8EC; (17) R-Batin 1.8EC; (18) Bletin 1.8EC; (19) Abaton 1.8EC; (20) Tytin 1.8EC; (21) Desert Extra 1.8EC; (22) Nubumectin 1.8EC; (23) Greenectin 1.8EC; (24) Acar 1.8EC; (25) Tonu 1.8EC; (26) Border Plus 1.8EC; (27) Serfimectin 1.8EC; (28) Kheya 1.8EC; (29) Makor 1.8EC; (30) EG-Mectin 1.8EC; (31) G-Mectin 1.8EC; (32) Alatin 1.8EC; (33) Keyatin 1.8EC; (34) Croptin 1.8EC; (35) Saitin 1.8EC; (36) Uniba 1.8EC; (37) Libectin 1.8EC; (38) Thriler 1.8EC; (39) Actin 1.8EC; (40) Shitol 1.8EC; (41) World 1.8EC; (42) Actos 1.8EC; (43) Ecotin 1.8EC; (44) Biotin 1.8EC; (45) Best Albatin 1.8EC; (46) Himectin 1.8EC; (47) Rima 1.8EC; (48) Mapin 1.8EC; (49) Helico 1.8EC; (50) Lilimite 1.8EC; (51) Onemectin 1.8EC; (52) Actin 1.8EC; (53) Abasun 1.8EC; (54) Roly-Poly 1.8EC; (55) Tuning 1.8EC; (56) SB-Care 1.8EC; (57) Rain-Bag 1.8EC; (58) Tata-Aba 1.8EC; (59) K-Mectin 1.8EC.
Abamectin (0.3%) + Propargite (39.7%)	(1) Lido 4EC; (2) Acetin 4EC; (3) Aalok 4EC; (4) Forway 4EC; (5) Keratin 4EC; (6) Descopritin 4EC; (7) Abaprid 4EC; (8) Faand 4EC.
Abamectin (2%) + Imidacloprid (36%)	(1) Lahib 38WDG; (2) Flare 38WDG; (3) Abamid 38WDG; (4) Aba Imi Baba 55WDG.
Abamectin (1%) + Chlorpyrifos (40%)	(1) Forfocus 41EC.

Abamectin (0.20%) + Triazophos (19.80%)	(1) Topnoch 20EC.
Abamectin (3%) + Indoxacarb (6%)	(1) Laraco 9SC.
Abamectin (3%) + Spirodiclofen (27%)	(1) Marhaba 30SC.
Acephate	(1) sataf 75SP; (2) Fortunate 75SP; (3) Sinophate 75SP; (4) Banish 75SP; (5) Challenger 75SP; (6) Megaphate 75SP; (7) Jung 75SP; (8) Mimphate 75SP; (9) Haycephate 75SP; (10) Queenphate 75SP; (11) Mapdon 75SP; (12) KriPhate 75SP; (13) Acelar 75SP; (14) Bicoace 75SP; (15) Reset 75SP; (16) E-Phate 75 SP; (17) Acking 75 SP; (18) Rusate 75SP.
Acephate (50%) + Imidaclorpid (1.8%)	(1) Acemida 51.8SP.
Acephate (45%) + Imidaclorpid (25%)	(1) Automida 70WDG.
Azocyclotin (5%) + Acetamiprid (10%)	(1) Seapall 15WP.
Acetamiprid (20%)	(1) Platinum 20SP; (2) Bismark 20SP; (3) Sulvo 20SP; (4)Prize 20SP; (5)Nize 20SP; (6)Sinleaf 20SP; (7)Bicomiprid 20SP; (8)Jaf 20SP; (9)Acetanate 20SP; (10)Uniprid 20SP; (11)Arriban 20SP; (12)Aspor 20SP; (13)G-Ekka 20SP; (14)Satin 20SP; (15) Serftamiprid 20SP; (16) Alert 20SP; (17) Joymala 20SP.
Azadirachtin	(1) Nimbicidine.
Buprofezin	(1) Award 40SC; (2) Tacoma 40SC; (3) Bolo 25SC.
Buprofezin (40%) + Emamectin Benzoate (10%)	(1) Memozin 50WP.
Isoprocarb (20%) + Buprofezin (5%)	(1) Lamah 25WP.
Buprofezin (40%) + Pymetrozine (20%)	(1) Torry 60WDG.
Isoprocarb (22%) + Thiamethaxam (3%)	(1) Genecarb 25WP.
Carbaryl	(1) Sevin 85SP; (2) Vitabryl 85WP; (3) Kalvin 85WP; (4) Ravin 85WP; (5) Coral 85WP; (6) Pilot 85WP; (7) Reflex 85WP; (8) Jupiter 85WP; (9) Expose 85WP; (10) Gevin 85WP; (11) Kubaryl 85WP; (12) Acicarb 85WP; (13) Sarkking 85WP; (14) Padmaryl 85WP; (15) Pai-Ryl 85WP; (16) Abin 85WP; (17) Seril 85WP; (18) Farmryl 85WP; (19) Cinaryl 85WP; (20) Robin 85WP; (21) Drone 85WP; (22) Osbin 85WP; (23) Orogold 85WP; (24) Evil 85WP.
Clothianidin	(1) Optimus 5G.
Carbofuran	(1) Carbofuran 3G; (2) Iridon 3G; (3) Forwafuran 5G; (4) Sunfuran 5G; (5) Furataf 5G; (6) Cabufudan 3G; (7) Biesteran 5G; (8) Pillarfuran 5G; (9) Carbomt 5G; (10)Vitafuran 5G; (11) Agrifuran 5G;

	(12) Brifur 5G; (13) Amcofuran 3G; (14) Cemifuran 5G; (15) Paradox 5G; (16) Limicarb 5G; (17) Camfuran 5G; (18) Corofuran 5G; (19) Sinodan 5G; (20) Hayfuran 5G; (21) Amcofuran 5G; (22) Unifuran 5G; (23) Sarafuran 5G; (24) Edfuran 5G: (25) New Furan 5G; (26) Krishan 5G; (27) Chezer 3G; (28) Wenfuran 5G; (29) Baifuran 5G; (30) Nikidan 3G; (31) Wangdan 3G; (32) Mimfuran 5G; (33) Carbotaf 5G; (34) Myfuran 3G; (35) Borer 5G; (36) Pardan 5G; (37) Furan 3G; (38) Foster 5G; (39) M-Furan 5G; (40) Ecofuran 5G; (41) Filfuran 5G; (42) Carbodhan 5G; (43) Shikari 5G; (44) Touchfuran 5G; (45) Dunfuran 5G; (46) Helifuran 5G; (47) Dfuran 5G; (48) Rexidan 3G; (49) Greenfuran 5G; (50)Amafuran 5G; (51) Autotaf 3G; (52) Carbodana 3G; (53) Seafuran 3G; (54) Bicodan 3G; (55) Greenfuran 3G; (56) Furasafe 5G; (57) Fana 5G; (58) Goldafuran 5G; (59) Z Furan 5G; (60) Mapfuran 5G; (61) Rbofuran 5G; (62) Baifuran 3G; (63) Genefuran 5G; (64) Patriot 5G; (65) Tatafuran 3G; (66) Bicofuran 5G; (67) Mega 5G; (68) Emifuran 5G; (69) Carboran 5G; (70) Dreamfuran 5G; (71) Rekafuran 5G; (72) Sharfuran 5G; (73) Dekofuran 5G; (74) Trifuran 3G; (75) Anafuran 5G; (76) Rajteer 5G; (77) Bi fur 5G; (78) Aungkur 5G; (79) Welldone 3G; (80) R-Furan 5G; (81) Panza 3G; (82) Nurfuran 5G; (83) Paradan 5G; (84) Kingfuran 5G; (85) Multifuran 5G; (86) Deltafuran 3G; (87) Qurafuran 5G; (88) Nazidan 5G; (89) Bigfuran 5G; (90) Freshfuran 5G; (91) Duranta 5G; (92) Pinfor 5G; (93) Mimcarb 3G; (94) Winran 5G; (95) Fidan 5G; (96) Polok 3G; (97) Nalfuran 5G; (98) Seavafuran 3G; (99) ICI Furan 5G; (100) Biszeen 5G; (101) Fasalfuran 5G; (102) MS Furan 3G; (103) Thaifuran 5G; (104) Tillage 5G: (105) Basicfuran 3G; (106) EG-Dana 5G; (107) SB-Furan 5G; (108) M-Furan 3G; (109) Skyfuran 5G; (110) Herofuran 5G; (111) Delcofuran 5G; (112) Greatfuran 5G; (113) Adbhafuran 5G; (114) Runfuran 5G; (115) Masterfuran 5G; (116) Bestfuran 5G; (117) Limfuran 5G; (118) Furarus 5G; (119) Mohafuran 5G; (120) Autofuran 5G; (121) Utsafuran 5G; (22) Descodan 5G.
Carbosulfan	(1) Marshal 20EC; (2) Sunsulfan 20EC; (3) Amcosul 20 EC; (4) Advantage 20SC; (5) Sicosulfan 20EC; (6) General 20EC; (7) Benefit 20EC; (8) Haysulfan 20EC; (9) Mimsulfan 20EC; (10) Delcy 20EC; (11) Corosulfan 6G; (12) Orosulfan 20EC; (13) Sizafan 20EC; (14) Vifan 20EC; (15) Baisulfan 20EC; (16)

