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Price and Output Response of Major Food Grains of Nadia District of West Bengal

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Received: 10 September 2024; Accepted: 11 December 2024; Available online: 16 December 2024

ABSTRACT: The price and output response of food crops is a critical area in agricultural economics as this interaction refers to how the quantity of food grains supplied responds to changes in market prices. This research investigates the surplus ratios and price elasticities for rice, lentil, and gram in the Nadia district of West Bengal. Two hundred farmers were interviewed in different villages of the district and information was collected regarding socio-economics, marketed surplus and, selling price, etc. Further, elasticity and a modified version of the Raj Krishna model have been employed. The findings reveal that for rice, the ratios of gross, net marketed, and marketable surplus are 69.59%, 55.46%, and 16.27%, respectively. The gross marketed surplus ratio decreases with a reduction in farm size, while net marketed and marketable surpluses increase as farm size expands. For lentils, the gross and net marketed surplus ratios are recorded at 66.64% and 65.57%, with an average marketable surplus of 35.30%. Marginal gram farmers have a gross marketed surplus ratio of 80.33%, slightly lower than the overall average of 81.12%, whereas larger farms exceed this average, with ratios of 82.19% and 83.18%. Output elasticities for rice are positive and exceed unity for both marginal and large farms, at 1.03 and 1.45, respectively, though slightly below unity at 0.85 for small farms. The average elasticity for rice across all farm sizes is 1.12. Lentil output elasticities are also positive and greater than unity for marginal and large farms (1.00 and 1.07, respectively) but fall below unity at 0.78 for medium farms, with an overall average of 0.91. The output elasticities for gram remain consistently positive and above unity across all farm sizes, averaging 1.09.

Keywords: Supply response; Marketable surplus; Price elasticity; Food grains; Agricultural production

1. Introduction

The degree to which the area planted with a crop responds to changes in its price is referred to as the supply response [1]. The concept of marketed surplus is objective in nature because it refers to the actual quantity that enters the market [2]. These two concepts are employed to assess the impact of price policies and guide farmers in optimizing resource allocation. Thus, supply response pertains to the chain reaction where price fluctuations of outputs influence input adjustments, eventually affecting production [3]. Given that both the supply and the marketed surplus of food grains are vital components of the food security system, a comprehensive analysis of the factors influencing supply and marketed responses is crucial [4,5]. Over the past few decades, farmers' reactions to economic variables have attracted significant attention in both developing and developed nations [6]. Developing economies need to grasp supply dynamics in order to craft policies aimed at boosting production to ensure adequate nutrition for their expanding populations and stimulate economic growth [7]. Similarly, understanding these dynamics in developed nations is critical

https://doi.org/10.70322/rrd.2024.10022

for managing surpluses, increasing farm incomes, and improving resource productivity [8]. In the 1950s, there was a widespread belief that farmers in underdeveloped countries like India did not react to price variations, or when they did, the reaction was negative. This assumption stemmed from a lack of reliable research on how agricultural output in India responded to price shifts at that time. In the following years, researchers applied Nerlove's expectation model (1958) [9] to analyze this phenomenon. Raj Krishna (1962) [10] was among the first to evaluate the supply response of specific food and cash crops in the Punjab region, examining the impact of both price and non-price factors. His findings revealed a significant and positive price elasticity of acreage for all crops except jowar, which negatively correlated with price movements. Recent research in Odisha demonstrated that boosting marketable surplus can elevate farmers' incomes, as they can sell a larger portion of their produce at market prices [11]. Such increases in marketable surplus contribute to agricultural growth, with positive effects on productivity, income, and rural development [12]. Similarly, a study in Rajasthan concluded that a rise in marketed surplus could enhance small farmers' incomes by allowing them to sell more produce in the marketplace [13]. Dharm Narain's seminal work (1961) [14] highlighted that marketable surplus, as a proportion of total output, declines with increasing farm size up to 10–15 acres, beyond which it rises steadily. He also noted that prices played a decisive role in farmers' decisions to plant cash crops, while rainfall had a more significant impact on their choice of food crops. Krishnan (1965) [15] established that the negative elasticity of marketable surplus was a clear phenomenon, and distress sales among farmers had not diminished. Thakur, D.S. et al. (1997) [16] further demonstrated that the elasticity of marketed surplus relative to output was positive and greater than one for all crops, with small farmers showing greater responsiveness in selling surplus than larger farmers. A study in Bihar explored the marketable surplus of key food grains such as rice, wheat, maize, and pulses [17]. While numerous studies have investigated supply responses in Indian agriculture over recent decades, the findings often present conflicting perspectives. Besides price, other non-price factors also significantly influence farmers' acreage decisions. Variables such as agro-climatic conditions, land characteristics, and the farmers' familiarity with the crop, along with price, affect cropping choices. Additionally, a low risk-bearing capacity may weaken the acreage-price response, particularly when more profitable crops are linked to greater risks. The key determinants of this response can vary notably at the household, state, zonal, or national level [18]. Hence, it becomes necessary to understand the behaviour of marketed surplus of food crops grown partly for home consumption is of prime importance [10,19].