	Ecosulfan 20EC; (17) Ricosulfan 20EC; (18) Bicosulphan 20EC; (19) Fido 20 EC; (20) Rupa 20EC.
Carbosulfan (10%) + Cypermethrin (10%) (5%)	(1) erfectsulfan 20 EC.
Cartap	(1) Suntap 50SP; (2) Forwatap 50SP; (3) Katap 50SP; (4) Cartap 50SP; (5) Cidan 4G; (6) Rider 50SP; (7) Cikotap 50 P; (8) Sundan 4GR; (9) Ferdan 50SP; (10) Sinotap 50SP; (11) Tenup 50SP; (12) Hero 50SP; (13) Rexitap 50SP; (14) Megatap 50WP; (15) Care 50SP; (16) Victor 50SP; (17) Wendan 4G; (18) Wentap 50SP; (19) Baitap 50SP; (20) Mimtap 50SP; (21) Riversun 4G; (22) Arotap 50SP; (23) Haytap 50SP; (24) Filtap 50SP; (25) Seatap 50SP; (26) Alpha Tap 50SP; (27) Kadan 50SP; (28) Goldtap 50SP; (29) Moontap 50SP; (30) Jose 50SP; (31) King Tap 50SP; (32) Ratan 50SP; (33) Bravo 50SP; (34) Apex 50SP; (35) Agrotap 50SP; (36) Bletap 50SP; (37) Dtap 50SP; (38) Tazri 50SP; (39) Shut Up 50SP; (40) Bolder 50 SP; (41) Rekatap 50SP; (42) Rantap 50SP; (43) Fitap 50SP; (44) Padmatap 50SP; (45) CP-Tap 50SP; (46) Protector 4GR; (47) Real 4GR; (48) Amatap 50SP; (49) Ecotap 50SP; (50) Meritap 50SP; (51) Aristotap 50 SP; (52) Hinotap 50SP; (53) Onetap 50SP; (54) Tytap 50SP; (55) Rantap 4G; (56) Smartap 50SP; (57) Polotap 50SP; (58) Venus 50SP; (59) Ratan 4GR; (60) City Tap 50 SP; (61) Rajtap 50SP; (62) Shahitap 50SP; (63) Siamtap 50SP; (64) Rycar 50SP; (65) Genetap 50SP; (66) Ricotap 50SP; (67) Hossatap 50SP; (68) Sonotap 50SP; (69) Cart 50SP; (70) Vigour 80 SP; (71) Extap 50SP; (72) Paratap 50SP; (73) Unitap 50 SP; (74) Freshtap 50SP; (75) Mahitap 50SP; (76) Chamok 50SP; (77) Besttap 50 SP; (78) Rajtap 50 SP; (79) Tapwin 50 SP; (80) Care Plus 50SP; (81) Sharitap 50SP; (82) Neo-Tap 50SP; (83) Fasal Tap 50SP; (84) Ecotap Plus 85SP; (85) Baitap Plus 85SP; (86) Rider Plus 85SP; (87) Moontap 4G; (88) Adbhatap 50SP; (89) Bhatap 50SP; (90) Holotap 50 SP; (91) Nokotap 6G; (92) Forcart 50SP; (93) Farmtap 50SP.
Acetamiprid (3%) + Cartap (92%)	(1) Dufen 75SG; (2) Imicart 70SP; (3) Batir 95WP; (4) Aciprid Plus 95SP; (5) Keyaton 95SP; (6) Mine 95SP; (7) Acecar 95SP; (8) Powerprid 95SP; (9) Naptaprid 95SP; (10) Fatal 95SP.
Acetamiprid (20%) + Imidacloprid (50%)	(1) Ricomid Plus 70WDG; (2) Fame 70WDG.
Cartap (47.5%) + Fipronil (2.5%)	(1) Suntap Plus 50WP.
Chlorfenapyr (10%) + Fipronil (10%)	(1) Puni 20WDG.

Chlorpyrifos	(1) Dursban 20EC; (2) Chlorban 20EC; (3) Chlorpyriphos 20EC; (4) Shimba 20EC; (5) Luxan Chlorpyrifos 20EC; (6) Chlorocid 20EC; (7) Helix 20EC; (8) Chlopyrifos 20EC; (9) Rexiban 20EC; (10) Monitor 20EC; (11) Morter 48EC; (12) Marine 20EC; (13) Agphos 20EC; (14) Action 20EC; (15) Megaban 20EC; (16) Fossil 20EC; (17) Wenphos 20EC; (18) Neptune 48EC; (19) Agriban 20EC; (20) Mimban 20EC; (21) Allout 20EC; (22) Arokill 20EC; (23) Arofos 48EC; (24) Linker 20EC; (25) Cheta 48EC; (26) Petrofos 20EC; (27) Kensban 20EC; (28) Ranger 20EC; (29) Vitaban 48EC; (30) Chlorocel 48EC; (31) Terminal 48EC; (32) Action Gold 48EC; (33) Gola 48EC; (34) Kingphos 48EC; (35) Modart 48EC; (36) Firefos 48EC; (37) Thrive 48EC; (38) Striker 48EC; (39) Follicle 20EC; (40) Heliphos 48EC; (41) Sesban 48EC; (42) Severe 50EC; (43) Heraban 20EC; (44) Superphos 48EC; (45) Deltafos 48EC; (46) Iproban 48EC; (47) Tomak 48EC; (48) Ashaban 48EC; (49) Cartar 48EC; (50) Evacon 48EC; (51) Chemefos 20EC; (52) Colour 20EC; (53) Guard 48EC; (54) M.S. Chlorpyrifos 20EC; (55) Pioneer 48EC; (56) Ribbon 48EC; (57) Raymond 48EC; (58) Newphos 48EC; (59) Tyfos 48EC; (60) Plantphos 48EC; (61) Genephos 48EC; (62) Starban 48EC; (63) Regun 48EC; (64) Doller 480EC; (65) Knocker 48EC; (66) Mahifos 20EC; (67) Marwel 48EC; (68) Beater 50EC; (69) Cactus 48EC; (70) Metrophos 48EC; (71) Siamphos 48EC; (72) Laphos 20EC; (73) Redport 48EC; (74) Field Star 50EC; (75) Aniter 48EC; (76) Nazban 48EC; (77) CLC Plus 500EC; (78) Centerkill 48EC; (79) Traf 48EC; (80) Calta 48EC; (81) Kisho 48EC; (82) Fasalfos 48EC; (83) Gola Plus 48EC; (84) Petra 48EC; (85) Raicy 48EC; (86) Comple 48EC; (87) Termiban 48EC; (88) Digit 48EC; (89) Lirifos 48EC; (90) Diamate 20EC; (91) Winfos 48EC; (92) B-Phos 48EC; (93) Bandhan 48EC; (94) 2-Phos 20EC; (95) Ruphos 48EC; (96) Oropyrifos 48EC; (97) Asphos 48EC; (98) Tanpura 15G; (99) Everfos 48EC; (100) Agphos 48EC; (101) Bestfos 48EC; (102) Dascofos 48EC; (103) Hossafos 48EC.
Deltamethrin	(1) Zero Fly Storage Bag.
Diazinon	(1) Diatone 10G; (2) Sabion 60EC; (3) Diazon 10G; (4) Dizinol 60EC; (5) Diazon 60EC; (6) Diazinon 10G; (7) Razdan 10G; (8) Diazinon 60EC; (9) Dianon 10G; (10) Amcozinon 10G; (11) Baizinon 10G; (12) Devizinon 14G; (13) Biodin 10G; (14) Wenzinon 60EC; (15) Turab 60EC; (16) Mapzinon

	10G; (17) Rizinon 10G; (18) Rekazinon 14G; (19) Rekadin 10G; (20) Noknon 60EC; (21) Diatox 60EC; (22) Dizol 10GR; (23) Deltazol 10GR; (24) Dezi 10G; (25) Dzen 10G; (26) Mazudin 10G; (27) Heritage 10G; (28) Ecozinon 10G; (29) D-ten 10G; (30) Dizizol 10G; (31) Agristozin 10G; (32) Sunzinon 10G; (33) Ravzinon 60EC; (34) Diadin 10G; (35) Sarazon 10G; (36) Genedin 10G; (37) Benzin 10G; (38) Suzinon 10G; (39) Symbozinon 10G; (40) Sharidan 10G; (41) Basumeal 10G; (42) Laidan 10G; (43) Dekozinon 10G; (44) Acinon 10G; (45) Acidin 10G; (46) Diaraz 60EC; (47) Bdhan 10G; (48) Pro-zin 10G; (49) G-Dan 10G; (50) Culture 60EC; (51) Niradin 10G; (52) Bicozinon 10G; (53) Winzinon 10G; (54) Agrozin 10G; (55) X-Din 10G; (56) Xzinon 10G; (57) Bada 10G; (58) Becozinon 60EC; (59) Emidan 10G; (60) G-None 10G; (61) Rexizinon 10G; (62) Danzin 10G; (63) Kazudin 10G; (64) Ecodin 10G; (65) Moronpon 10G; (66) Orozon 10G; (67) Miladzinon 10G; (68) Shakezinon 10G; (69) Chicodin 10G; (70) Sudin 10G.
Dimethoate	(1) Delathoate 40EC; (2) Selathoate 40EC; (3) Dimegro 40EC; (4) Sunagor 40EC; (5) Tafgor 40EC; (6) Dimethion 40EC; (7) Biesterthoate 40EC; (8) Novathoate 40EC; (9) Haymethoate 40EC; (10) Starter 40EC; (11) Dynamic 40EC; (12) Rexithoate 40EC; (13) Agrothate 40EC; (14) Logor 40EC; (15) Ecothoate 40EC; (16) Baithoate 40EC; (17) Borshan 40EC; (18) Twinkle 40EC; (19) Thiomet 40EC; (20) Methoat 40EC; (21) Prangor 40EC; (22) Orothoate 40EC; (23) Uniban 40EC.
Dinotefuran	(1) Token 20SG; (2) Dinote 20SG; (3) Superben 20SG; (4) Moran 20SG; (5) Disco 20SG; (6) Zeen Gold 20SG; (7) Dura 20WDG; (8) Difran 20WDG; (9) Daban 20SG; (10) Nuevo 20SG; (11) Thiefram 20WDG; (12) Robix 20SG.
Dinotefuran (40%) + Fipronil (40%)	(1) Comrade 80WDG.
Diafenthiuron	(1) Diaron 50WP; (2) Pai 50EC.
Emamectin Benzoate	(1) Proclaim 5SG; (2) Ac Plus 10WDG; (3) Medilam 5SG; (4) Heping 10WDG; (5) Supon 5SG; (6) Anazoate 5SG; (7) Fea Plus 10WDG; (8) Balaka 5WDG; (9) Chatfat 10WDG; (10) Ematen 10WDG; (11) Ema Gold 10SG; (12) Benzamin 5SG; (13) L-Ben 5SG; (14) Fennel 10SG; (15) Emectin 5SG; (16) Ajwad 5SG; (17) Urmi 5SG; (18) Common 5SG; (19) Umectin 5SG; (20) Fairben 5SG; (21) Astin 5SG; (22) Babaji 5SG; (23) Sinatake 10SG; (24) Redema 5SG.

Hexaflumuron (10%) + Emamectin Benzoate (0.5%)	(1) Forfeat 10.5WDG.
Abamectin (2%) + Emamectin Benzoate (4%)	(1) Band 6WDG; (2) Capacity 6WDG; (3) Sienna 6WDG; (4) Alite 6WDG; (5) G-Chamka 6WDG; (6) Keyaprid 6WG; (7) Freze Plus 6WDG; (8) Jassgold 12.5WDG; (9) Zinia 6WDG; (10) Nill Plus 6WDG.
Emamectin Benzoate (4%) + Beta Cypermethrin (2%)	(1) SB Marble 6WDG.
Indoxacarb (17%) + Emamectin Benzoate (8%)	(1) Toraj 35WDG; (2) Phobia 10SC.
Emamectin Benzoate (5%) + Chlorpyriphos (50%)	(1) Fixal 55WG; (2) Tora 55WDG; (3) Mirako 55WDG.
Ethion (5%) + Thiamethoxam (20%)	(1) Buruj 25WDG.
Fenitrothion	(1) Emithion 50EC; (2) Sumithion 50EC; (3) Corofen 50EC.
Fipronil	(1) Regent 3GR; (2) Regent 50SC; (3) Longent 3GR; (4) Goolee 3GR; (5) Goolee 50SC; (6) Aronil 3GR; (7) Aronil 50SC; (8) Bonanza 3GR; (9) Envoy 50SC; (10) Nema 50SC; (11) Seagent 3GR; (12) Ferogen 3GR; (13) Fiprosun 50SC; (14) Revive 50SC; (15) Support 50SC; (16) Fendol 3GR; (17) Jahor 3GR; (18) Refree 50SC; (19) Ascend 50SC; (20) Ronil 3GR; (21) Bleguard 50SC; (22) Balaka 50SC; (23) Ficor 50SC; (24) Econil 50SC; (25) Ascend 3GR; (26) Eilder 3GR; (27) Lighter 50SC; (28) Agro Gold 50SC; (29) Chalcid 50SC; (30) Eilder 50SC; (31) Ruller 3GR; (32) Finil 3GR; (33) T-Konil 50SC; (34) Pronil 50SC; (35) Provident 3GR; (36) Provident 50SC; (37) Refree 3GR; (38) Aroma 50SC; (39) Procure 3GR; (40) Procure 50SC; (41) Grant 50SC; (42) Positron 50SC; (43) Pafer 50EC; (44) Filbert 50SC; (45) Bicogent 50SC; (46) Prince 3GR; (47) Aroma 3GR; (48) Ravnil 50SC; (49) Tynil 50SC; (50) Prositron 3GR; (51) Ronil 50SC; (52) Get-Nobel 50SC; (53) Shaeconil 50SC; (54) Fiprogent 50SC; (55) Biogent 50SC; (56) Placard 50SC; (57) Eyegent 50SC; (58) Bornil 50SC; (59) Sunrof 50SC; (60) Digont 50SC; (61) Lagent 3GR; (62) Gentco 3GR; (63) Shebanil 3GR; (64) Aashirbad 50SC; (65) Bestnil 5SC; (66) Pafip 3GR; (67) Margin 3GR; (68) U-Gent 0.3GR; (69) Aplus 50SC; (70) Filanto 80WDG.
Fipronil (50%) + Thiamethoxam (30%)	(1) Vipco 80WDG.
Fipronil (3%) + Phoxim (2.00%)	(1) Tomahulk 5G.
Fipronil (12.50%) + Sulfoxaflor (17.50%)	(1) Xemco 30EC.
Fipronil (20%) + Acetamiprid (20%)	(1) Apon 40WDG; (2) Vanguard 40WG.
Flubendiamide	(1) Belt 24 WG.

Imidacloprid	(1) Admire 20SL; (2) Imitaf 20SL; (3) Tiddo 20SL; (4) Empire 20SL; (5) Bildor 20SL; (6) Power Sun 20SL; (7) Limida 17.8SL; (8) Bidder 20SL; (9) Imidachlor 10WP; (10) Gain 20SL; (11) Premier 20SL; (12) Sunchlorprid 20SL; (13) Tez 20SL; (14) Ipromar 20SL; (15) Simida 20SL; (16) Confidor 70WG; (17) Impale 20SL; (18) Confident 200SL; (19) Falcon 20SL; (20) Aropid 20SL; (21) Adclop 20SL; (22) Emu 17.8SL; (23) Mukti 200SL; (24) Imidor 17.8SL; (25) Jadid 200SL; (26) Barrier 20SL; (27) Impride 17.8SL; (28) Dharbahaar 200SL; (29) Rido 20SL; (30) E-Tap 20SL; (31) Aciprid 200SL; (32) Paramid 20SL; (33) Promise 200SL; (34) Radius 200SL; (35) Theme 20SL; (36) Imida 200SL; (37) Imicon 200SL; (38) Courage 20SL; (39) Kreshok Bandhu 200SL; (40) Beauty 200SL; (41) Locker 20SL; (42) Pamir 200SL; (43) Panama 20SL; (44) Haymidor 70WG; (45) Innova Super 20SL; (46) Feeder 20SL; (47) Sapta 70WG; (48) Jamuna 20SL; (49) Audis 20SL; (50) Pinador 70WG; (51) Tirondaz 20SL; (52) Moncut 20SL; (53) Consus 20SL; (54) Ultra 20SL; (55) Agropid 20SL; (56) Tearon 20SL; (57) EG-Suck 20SL; (58) Best Action 20SL; (59) Imixtreme 20SL; (60) Typid Gold 70WDG; (61) Admit 20SL; (62) Imitrust 20SL; (63) Eraprid 20SL; (64) Conductor 70WG; (65) Clotaf 20SL; (66) Tidal 70WDG; (67) Mooncut 70WDG; (68) Demer 20SL; (69) Ampera 20SL; (70) Imida System 20SL; (71) Hiprid 20SL; (72) Imidacel 20SL; (73) Pami 70WG; (74) Imvision 20SL; (75) Innova Super Plus 70WG; (76) Promise Plus 70WG; (77) Radius Plus 70WG; (78) Deltaprid 20SL; (79) Imitex 20SL; (80) Krishan Bandhu 20SL; (81) Fiza 70WG; (82) Cherry 70WG; (83) Flame 20SL; (84) Anamda 70WG; (85) Imisun 20SL; (86) Holoda 20SL; (87) Fotic 70WDG; (88) Y-chlor 70WG; (89) Ashar Alo 70WG; (90) Gender 70WDG; (91) Gain Super 70WG; (92) Pitter 20SL; (93) Sonaprid 10WP; (94) Sicofidor 70WDG; (95) Amipid 70WDG; (96) Calculus 70WDG; (97) Emilon 20SL; (98) Midu 20SL; (99) Technopori 70WDG; (100) Ranesa 70WDG; (101) Hosacloprid 20SL; (102) Canopy Plus 70WG; (103) Tiddo Plus 70WDG; (104) Aeropid Plus 70WG; (105) Kalfa 20SL; (106) Imimed 20SL; (107) Trim 70WDG; (108) Ranza 70WDG; (109) Dino 70WDG; (110) Sinaprid 20SL; (111) Fend 70WDG; (112) Option 70WG; (113) Imida Up 20SL; (114) Icoprid

	70WDG; (115) Percuss 70WDG; (116) Ittadi 70WDG.
Imidacloprid (2%) + Monomehypo (58%)	(1) Golf 60WP.
Imidacloprid (40%) + Ethiprole (40%)	(1) Glamore 80WG.
Imidacloprid (40%) + Fipronil (40%)	(1) Fiprid 80WDG; (2) Fima 80WDG; (3) Ray 80WDG; (4) Procure Plus 80WDG; (5) Tomcat 80WDG; (6) Positron Plus 80WDG.
Imidacloprid (15%) + Lamda Cyhalothrin (5%)	(1) Movecash 75WDG; (2) Topgate 57.5WDG.
Indoxacarb (14.5%)	(1) Rav-Zoom 14.5SC; (2) Jaja 14.5SC; (3) Tower 15SC; (4) Kingcarb 15SC; (5) Polaris 14.5SC.
Isoprocarb (MIPC)	(1) Sopcin 75WP; (2) Mipcin 75WP; (3) Suncin 75WP; (4) Waprocarb 75WP; (5) Smooth 75WP; (6) Wind 75WP A; (7) Chabi 75WP.
Lufenuron	(1) Seron 5EC; (2) Hayron 5EC; (3) Winron 5EC; (4) Menon 5EC; (5) Bilson 10EC.
Lufenuron (40%) + Emamectin Benzoate (10%)	(1) Fultime 50WDG; (2) Lufender 50WDG; (3) Tear Plus 50WDG A; (4) E-Tap Plus 50WDG; (5) Lumia 50WDG; (6) Define 50WDG; (7) MH-Mectin 50WDG; (8) Unigate 50WDG; (9) Apron 50WDG; (10) Latim 50WDG; (11) Luitin 50WDG.
Malathion	(1) Fyfanon 57EC; (2) Hilthion 57EC; (3) Syfanon 57EC; (4) Malasun 57EC; (5) Semtox 57EC; (6) Ficom Malathion 57EC; (7) Hyfanon 57EC; (8) Sicothion 57EC; (9) Ashation 57EC; (10) G-Thion 57EC; (11) Sharmal 57EC; (12) Quiathion 57EC; (13) Methiol 57EC; (14) Bicothion 57EC; (15) Maladion 57EC; (16) Guruthion 57EC; (17) Orothion 57EC.
Monomehypo	(1) Monome 90SP.
Nitenpyram 10SL	(1) Pilarnit 10SL; (2) Sega 10SL; (3) Forpyram 10SL.
Nitenpyram (20%) + Pymetrozine (60%)	(1) Pyrazin 70WDG; (2) Nyzin 80WDG; (3) Ignite 80WDG; (4) Roughter 80WDG; (5) Kangaru 80WDG; (6) Symten 80WDG; (7) Foring 80WDG; (8) Peda Ting Ting 80WDG; (9) Shikha 80WDG; (10) Gungun 80WP; (11) Nior 80WDG; (12) Torit 80WDG; (13) Pymet 80WDG; (14) Alzin 80WDG; (15) Bazraghat 80WDG; (16) Hoppercare 70WDG; (17) Quickdown 70WDG; (18) Hakkar 80WDG; (19) Phorate 70WDG; (20) Pahar 80WDG; (21) Currency 80WDG.
Osfencarb (BPMC)	(1) Mis-Kill 50EC.
Phenthoate	(1) Cidial 5G; (2) Kiran 50EC; (3) Ruby 50EC; (4) Bilsan 50EC; (5) Bicoelsan 50EC; (6) SemKap 50EC; (7) Cinedal 5G.
Profenofos	(1) Celcron 50EC; (2) Farmfos 50EC.
Profenofos (50%) + Lufenuron (5%)	(1) Lufa 55EC; (2) Parash 55EC.