Nadia district is situated in the heart of the Ganges delta in West Bengal. The entire district lies in the alluvial plain of the Ganga and its tributaries. Topographical characteristics determine the agricultural profile of any region. Nadia district is situated in the heart of the lower Gangetic plain, which is why the soil of the district is classified as Gangetic alluvium and has a light texture. The physiography of the district is mostly plain. There are pockets of mild slopes here and there. The entire district is crisscrossed by numerous rivers and streams. The principal rivers of the district are Bhagirathi, Jalangi, and Mathahbhanga. Agriculture plays a critical role in rural development, as it is the primary source of livelihood in this district. With a large rural population, those who depend on agriculture should be given priority, as this would benefit not only the rural population but also contribute to agriculture's role in the national economy. The most important crop in the Nadia district is rice, but vegetables are also cultivated vastly nowadays. The total gross cropped area is 697.7 thousand hectares, whereas the net sown area is 280.2 thousand hectares, with 249% cropping intensity in this district. According to the Government of West Bengal, about 60% of the area comes under rainfed area, which is 417.5 thousand hectares. The total gross irrigated area is 217.9 thousand hectares, whereas the net irrigated area is 209.6 thousand hectares. The agricultural sector of Nadia district is predominantly dominated by marginal and small farmers, who constitute more than 90% of the total farmers. The area in which they operate accounts for 89% of the total operational area of the district.

Rice, lentils, and gram were selected for surplus response studies in Nadia District, West Bengal, due to their significance as staple food crops and extensive cultivation in the region. These crops play a crucial role in the local diet and economy, making them vital for food security and agricultural sustainability. However, studies related to price and output responses in these crops in this region are very scarce. This study aims to analyze the marketed and marketable surplus of these crops, to stimulate development in both farm and non-farm sectors. Additionally, the socio-economic characteristics of farmers in Nadia, such as age distribution, education levels, and family size, influence their agricultural practices and surplus production. Understanding how farmer demographics, particularly between marginal and large-scale farmers, influence surplus responses is crucial for designing effective agricultural policies. By focusing on rice, lentil, and gram, the study seeks to provide actionable insights to enhance productivity and market access for farmers in Nadia District.

After the introduction, the methodology is discussed, followed by the results and discussion sections. The paper concludes with a final section.

2. Methodology

2.1. Data Source, Survey Technique and Number of Respondents

The primary data used to analyze marketed and marketable surplus, along with other relevant information, were collected from 200 farmers (Figure 1). These farmers were chosen from two clusters, each consisting of three villages located in the Haringhata and Chakdah blocks of Nadia district, West Bengal. Each cluster contributed 100 farmers cultivating rice, gram, and lentils, and these farmers were selected using a population proportionate to size sampling method. Within each village, the specified number of farmers was selected through the Simple Random Sampling without Replacement (SRSWOR) method. Data was gathered through personal interviews using a pretested schedule (Appendix A). Notably, rice, lentil, and gram were selected as proxies for food grains in this study, with rice representing cereals, and lentil and gram representing pulses.