Pymetrozine	(1) Agricon 50WG; (2) Pytaf 50WDG; (3) Hoppershot 50WG; (4) Kotan 50WG; (5) Pullet 50% (Effervescent Tablet); (6) SR-Metrozine 50WG.
Pymetrozine (50%) + Imidacloprid (18%)	(1) Pyrid 68WG; (2) V-Tara 68WG.
Pymetrozine (50%) + Thiamethoxam (20%)	(1) Such 40WDG.
Pyridaban (20%)	(1) Pyrin 20WP.
Pyriproxyfen (10.8%)	(1) Pyrifen 10.8EC; (2) Forhit 10EC.
Quinalphos (25%)	(1) Kinalux 25EC A; (2) Corolux 25EC; (3) Deviquine 25EC; (4) Quilax 25EC; (5) Konika 25EC; (6) Amcolux 25EC A; (7) Mimlux 25EC; (8) Bailux 25EC; (9) Dhanulux 25EC; (10) Wenquine 25EC; (11) Cure 25EC; (12) Cobraking 25EC; (13) Supersun 25EC; (14) Delux 25EC; (15) Ecolux 25EC; (16) Q-Phos 25EC.
Spinosad	(1) Entrust 45SC; (2) Conserve 45SC; (3) Rush 45SC; (4) Sound 45SC; (5) Obey 45SC.
Thiacloprid	(1) Futanto 24SC.
Thiamethoxam (25%)	(1) Actara 25WG; (2) Cruiser 70WS; (3) Spike 25WG; (4) Maxima 25WG; (5) Renova 25WDG; (6) Ratnatara 25WG; (7) Rexitara 25WG; (8) Methox 25WG; (9) Rex 25WG; (10) Slayer 25WDG; (11) Dotara 25WG; (12) Zabat 25WG; (13) Marvel XL 25WG; (14) Quiz Xtra 25WG; (15) Random Star 25WG; (16) Tala 25WP; (17) Baul 25WG; (18) Pro-Xam 25WDG; (19) Pachtara 25WP; (20) Formethoxam 25WG; (21) Laltara 25WG; (22) Nilton 70WDG.
Thiamethoxam 25% + Imidacloprid 45%	(1) Todon 70WDG; (2) Thiaprid 70WDG; (3) Imixam 70WDG; (4) Thiami 70WDG; (5) Mushy 73WDG; (6) Niamot 70WDG; (7) Luvan 70WDG; (8) Muntaha 70WDG; (9) Rimixam 70WDG.
Emamectin Benzoate (5%) + Imidacloprid (70%)	(1) Capture 75WDG; (2) Huntking 75WDG.
Chlorantraniliprole	(1) Ferterra 0.4G; (2) Coragen 18.5SC.
Thiamethoxam (20% / 10%) + Emamectin Benzoate (20%)	(1) Kaplan 300SC; (2) Ultima Plus 40WG; (3) Valor 40WDG; (4) Fix Two 40WG; (5) Fair Plus 40WG; (6) Express 40WDG A; (7) Exponent 40WD; (8) Flame 30SC; (9) Shengh-Li 30SC; (10) Xu-Long 40WG; (11) Benthiam 40WDG; (12) White Wash 40WG; (13) Over 40WDG; (14) Herculex 40WG; (15) Chromium 30SC; (16) Emperior 40WG; (17) Corus 40WDG; (18) Lactima 40WDG; (19) Fair Plus 30SC; (20) Express 30SC; (21) Exponent 30SC; (22) Fizoate 40WG; (23) Mix Two 40WDG; (24) Methotin 30WDG; (25) Hope Plus 40WDG; (26) Nirjhor Super 40WG; (27) Winmax 40WDG; (28) Square Super 40WDG; (29) Suktara 40WG;

	(30) Tanel 40WG; (31) Serf Two 40WDG; (32) Voyage Two 40WDG; (33) Vigoraj 40WDG; (34) Absotima 40WG; (35) KB Xam 40WG; (36) Aline 40WDG; (37) Ether Plus 40WG; (38) G-Zot 40WG; (39) Thiatin 40WG; (40) D-Shine 40WG; (41) Confirm 40WDG; (42) Nopa 40WDG; (43) SB Super 40WDG; (44) Vision Plus 40WDG; (45) Atlanta Plus 40WDG; (46) Gurdian 40WDG; (47) Best Finisher 40WDG; (48) Nap Think Plus 40WDG; (49) Repeal 40WDG; (50) Prostar 40WDG; (51) Pasthima 40WDG; (52) Chiefboss 40WDG; (53) Duishw Duishw 40WDG; (54) Hytron 40WDG; (55) Gmex 40WDG; (56) Unimaa Plus 40WDG; (57) Zoom Plus 40WDG; (58) Prime Plus 40WDG; (59) Thiamectin 40WDG; (60) Erix 40WDG; (61) Kompon 40WDG; (62) Power Ematin 40WDG; (63) Limitako 40WDG; (64) Tabthiam 40WDG; (65) Sisnova Super 40WDG A; (66) KG Plus 40WDG; (67) MMI New World 40WDG.
Thiamethoxam (12%) + Fipronil (6%)	(1) Fixam 180SC; (2) Duel Core 180SC; (3) Reload 18SC; (4) Yellow Flexi 18SC.
Cyromazine	(1) Hayromazine 75WP; (2) Koradex 50SP.
Lufenuron (10%) + Thiamethoxam (30%)	(1) Jastin 40WG; (2) Amber 40WDG; (3) Dorfen 40WDG; (4) Lutham 40WDG; (5) Lufzan 40WDG; (6) Ronomax 40WDG.
Lufenuron (5%) + Emamectin Benzoate (5%)	(1) Lumectin 10WDG; (2) Forecho 6EC.
Flonicamide	(1) Ulala 50WDG.
Flubendiamide (24%) + Thiacloprid (24%)	(1) Belt Expert 48SC.
Flupyradifurone (10%) + Flonicamide (10%)	(1) Red Card 20WDG.
Pymetrozine (50%) + Acetamiprid (25%)	(1) Supershot 75WDG.
Isocycloseram 20%	(1) Incipio 20SC.
Chlorantraniliprole + Thiamethoxam	(1) Virtako 40 WG.
Azoxystrobin + Cyproconazole	(1) Acibin 28 SC.
Chlorpyrifos 50% + Cypermethrin 5%	(1) AC Mix 55 EC.
Lambda-cyhalothrin 2.5%	(1) Fighter 2.5 EC.
Chlorpyrifos 48%	(1) Gola 48EC.
Pymetrozine 10.70%	(1) Pilarex 10.70 SC.
Abamectin 1.8%	(1) Reload 18SC.
Imidacloprid 20%	(1) Tiddo 20 SL.
Diazinon 60%	(1) Diaraz 60 EC.
Cartap Hydrochloride 50%	(1) Care 50 SP.
Phenthoate 5%	(1) Cidial 5G.
Fipronil 0.3%	(1) Goolee 3 Gr.
Pymetrozine 70%	(1) Pyrazin 70 WDG.

Cartap Hydrochloride 10%	(1) Rajdhan 10G.
Chlorphenapyer 20% + Emamectin Benzoat 5%	(1) Fenzate-25EC.
Kasugamycin (4% + Carbendazim 50%)	(1) Nacsumin-54 WP.
Azoxystrobin 20% + Cyproconazole 8%	(1) Tipoff-28 SC.
Tricyclazole 50% + Fenoxanil 20%	(1) Veer-70 WP.
Emamectin Benzoate	(1) Sharper-5WDG.
Cartap 50% + Fipronil 2.5%	(1) Grip 52.5 WDG.
Imidacloprid 52.5% + Emamectin Benzoate 5%	(1) Topgate-57.5 WDG.
Dimethoate	(1) Starter -40EC.
Aluminium Phosphid	(1) Fumitox 56%.
Cartap 92% + Acetamiprid 3%	(1) Cartaprid-95 SP.
Imidacloprid	(1) Adclop 20 SL.
Streptomycin sulfate 9% + Tetracycline hydrochloride 1% SP	(1) Cristocycline.
Imidacloprid 70% WDG	(1) Hyfidor 70 WDG.
Pyriproxyfen 5% + Fenpropathrin 15% EC	(1) Suhi Proud.
Pymetrazine 50% + Dinotifuran 20%	(1) Araf 70 WDG.
Emamectin Benzoate 10% + Lufenuron 40% WG	(1) Define 50 WDG.
Cartap 50%	(1) Sharitap 50 SP.
50g Fipronil	(1) Sharconil 50SC.
200 g Imidacloprid	(1) Tirondaz 20 SL.
Abamectin 2%+ emamectin benzoate 6%	(1) BAND 6 WG.
Diazinon 10%	(1) Basudeb 10 GR.
Cartap Hydrochloride 4%	(1) Cartap 4G.
Thiamethoxam 20%+ Emamectin Benzoate 20%	(1) Corus 40 WDG.
Imidacloprid	(1) FOTIC 70 WDG.
Monomehypo 95%	(1) Monome 95 SP.
0.50% Fipronil	(1) Urgent 3 GR.
500g of Fenthion	(1) Bilsan 50 EC.
Buprofezin 40%	(1) Chentor 40 SC.
Dimethoate 40%	(1) Dynamic 40 EC.
Chlorpyrifos 20%	(1) Helix 20 EC.
Quinalphos 25%	(1) Konika 25% EC.
Emamectin benzoate 2.2%	(1) Pictor 2.2 EC.
Malathion 57%	(1) Red Star 57 EC / Meladion 57 EC.
Abamectin 1% + Acetamiprid 3%	(1) Abacete 40 EC.
Fenitrothion 50%	(1) Silican 50 EC.
Acetamiprid 20%	(1) Acetanet 20 SP.
Acephate 75%	(1) Banish 75 SP.

Carbofuran 3%	(1) Chaser 3G.
Carbosulfan 20%	(1) Delsi 20 EC.
0.30% Fipronil	(1) Eilder 3 GR
20 g Beta-cypermethrin	(1) Emabeta 6 WDG.
Carbofuran 5%	(1) Paradox 5G.
Emamectin benzoate 5%	(1) Pictor 50 SG.
Thiamethoxam 25%	(1) Rex 25 WG.
Pymetrozine 50%	(1) Sam One 50 WG.
Imidacloprid 70 WG	(1) Calculus 70 WG.
Abamectin 1.8 EC	(1) Desert Extra 1.8 EC.
Thiamethoxam 20% + Emamectin Benzoate 20%	(1) Hope Plus 40 WG.
Cartap 92% + Acetamiprid 3% SP	(1) MINE 95 SP.
Imidacloprid 40% + Fipronil 40%	(1) Ray 80 WG.
Bifenthrin 5% + Pyridaben 10% + Thiodicarb 50%	(1) Aim Goal 65 WDG.
Emamectin benzoate 10%	(1) Haltup 10 WDG.
Cypermethrin 10%	(1) Radar.
Pymetrozine 60% + Nitenpyram 20%	(1) Roughter 80 WDG.
Wheat:	
Deltamethrin	(1) Zero Fly Storage Bag.
Azoxystrobin 20% + Cyproconazole 8%	(1) Acibin 28 SC.
Kasugamycin (4% + Carbendazim 50%)	(1) Nacsumin-54 WP.
Tricyclazole 50% + Fenoxanil 20%	(1) Veer-70 WP.
Aluminium Phosphid	(1) Fumitox 56%.
50g Fipronil	(1) Sharconil 50SC.
Maize:	
Lambda Cyhalothrin	(1) Karate 2.5EC.
Cyantraniliprole	(1) Fortenza 60FS.
Lambda-cyhalothrin	(1) Karate 2.5 EC.
Chlorpyrifos 50% + Cypermethrin 5%	(1) AC Mix 55 EC.
Pymetrozine 10.70%	(1) Pilarex 10.70 SC.
Pymetrozine 50%	(1) Reload 18SC.
Fipronil 5%	(1) Full Time 50 WDG.
Chlorpyrifos	(1) Morter-48 EC.
50g Fipronil	(1) Sharconil 50SC.
Bifenthrin 5% + Pyridaben 10% + Thiodicarb 50%	(1) Aim Goal 65 WDG.
Emamectin benzoate 10%	(1) Haltup 10 WDG.
Lentil:	
Malathion 57%	(1) Red Star 57 EC / Meladion 57 EC.
Mustard:	
Acephate	(1) Mimphate 75SP.
Alpha Cypermethrin	(1) Prabal 10EC.

Chlorpyrifos (50%) + Cypermathrin (5%)	(1) Cyclobond 55EC.
Cypermethrin	(1) Cypraplus 10EC.
Diazinon	(1) Sabion 60EC.
Dimethoate	(1) Dimegro 40EC; (2) Tafgor 40EC.
Imidacloprid	(1) Bidder 20SL.
Malathion	(1) Wenthion 57EC.
Profenofos	(1) Celcron 50EC.
Thiamethoxam (25%)	(1) Actara 25 WG
Imidacloprid (20%) + Fipronil (7.00%) + Deltamethrin (5.00%)	(1) Proloy 32SC.
Pymetrozine 60% + Nitenpyram 20%	(1) Splender-80WDG.
Chlorpyrifos 20%	(1) Helix 20 EC.
Singapore Diazinon 60%	(1) Pounder 600 EC.
Emamectin benzoate 10%	(1) Haltup

Table A2. List of fungicide for respective crops (i. e., rice, wheat, maize, lentil, mustard).

Common name	Trade name
Rice:	
Azoxystrobin (20%) + Cyproconazole (8%)	(1) Novera 28SC.
Azoxystrobin (20%) + Difenoconazole (12.5%)	(1) Amistar Top; (2) Power Blast 32.5SC; (3) Emiscore 32.5EC; (4) Salvation 32.5SC; (5) Aspire 32.5SC; (6) Artisan 32.5SC; (7) Pazodi 32.5SC; (8) M-Top 32.5SC; (9) Limostar Top 32.5SC.
Azoxystrobin (6%) + Chlorothalonil (50%)	(1) Azonil 56EC.
Bismerthiazole	(1) Bactroban 20WP.
Carbendazim	(1) Knowin 50WP; (2) Aimcozim 50WP; (3) Agben 50%F; (4) Forastin 50WP; (5) Genuine 50WP; (6) Cindazim 50WP; (7) Evazim 50WP; (8) Haydazim 50WP; (9) Sinodazim 50WP; (10) Dimbazim 50WP; (11) Knobin 50WP; (12) Turbo 50WP; (13) Lazim 50WP; (14) Mahizim 50WP.
Carbendazim (25%) + Thiram (25%) + Imidacloprid (25%)	(1) Atavo 75WDG; (2) Topzim Super 75WDG.
Carbendazim (10%) + Imidacloprid (10) + Metalaxyl (10%)	(1) Regiment 30WP.
Carboxin (37.5%) + Thiram (37.5%)	(1) Provax 200WP; (2) VitaFlo 200FF.
Carbendazim (25%) + Iprodione (25%)	(1) Hyprozim 50WP.
Difenoconazole (25%)	(1) Score 250EC; (2) Rofenon 25EC.
Difenconazole (15%) + Propiconazole (15%)	(1) X-Tra Care 300EC; (2) Combi-2 30EC; (3) Evaeilt Super 300EC; (4) Positive 30EC; (5) Teslore 30EC.
Pyraclostrobin (10%)	(1) Seltima 10 CS.
Edifenphos	(1) Edifen 50EC.
Epoxiconazole	(1) Opal 7.5EC.

Hexaconazole	(1) Contaf 5EC; (2) Hayconazol 5EC; (3) Force 5EC; (4) Control 5EC; (5) Titan 5EC; (6) Orozole 5SC; (7) Conza 5EC; (8) Chokka 5EC; (9) Blezole 5EC; (10) Hexazole 5EC; (11) Shabab 5EC; (12) Herazole 5EC; (13) Shabab-D 10EC; (14) Fiscal 10EC.
Tricyclazole (22%) + Hexaconazole (3%)	(1) Murate 25SC; (2) Sunfighter 25SC; (3) Pair 55WG.
Isoprothiolane	(1) Nac-Pro 40EC.
Mancozeb (63%) + Carbendazim (12%)	(1) Unisaaf 75WP.
Propiconazole	(1) Tilt 250EC; (2) Corozole 250EC; (3) Evaeilt 25EC; (4) Proud 25EC; (5) Steel 250EC; (6) Green Care 250EC; (7) Proven 250EC; (8) Propicon 250EC; (9) Shadid 250EC; (10) Sunconazole 250EC; (11) Potent 250EC; (12) Popizole 250EC; (13) Amazole 25EC.
Propiconazole (12.5%) + Tricyclzole (40%)	(1) Filia 52.5SE.
Pyraclostrobin (5%) + Metiram (55%)	(1) Cabrio Top.
Tebuconazole (25%)	
Tebuconazole (50%) + Trifloxystrobin (25%)	(1) Folicur 25EC.
Tetraconazole (12.50%) + Carbendazim (15%)	(1) Nativo 75WG; (2) Palki 75WG; (3) Grade-1 75WG; (4) Mactivo 75WG; (5) Opponent 75WG; (6) Digivo 75WG; (7) McVo 75WG; (8) Blastin 75WDG; (9) Allright 75WG; (10) Lamivo 75WDG; (11) Faflo 75WG; (12) Stromin 75WG; (13) Maxivo 75WDG.
Tricyclazole (75%)	(1) Trooper 75WP; (2) Zeal 75WP; (3) Difa 75WP; (4) Umoke 75WP; (5) Mela 75WP; (6) L-Clazol 75WP; (7) Oboni 75WP; (8) Stanza 75WP; (9) Suzole 75WP; (10) Adarsho 75WP.
Zineb (68%) + Hexaconazole (4%)	(1) Awal 72WP.
Azoxystrobin + Difenoconazole	(1) Amistar Top 325 SC.
Difenoconazole	(1) Score 250 SC.
Sulfur	(1) Thiovit 80 WG.
250g/l Propiconazole	(1) TILT 250 EC.
Azoxystrobin + Cyproconazole	(1) Acibin 28 SC.
Carbendazim	(1) Aimcozim 50 WP.
Tebuconazole (50%) + Trifloxystrobin (25%)	(1) Blastin 75 WDG.
Propiconazole	(1) Proud 25 EC.
Tricyclazole 50% + Fenoxanil 20%	(1) Veer-70 WP.
Azoxystrobin 20% + Cyproconazole 8%	(1) Tipoff-28 SC.
Kasugamycin (4% + Carbendazim 50%)	(1) Nacsumin-54 WP.

Difenconazole 15% + Propiconazole 15%	(1) Combi-2 30 EC.
Fenaminstrobin 10% + Tebuconazole 10%	(1) Aiker-20 SC.
Streptomycin sulfate 9% + Tetracycline hydrochloride 1% SP	(1) Cristocycline 90 SP.
Hexaconazole 5% EC	(1) Visa 5EC.
Sulfur 80% WG	(1) Dewvit 80 WDG.
500g Iprodione	(1) Gonder 50 WP.
Tebuconazole & Trifloxyststrobin	(1) Novita 75 WG.
Carbendazim per 100 gm	(1) Ravistin 50WDG.
Azoxystrobin 20 + Difenoconazole 12.5	(1) Seven Star Top 32.5 SC.
Tricyclazole 75%	(1) Amok 75 WP.
Azoxystrobin, Difenoconazole	(1) Binojol 32.5 S C.
Carbendazim 50%	(1) Reguard 50 W P.
Cymoxanil 6% + Chlorothalonil 30%	(1) Samidue 36 W P.
Validamycin 10%	(1) Samisen 10 SL.
Tebuconazole 50% + Trifloxystrobin 25%	(1) Bingo 75 WG.
Azoxystrobin 20% + Difenoconazole 12.5%	(1) Catlin 32.5 SC.
Carbendazim 50 WP	(1) Greatzim 50 WP.
Hexaconazole 5 EC	(1) Greatzole 5 EC.
Difenoconazole 15% + Propiconazole 15%	(1) Tintin 300 EC.
Carbendazim 50 DF	(1) Zimda 50 DF.
Azoxystrobin 15% + Cyproconazole 12.5% + Buscalid 27.5%	(1) 3-Option 55 SC.
Copper oxychloride 50%	(1) Copper 50 WP.
Wheat:	
Azoxystrobin (20%) + Cyproconazole (8%)	(1) Jinazole 28SC; (2) Cyprobin 28SC.
Carbendazim	(1) Cuptun 50WP; (2) Nova 50WP.
Carbendazim (32.5%) + Hexaconazole (2.5%)	(1) Defense 35SC.
Carboxin (37.5%) + Thiram (37.5%)	(1) Provax 200WP.
Carboxin 20%+ Thiram 20%	(1) Asavax 40WP.
Difenconazole (15%) + Propiconazole (15%)	(1) Positive 30EC.
Hexaconazole	(1) Cona 5EC.
Tricyclazole (22%) + Hexaconazole (3%)	(1) Sunfighter 25SC.
Kasugamycin	(1) Kasumin 2% Liquid.
Propiconazole	(1) Tilt 250EC; (2) Protaf 250EC; (3) Corozole 250EC; (4) Proud 25EC; (5) Green Care 250EC; (6) Propicon 250EC; (7) Sunconazole 250EC; (8) Popi 25EC; (9) Potent 250EC; (10) CP-Zole 25EC; (11)

	Bicopizole 250EC; (12) Suprazol 25EC; (13) Aristozole 250EC; (14) Prompt 25EC.
Validamycin	(1) Samycin 10SL.
Zineb (68%) + Hexaconazole (4%)	(1) Awal 72WP.
Azoxystrobin + Cyproconazole	(1) Acibin 28 SC.
Tricyclazole 50% + Fenoxanil 20%	(1) Veer-70 WP.
Kasugamycin (4% + Carbendazim 50%)	(1) Nacsumin-54 WP.
Maize:	
Carbendazim	(1) UniZoom 50WP.
Carboxin (37.5%) + Thiram (37.5%)	(1) VitaFlo 200FF
Ipriodione 50%	(1) Nacblotch-50 WP.
Carbendazim 50%	(1) Tensim 50 DF.
Lentil:	
Copper oxychloride (50%)	(1) Oxyvit 50 WP.
Carbendazim 50%	(1) Tensim 50 DF.
Mustard:	
Carbendazim (17.5%) + Iprodione (35%)	(1) Gravity 52.5WP.
Iprodione (50%)	(1) Rovral 50WP; (2) Curate 50WP; (3) Iprosun 50WP; (4) Evaral 50WP; (5) Rovanon 50WP; (6) Hayprodione 50WP; (7) Googlee 50WP; (8) Sevral 50WP; (9) Aristodione 50WP; (10) Agrodione 50WP; (11) Memoral 50WP; (12) Alphadione 50WP; (13) Okral 50WP; (14) Imperial 50WP; (15) RPC 50WP; (16) Ipro 50WP; (17) Telus 50WP; (18) Pottary 50WP; (19) Match 50WP; (20) Rotund 50WP; (21) Nac-blotch 50WP; (22) Anoral 50WP; (23) Pural 50WP.
Iprodione (17.5%) + Carbendazim (8.5%)	(1) Iprozim 26WP.
Dicarboximate + Benzimidazole	(1) Topral 52.5 WP.
Carbendazim 50%	(1) Tensim 50 DF.

Table A3. List of herbicides for respective crops (i. e., rice, wheat, maize, lentil, mustard).

Common name	Trade name
Rice:	
2,4-D Amine	(1) Salix; (2) Amine Gold 48SL; (3) Pafaim 48SL; (4) All Safe 48SL.
2,4-D Dimethyl Amine Salt	(1) Hasclean 72SL; (2) Ding Dong 86SL.
2,4-D Butyl Ester	(1) Rampitox 45WP.
Acetochlor	(1) Offer 50EC.
Bensulfuron methyl (4%) + Acetochlor (14%)	(1) Changer 18WP; (2) Binash 18WP; (3) Washout 18WP; (4) Jhilik 18WP; (5) Nirmul 18WP; (6) Wiper 18WP; (7) Mixt 18WP; (8) Denso 18WP; (9) Beta Power 18WP; (10) Compound 18WP; (11) Sarinda 18WP; (12) Forex 18WP; (13) Biswas 18WP; (14) Benace-G 18WP; (15) Reviser 18WP;

	(16) Nirjhor 18WP; (17) Chloran Plus 18WP; (18) Benchlor 18WP; (19) Nikash 18WP; (20) Herbisul 18WP; (21) Elan 18WP; (22) Supermix 18WP; (23) Mithuben 18WP; (24) Shabil 18WP; (25) Paddy Plus 18WP; (26) Bensanil 18WP; (27) Agami 18WP; (28) Clean Boss 18WP; (29) Excellent 18WP; (30) Nibaron 20WP; (31) Totalcare 18WP; (32) Melor 18WP; (33) Agritop 18WP; (34) Sunchance 18WP; (35) Ben Plus 18WP; (36) Georjerice Gold 18WP; (37) Boomer 18WP; (38) Lalteer 18WP; (39) Naingla 18WP; (40) Palam 18WP; (41) Luxed 18WP; (42) Dibar 18WP; (43) Ascot 18WP; (44) Sakura 18WP; (45) Hosazen 18WP; (46) Muclor 18WP; (47) Super Suspension 18WP; (48) Evaclean 18WP; (49) Paton 18WP; (50) Avizan 18WP; (51) Wideour 18WP; (52) Genesaf 18WP; (53) Hisaf 18WP; (54) Pashun 18WP; (55) Red Clean 18WP; (56) Hurricane 30WP; (57) A-Chlor 18WP; (58) Aceben 18WP; (59) Land Clean 18WP; (60) Power Bean 18WP; (61) Uzar 18WP; (62) Mayar 18WP; (63) KG Kamla 18WP; (64) Orindham 18WP; (65) Sylon Plus 18WP; (66) Darkclean 18WP; (67) Fachlor 18WP; (68) Swath 20WP; (69) Florida 18WP; (70) K Raad Plus 18WP; (71) Paceben 18WP; (72) Hytoclean 18WP; (73) Livina 18WP; (74) Nishes 18WP; (75) Biborna 18WP; (76) Pixar 18WP; (77) Agacha Clear 18WP.
Bensulfuron methyl (0.6%) + Pretilachlor (6%)	(1) Londax Powder 6.6GR.
Bensulfuron methyl (3%) + Mefenacet (50%)	(1) Super Clean 53WP; (2) Clean Master 53WP; (3) Ghash Killer 53WP; (4) Relief 53WP; (5) Get-Clean 69WP.
Bensulfuron methyl (4%) + Quinclorac (28%)	(1) Vacate 32WP; (2) Move 40WP; (3) Namir 32WP; (4) Forise 36WP; (5) Quiben 32WP; (6) Desiquat 36WP; (7) Ble Raj 32WP; (8) Tata Clear 40WP; (9) Mapclorak 40WP; (10) Ronorac 40WP.
Bensulfuron methyl (18%) + Bispyribac Sodium (12%)	(1) Sirius Plus 300WP; (2) Rexikiller 30WP; (3) Lorox 30WP; (4) Benbake 30WP; (5) Dhaman 30WP; (6) Lamia 30WP; (7) Beta Jass 30WP; (8) Bispa 30WP; (9) Bisben 30WP.
Bispyribac Sodium	(1) Surpass 20SC; (2) Xtra Power 20WP; (3) Prune 20WP; (4) Demand 20WP; (5) Fasal Extra 20WP; (6) Beat 20WP AP-4365; (7) Risbac 20WP; (8) Bisdium 20WP; (9) Kris 40SC; (10) Tybac 10SC; (11) Killbro 80WP; (12) Top Clean 40SC.
Butachlor	(1) Aimchlor 5G; (2) Butabel 5G; (3) Vichete 5G; (4) Amcobuta 5G; (5) Baibuta 5G; (6) Betaplus 5G; (7) Nuchlor 5G; (8) Avant 5G; (9) Sunchlor 5G; (10) Ichlor 5G; (11) M-Buta 5G; (12) Echlor 5G; (13)

	Orbuta 5G; (14) Butasin 5G; (15) Kildor 5G; (16) Ravchlor 5G; (17) G-Chlor 5G; (18) Aristochlor 5G; (19) Butax 5G; (20) Bicolor 5G; (21) Ecobuta 5G; (22) Butaguard 60EW.
Butachlor (35 %) +Propanil (35%)	(1) Gang 700EC; (2) Butacrop 70EC.
Carfentrazone Ethyl (50%) + Isoproturon (0.75%)	(1) Sunfinity 50.75WP.
Carfentrazone Ethyl	(1) Aim 40DF; (2) Hammer 24EC.
Cyhalofop-butyl	(1) Rain 10EC; (2) Mitson 10EC; (3) Foray 10EC.
Ethoxysulfuron	(1) Sunrice 15WG; (2) Rigon 15WG; (3) Rigon 15WG; (4) Sunlin 15WG; (5) Picat 15WDG; (6) Sony 15WDG; (7) Ricorice 15WDG; (8) Grazon 15WDG; (9) M-Rice 15WDG.
Fenoxaprop-p-Ethyl	(1) Accurator 69EW; (2) Rai Super 9EC.
Fluazifop-p-butyl	(1) Flomax 12.5EC.
Ethoxysulfuron (10%) + Fluazifop-p-ethyl (10%)	(1) Viber 20WG.
Fenoxaprop-p-ethyl (10%) + Ethoxysulfuron (10%)	(1) Sunjute Plus 20WG.
MCPA-500	(1) MCPA 500.
Metamifop	(1) Pyzero 10EC; (2) Metanil 10EC.
Orthosulfamuron	(1) Kelion 50WP.
Oxadiazon (25%)	(1) Corostar 25EC; (2) Oxastar 25EC; (3) Longstar 25EC; (4) Amcostar 25EC; (5) Activar 25EC; (6) Weeder 25EC; (7) Sentry 25EC; (8) Super Care 250EC; (9) Oxytop 25EC; (10) Dewstar 25EC; (11) Mimstar 25EC; (12) Fadeox 25EC; (13) Ricobar 25EC; (14) Raktivar 25EC.
Oxyfluorfen	(1) Hayguard 24EC; (2) Adecko 24EC.
Paraquat	(1) Gramoxone.
Pendimethalin	(1) Panida 33EC; (2) Monsoon 33EC; (3) Ashrafi 33EC; (4) Gourilin 33EC; (5) Pendi 33EC; (6) Danida Plus 33EC; (7) Pendakill 33EC; (8) Penthalin 33EC; (9) Crezendo 33EC; (10) Agripen 33EC; (11) Fedlin 33EC; (12) Patron 40EC; (13) Pendibon 33EC; (14) Pentaline 33EC; (15) Nila 33EC; (16) Orosun 33EC; (17) Mithylin 33EC; (18) Plasom 33EC.
Penoxulam	(1) Granite 240SC.
Pretilachlor	(1) Rifit 500EC; (2) Saaf 500EC; (3) Longfit 500EC; (4) Commit 500EC; (5) Superheat 500EC; (6) Clear 500EC; (7) Silah 500EC; (8) Richlor 500EC; (9) Sarakill 50EC; (10) Check 500EC; (11) Top 500EC; (12) Mimfit 500EC; (13) Contra 500EC; (14) Amcofit 50EC; (15) Baichlor 50EC; (16) Profit 500EC; (17) Rav 500EC; (18) Pretil 500EC; (19) Weed Guard 50EC; (20) Bumperhit 500EC; (21) Chemchlor 500EC; (22) Prechlor 500EC; (23) Pretilasun 500EC; (24) Refine 500EC; (25) Fast

	500EC; (26) Remote 500EC; (27) Aver 500EC; (28) Seavafit 500EC; (29) Rigid 500EC; (30) Bigboss 500EC; (31) Razfit 500EC; (32) Succour 500EC; (33) G-Clear 50EC; (34) Penicle 500EC; (35) Aerofet 500EC; (36) Rekachlor 500EC; (37) Forfit 500EC; (38) Amahit 500EC; (39) Anand 500EC; (40) Coro Clean 500EC; (41) Pegeon 500EC; (42) Loreto 500EC; (43) Tilachlor 500EC; (44) Parachlor 500EC; (45) Redifit 500EC; (46) Bicofit 500EC; (47) Remit 50EC; (48) Sectila 500EC; (49) Rajfit 500EC; (50) Agasanash 50EC; (51) Ecofit 50EC; (52) Lachlor 500EC; (53) Tenfit 50EC; (54) Macchlor 500EC; (55) Remit 500EC; (56) Takat 500EC; (57) Defeat 500EC; (58) Papil 500EC; (59) Rexichlor 500EC; (60) Sifit 500EC; (61) Green Pretila 50EC; (62) ICI Fit 50EC; (63) Macfit 500EC; (64) Khanchlor 50EC; (65) Adfit 50EC; (66) L-Fit 50EC; (67) N-Fit 50EC; (68) Deschlor 50EC; (69) Pretistar 50EC; (70) Maifit 50EC; (71) Bestchlor 50EC; (72) Mollahcolor 50EC; (73) Agacha Clean Super 50EC; (74) Rifit Plus 37EW; (75) Orochlor 50EC.
Pyrazosulfuron Ethyl	(1) Sirius 10WP; (2) Saathi 10WP; (3) Seacord 10WP; (4) Pyrozosun 10WP; (5) Sior 10WP; (6) Mordern 10WP; (7) Sprit 10WP; (8) Super Power 10WP; (9) Fastklin 10WP; (10) Lubada 10WP; (11) Marajou 10WP; (12) Star 10WP; (13) Zealus 10WP; (14) Amaraj 10WG; (15) Sinoron 10WP; (16) Herbikil 10WP; (17) Remover 10WP; (18) Safety 10WG; (19) Laser 10WP; (20) Star Plus 10WP; (21) Pyrus 10WP; (22) Ghasmara 10WP; (23) Safa 10WP; (24) Pop 10WP; (25) Pyrogold 10WP; (26) Greenup 10WP; (27) Pathal 100WP; (28) Corocide 100WP; (29) Labor 10WP; (30) Signal 10WP; (31) Link 10WP; (32) Nirrani 10WP; (33) Overcome 10WP; (34) Azafuran 10WP; (35) Kosir 10WP; (36) Porishker 10WP; (37) Anima 10WP; (38) Superzo 10WP; (39) Blegold 10WP; (40) Cutout 10WP; (41) System Up 10WP; (42) Bicoron 10WP; (43) Tyraz 10WP; (44) Prime ethyl 10WP; (45) Rajclean 10WP; (46) Fata Kesto 10WP; (47) Nibash 10WP; (48) Danger 10WP; (49) Genesun 10WP; (50) Equation 10WP; (51) Grass Clean 10WP; (52) Pariza 10WP; (53) Get-Cut 10WP; (54) Pylon 10WP; (55) Green Pyra 10WP; (56) Winclean 10WP; (57) Harvest Furan 10WP; (58) Paraside 10WP; (59) SB-Punno 10WP; (60) Kamla 10WP; (61) Sayrazo 10WP; (62) Peak 10WP; (63) Sqadron 10WP; (64) Pyroking 10WP; (65) Stem 10WP; (66)

	Nikash 10WP; (67) Pyra 10WP; (68) Paroj 10WP; (69) Sarniethyl 10WP; (70) Teesta 10WP; (71) Sahara 10WP; (72) Pro-Ethyl 10WP; (73) Anamclean 10WP; (74) Siamethyl 10WP; (75) Empty 10WP; (76) Aid Clean 10WP; (77) MU Clean 10WP; (78) Asfuran 10WP; (79) Halaka 10WDG; (80) Delsuf 10WP; (81) Pyrocare 10WP; (82) Bette Clean 10WP; (83) Locus 10WP; (84) Mediclean 10WP; (85) Pyril 10WP; (86) Racker 10WP; (87) Seed Pyrazo 10WP; (88) Freshfield 10WP.
Pyrazosulfuron Ethyl (0.6%) + Pretilachlor (34.4%)	(1) Cleanser 35WP; (2) Pop Gold 35WP; (3) Tyraz Plus 35WP; (4) Basai 35WP; (5) Fasal Super 35WP; (6) Xper 35WP; (7) Moharaj 35WP; (8) Abolish 20WP; (9) Pychlor 35WP; (10) Kaste 35WP; (11) Pylac 35WP; (12) Vim chlor 35WP; (13) Milestone 35WP; (14) Escape 35WP; (15) Agacha Clean 35WP; (16) Oschlor 35WP; (17) Storite 16.5GG; (18) Eros 6.15GR; (19) Turup 16WG; (20) Eros Gold 30.75DF; (21) L-Pyrazo Plus 35WP; (22) Jiji 16G.
Pretilachlor (50%) + Triasulfuron (2%)	(1) Telone 52WP; (2) Super Wash 52WP.
Pyrazosulfuran-ethyl (3%) + Quinclorac (47%)	(1) Petal 50WP.
Quizalofop-p-Ethyl	(1) Hit Killer 5EC; (2) Gallery 5EC.
Metsulfuron methyl (10%) + Chlorimuron ethyl (10%)	(1) Almix 20WP; (2) Mesuron 20WP; (3) Somadhan 20WP; (4) Farmclean 20WP; (5) Tymix 20WP; (6) Gacha 20WP; (7) Amitrole 20WP.
Metolachlor (16%) + Bensulfuron methyl (4%)	(1) Destroy 20GR
Sulfentrazone	(1) Authority 48SC.
Triasulfuron	(1) Logran 75WG.
Bensulfuron (1.1%) + Metsulfuron (0.2%) + Acetachlor (14.7%)	(1) I-wash 16WP.
Triafamone (20%)	(1) Council Prime 20SC.
2,4-Dichlorophenoxyacetic Acid	(1) Amily 48SL.
Pyriftalid (36.60%) + Bensulfuron methyl (18.48%)	(1) Apiro Fort 55.08SC.
Bentazone (48%)	(1) Sashroyee 48SL.
Quinclorac (50%) + Fenoxaprop-p-ethyl (13%) + Pyrazosulfuran ethyl (7%)	(1) Upgrade 70WP; (2) Bicosaf 70WP.
Bensulfuron methyl (2%) + Pretilachlor (28%)	(1) Matali 30 OD.
Penoxsulam (1.5%) + Pretilachlor (38.5%)	(1) Nazif 40SE.
Paraquat Dichloride 1910-42-5 30.1%	(1) Gramoxone 20 SL.
Butachlor	(1) Aimchlor 5G.
2,4-D	(1) Fielder.

Bispyribac Sodium	(1) Xtrapower 20 WP.
Acetachlor 14% + Bensulfuran methyl 4%	(1) Changer-18 WP.
Oxadiazon	(1) Weeder-25 EC.
Pretilachor 15% Pyrazosulfuron Ethyl 1.5	(1) Storite-16.5 GG.
Pyrazosulfuron-ethyl	(1) Sayrazo 10WP.
Paraquat Dichloride	(1) Paratok 20 SL.
Bensulphuron Methyl+Acetachlor	(1) Sarenda 18 WP.
Bispyribac sodium 18% + Bensulfuron methyl 12%	(1) Ben Back 30 WP.
2,4-D Butyl Ester	(1) Rampitox 45 WP.
Pendimethalin 33%	(1) Samolin 33 EC
Paraquat 13%	(1) Samoxone 13 SL.
2,4-D Amine – 48%	(1) Weed Kill 480.
Pyrazosulfuron-ethyl 10%	(1) Zealus 10 WP.
Bensulfuron Methyl 4% + Acetochlor 14% WP	(1) Total Care 18 WP.
Butachlor 50%	(1) G-Clear 50 EC.
Bispyribac sodium 18% + bensulfuron-methyl 12%	(1) Innosaf 30 WP.
Glufosinate Ammonium 36% + Oxyfluorfen 3%	(1) Root Off 39 SC.
Wheat:	
2,4-D Amine	(1) Fielder 48SL; (2) D-Pro 72SL.
2,4-D Dimethyl Amine Salt	(1) Ding Dong 86SL.
Carfentrazone Ethyl (50%) + Isoproturon (0.75%)	(1) Affinity 50.75WP.
Carfentrazone Ethyl	(1) Hammer 24EC.
Fenoxaprop-p-Ethyl	(1) Winnow Super 10EC; (2) Uber 10EC.
Pendimethalin	(1) Fist 33EC; (2) G-Penda 33EC.
2,4-D	(1) Fielder.
2,4-D Butyl Ester	(1) Jessemine 72 SL.
Pendimethalin 33%	(1) Samolin 33 EC.
Glufosinate Ammonium 36% + Oxyfluorfen 3%	(1) Root Off 39 SC.
Maize:	
2,4-D Amine	(1) Alphamine 72SL.
Bensulfuron methyl (4%) + Acetochlor (14%)	(1) Darkclean 18WP.
Ethoxysulfuron	(1) Exoron 15WDG.
Fluazifop-p-butyl	(1) Ajafa 12.5EC.
Cyhalofop-butyl (5%) + Fecoxaprop-p-ethyl (5%)	(1) Depon 10EC.
Metribuzin	(1) Neon 70WG; (2) Dhani 70WG; (3) Samodish 70WG.
Clomazone (5%) + Metribuzine (20%)	(1) Metric 25ZC.

Atrazine (50% + 5%)	(1) G-Maize 50SC; (2) Atraforce 80WP.
Atrazine (25%) + Mesotrione (2.5%)	(1) Calaris Xtra 27.5SC; (2) Vepar 27.5SC; (3) Aneha 27.5SC; (4) Atraforce Plus 55SC; (5) Copter 55SC; (6) Triozine 55SC; (7) Moontex 55SC; (8) Prism 27.5SC; (9) Bajna 55SC; (10) Mesotin 50WP; (11) Jaba 55SC; (12) Aone 55SC.
Nicosulfuron	(1) Uribest 4SC; (2) Hulk 4SC.
Pendimethalin	(1) Herbilin 33EC.
Topramezone (33.60%)	(1) Clio 33.60SC.
Lentil:	
Glufosinate Ammonium 36% + Oxyfluorfen 3%	(1) Root Off 39 SC.
Mustard:	
Quizalofop-p-Ethyl	(1) Samfop 5 E C.
Glufosinate Ammonium 36% + Oxyfluorfen 3%	(1) Root Off 39 SC

Source: Department of Agricultural Extension (DAE), ACI Crop Care Ltd., Syngenta Bangladesh Ltd., Bayer, National AgriCare, Acme Pesticides Ltd., Raven Group, Nature & Care Agro Products Ltd., Tens Agro Ltd., Sam Agro Chemical, DM Crop Care Ltd.

Appendix F

Appendix F: Checklist for Key Informant Interview (KII) of Bangladesh Agricultural Development Corporation (BADC).

CHECKLIST FOR KEY INFORMANT INTERVIEW (KII)

STRICTLY PRIVATE & CONFIDENTIAL FOR ACADEMIC AND RESEARCH PURPOSES

Research Questionnaire:

"***From data to farm decisions: Developing grain-oilseed cost and return guide for Bangladesh***"

Project Code: BGD-25165

Study background

This research intends to develop comprehensive crop budgets, one of the most extensively used tools in farm economics, needed by farmers, agribusiness, academics and research, and policy makers to make data-driven decisions. In countries such as the United States, the United Kingdom, the European Union, and Canada, crop budgets are updated annually and made publicly available online/printed form to support decision-making. Unfortunately, over the last five decades, Bangladesh has not maintained systematically updated and publicly accessible crop budgets for farm enterprises. In response to the absence of crop budgets, this study seeks to develop costs and return guideline for grain-oilseed farms.

This research contributes to Bangladesh's growing economy and support the 'sustainable, safe and profitable' agriculture vision of the National Agriculture Policy (2018). This study maps the crop zones for major crops (*Aman* rice, *Boro* rice, and wheat) and key rotational crops (maize, lentil, and mustard) followed by development of crop budgets for grain-oilseed for that zone where particular crops are intensified. This research is designed as an extension of the IGC project (BGD-24192), addressing fundamental questions of farm productivity and economics in alignment with the IGC's firm, trade, and productivity theme.

The study is being conducted by the Hub for Smallholders Agri-Tech Economics (HSATE) under the *Department of Agricultural Economics*, *Faculty of Agricultural Economics and Rural Sociology*, *Bangladesh Agricultural University (BAU)*, *Mymensingh-2202, Bangladesh*. This study is funded by the *International Growth Centre (IGC)*, which is directed by *The London School of Economics and Political Science (LSE)* and *University of Oxford*.

Who is eligible to take part?

This KII is conducted with the officials from the Bangladesh Agricultural Development Corporation (BADC).

How long will the study last?

On average, the duration of this survey will be for 30 minutes.

Confidentiality:

Your responses will be kept strictly confidential and will only be used for academic and research purposes envisages in this study. Personal information will not be shared or disclosed to any third parties.

Ethical Approval:

This research and survey are ethically approved by the Bureau of Socioeconomic Research and Training (BSERT) subject to follow the BSERT code of ethics for research in the biological, economic, social and behavioural sciences involving human participants.

Consent:

By participating in this survey, you agree to share your responses for academic and research purposes. You have the right to withdraw from the survey at any time without any consequences. We will be happy to answer any questions you have about this study. For further queries or if you have any other research ideas related to this study, you may contact the Principal Investigator, Dr. A. K. M. Abdullah Al-Amin at Phone: +8801743120000 and/or Email: abdullah.alamin@bau.edu.bd.

Name of the Respondent	
Name of the Institution	
Do you agree to participate in this survey? (Yes=1, No=0)	
Signature	

Thank you in advance for your participation in this study

CHECKLIST FOR KEY INFORMANT INTERVIEW (KII)

1. Could you please specify what are the basic differences among foundation seed, certified seed, and truthfully labelled seed (TLS)? Which type is most accessible to farmers?

   ____

2. Is there any variation in seed prices (BDT/kg) across divisions? (Yes=1, No=0)

   ____

3. If yes, could you please provide the division-wise seed prices (BDT/kg) for the respective crops?

   - Rangpur:
     - HYV *Aman*: _____
     - Maize (Rabi): _____
   - Rajshahi:
     - HYV *Boro*: _____
     - Wheat: _____
     - Mustard: _____
   - Khulna:
     - Lentil: _____

4. What is the usual method of payment by farmers for purchasing seeds: cash, in-kind, or partly both?

   ____

5. Do farmers typically purchase seeds through conventional methods? (Yes=1, No=0)

   ____

6. Does the seed distribution process involve any formal contractual arrangement? (Yes=1, No=0)

   ____

7. If yes, please describe.

   ____

8. What are the mechanisms for purchasing seeds under typical farming practices and contract farming arrangements? Please describe.

   ____

9. What is the usual method of payment by farmers for irrigation charges: cash, in-kind, or partly both?

   ____

10. Does the irrigation service provision involve any formal contractual agreement? If yes, please describe.

    ____

11. What are the mechanisms for accessing irrigation services under typical farming practices and contract farming arrangements? Please describe.

    ____

12. What is the basis of calculating irrigation charges (e. g., hourly/seasonally)?
    ____

13. Could you please clarify the amount farmers typically pay for irrigation?
    ____

14. Is the irrigation charge uniform across all crops? If yes, please explain the reason. If no, what factors cause the irrigation rate to vary across different crops?
    ____

15. What is the irrigation charge rate in the respective divisions (i. e., Rajshahi, Rangpur, Khulna)?
    ____

16. How do irrigation rates differ between metered (meter card) and non-metered systems?
    ____

17. How do you monitor and determine irrigation charges? How frequently are the irrigation rates revised or adjusted?
    ____

18. How can irrigation charge data be made publicly available?
    ____

19. Do you have any plans to provide a user-friendly digital dashboard to publish and regularly update irrigation rate information on your website?
    ____

20. Could you explain why price information is available only for TSP, MOP and DAP fertilizers, and not for other types?
    ____

21. Do you have plans to provide price information for other fertilizers (e.g., urea, gypsum)? If yes or no, please explain the reason.
    ____

22. What is your perspective on promoting liquid fertilizers compared to conventional granular fertilizers?
    ____

23. If the government wants to link your data directly to their website, how would you handle and organize it? Any thoughts to digitized database to inform national decisions?
    ____

24. If a training session is held to discuss digitizing the data and linking it to a government website, how would you respond? Does your institution have any expectation from subject matter experts like us? How we could help your capacity building?
    ____

Appendix G

Appendix G: Checklist for Key Informant Interview (KII) of Department of Agricultural Marketing (DAM).

CHECKLIST FOR KEY INFORMANT INTERVIEW (KII)

STRICTLY PRIVATE & CONFIDENTIAL FOR ACADEMIC AND RESEARCH PURPOSES

Research Questionnaire:

"***From data to farm decisions: Developing grain-oilseed cost and return guide for Bangladesh***"

Project Code: BGD-25165

Study background

This research intends to develop comprehensive crop budgets, one of the most extensively used tools in farm economics, needed by farmers, agribusiness, academics and research, and policy makers to make data-driven decisions. In countries such as the United States, the United Kingdom, the European Union, and Canada, crop budgets are updated annually and made publicly available online/printed form to support decision-making. Unfortunately, over the last five decades, Bangladesh has not maintained systematically updated and publicly accessible crop budgets for farm enterprises. In response to the absence of crop budgets, this study seeks to develop costs and return guideline for grain-oilseed farms.

This research contributes to Bangladesh's growing economy and support the 'sustainable, safe and profitable' agriculture vision of the National Agriculture Policy (2018). This study maps the crop zones for major crops (*Aman* rice, *Boro* rice, and wheat) and key rotational crops (maize, lentil, and mustard) followed by development of crop budgets for grain-oilseed for that zone where particular crops are intensified. This research is designed as an extension of the IGC project (BGD-24192), addressing fundamental questions of farm productivity and economics in alignment with the IGC's firm, trade, and productivity theme.

The study is being conducted by the Hub for Smallholders Agri-Tech Economics (HSATE) under the *Department of Agricultural Economics*, *Faculty of Agricultural Economics and Rural Sociology*, *Bangladesh Agricultural University (BAU)*, *Mymensingh-2202, Bangladesh*. This study is funded by the *International Growth Centre (IGC)*, which is directed by *The London School of Economics and Political Science (LSE)* and *University of Oxford*.

Who is eligible to take part?

This KII is conducted with the officials from the Department of Agricultural Marketing (DAM).

How long will the study last?

On average, the duration of this survey will be for 30 minutes.

Confidentiality:

Your responses will be kept strictly confidential and will only be used for academic and research purposes envisages in this study. Personal information will not be shared or disclosed to any third parties.

Ethical Approval:

This research and survey are ethically approved by the Bureau of Socioeconomic Research and Training (BSERT) subject to follow the BSERT code of ethics for research in the biological, economic, social and behavioural sciences involving human participants.

Consent:

By participating in this survey, you agree to share your responses for academic and research purposes. You have the right to withdraw from the survey at any time without any consequences. We will be happy to answer any questions you have about this study. For further queries or if you have any other research ideas related to this study, you may contact the Principal Investigator, Dr. A. K. M. Abdullah Al-Amin at Phone: +8801743120000 and/or Email: abdullah.alamin@bau.edu.bd.

Name of the Respondent	
Name of the Institution	
Do you agree to participate in this survey? (Yes=1, No=0)	
Signature	

Thank you in advance for your participation in this study

CHECKLIST FOR KEY INFORMANT INTERVIEW (KII)

1. Although month wise crop selling price data are available, a few months are not recorded during the 2023–24 production year. Could you kindly clarify the reasons for these data gaps?

   ____

2. Could you please provide the month-wise selling prices of the respective crops (i.e., *Aman* rice, *Boro* rice, wheat, maize, lentil, and mustard) across divisions for the 2023-24 production year?

   ____

3. Do you have plans to gather and publish price information for by-products of major and rotational crops in Bangladesh?

   ____

4. Do you have plans to collect and publish seed price information for major and rotational crops in Bangladesh?

   ____

5. Although month wise fertilizer selling price data are available, a few months are not recorded during the 2023–24 production year. Could you kindly clarify the reasons for these data gaps?

   ____

6. Could you please provide the month-wise selling prices of the respective fertilizers (i.e., urea, TSP MOP gypsum) across divisions for the 2023-24 production year?

   ____

7. Could you clarify why local MOP prices are not listed on your website alongside imported prices?

   ____

8. Could you clarify why the fertilizer prices (i. e., TSP and MOP) offered by DAM differ from those of BADC?

   ____

9. Could you please explain why the selling prices of government-registered pesticides (e.g., insecticides, fungicides, and herbicides) are not published on your website?

   ____

10. Do you have any plans to publish the government registered pesticides (e. g., insecticides, fungicides, herbicides) selling price on your website?

    ____

11. Why are land prices (e.g., selling, renting, or other arrangements) not listed on your website? Do you have any plans to publish land price information at different administrative levels (e.g., division, district, upazila, or village)? Please explain.

    ____

12. Currently, accessing crop and fertilizer price data from your website requires navigating through multiple steps (e.g., selecting the price section, monthly average report, division, district, upazila, market directory, commodity group, sub-group, commodity name, and year). What are your views on simplifying this process to make the information more accessible and user-friendly?

    ____

13. Although you have data available at the upazila, thana, district, and division levels, we noticed that information for some regions is missing on your website. How would you address these data gaps?

    ____

14. As we are planning to develop an online cost and return guide tool, how can we establish a direct link or data integration with your website?

    ____

15. If the government wants to link your data directly to their website, how would you handle, organize and simplify it? For example, linking DAM data to government website dashboard may show farm economics like stock markets dynamics. Any thoughts to digitized database to inform national decisions?

    ____

16. If a training session is held to discuss digitizing the data and linking it to a government website, how would you respond? Does your institution have any expectation from subject matter experts like us? How we could help your capacity building? Do you prefer any hands-on training sessions to develop cost and return guide or simplify your data interface that may be user friendly?

    ____

17. What requirements or expectations do you have from academicians, researchers, or the government in this regard? Please advise your requirements and suggestions.

    ____

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