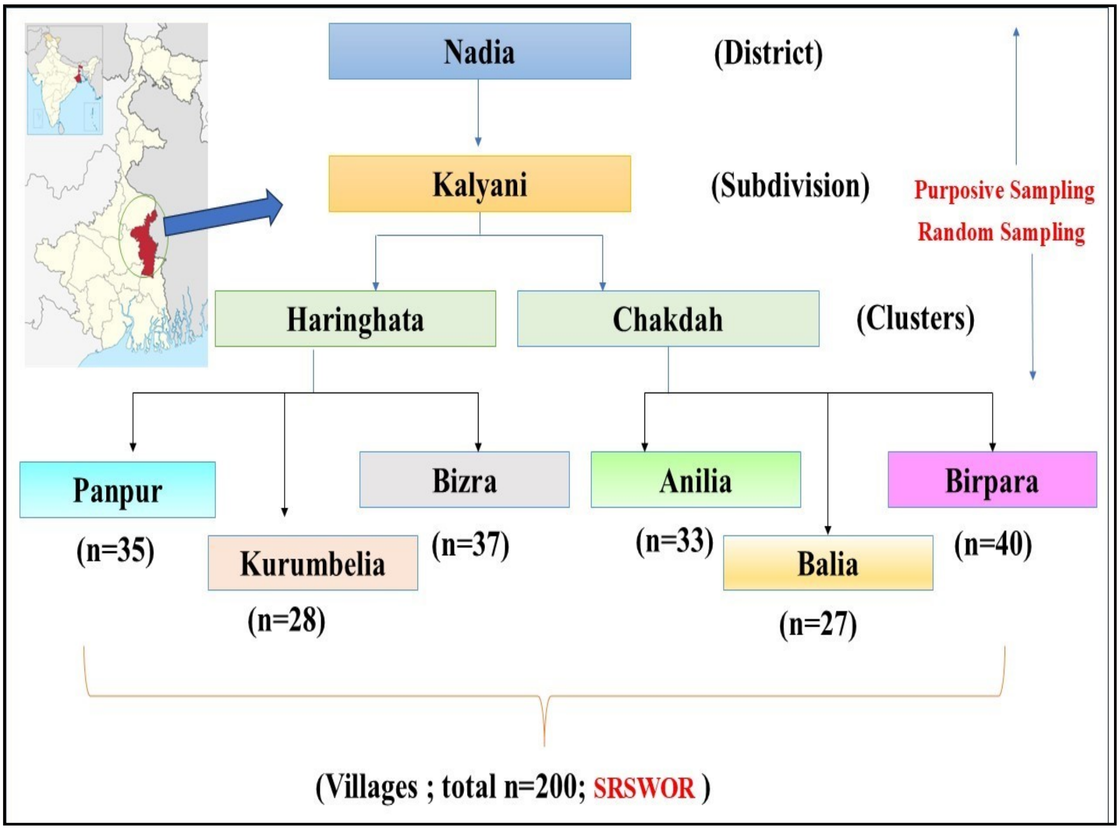

Figure 1. Details of the Study Area and Sampling method used. Here, *n* = number of sampled farmers.

2.2. Analytical Tool

In economics, elasticity refers to the responsiveness of one variable to changes in another variable. The most common type is price elasticity of demand, which measures how the quantity demanded of a good responds to changes in its price. It is calculated as the percentage change in quantity demanded divided by the percentage change in price. If the elasticity is greater than one, demand is considered elastic (sensitive to price changes), while if it is less than one, demand is inelastic (less sensitive to price changes).

The surplus ratio typically refers to the portion of a product that remains after accounting for consumption and other uses, and is available for sale or trade. In agricultural contexts, it can denote the proportion of total production that is marketed or sold after meeting household consumption needs. For example, if a farmer produces a certain amount of a crop and retains some for personal use, the surplus ratio would reflect the remaining amount available for sale. This ratio helps assess market dynamics and farmers' decision-making regarding production and consumption.

The marketed surplus is calculated by applying the following formula;

$$\text{Marketed Surplus (MS)} = A - B$$

where A stands for total production of the concerned crop and B indicates the quantity actually marketed.

Gross Marketed Surplus = Net availability − Quantity actually sold in the market

Net Marketed Surplus = Net availability − Quantity actually sold − Repurchase

Gross Marketed Surplus Ratio = Gross Marketed Surplus/Net Availability

Net Marketed Surplus Ratio = Net Marketed Surplus/Net Availability

By the term net availability, we actually mean the net of total production subtracting wastages at different stages, namely, during transportation, threshing, storage, *etc.*, which will not be available for either consumption or marketing.

To determine the production elasticity of marketed surplus, the following model was employed:

$$Y_i = b_0 + b_1 X_i + \mu_t Y_i = b_0 + b_1 X_i + \mu_t \quad (1)$$

where, Y_i denotes the quantity of marketed surplus of i^{th} crop; X refers to the amount of output of the i^{th}; μ_t is the error term; b_0 is the intercept and b_1 indicates the marginal propensity to sell.

The elasticity of marketed surplus is calculated using the formula:

$$\mathcal{E} = \frac{b_1 \bar{X}}{\bar{Y}} \quad (2)$$

where, Ɛ indicates an elasticity of marketed surplus; b_1 is the regression co-efficient of the variable; $\bar{X}$ is the mean value of output produced; and $\bar{Y}$ is the mean of marketed surplus.

Similarly, the impact of price on the marketed surplus can be estimated by the following linear market arrival function:

$$Y = b_0 + b_2 X + \mu_1 \quad (3)$$

where, Y is the quantity of marketed arrivals (quantity actually sold); X is the average price of the crop; b_0 is the intercept term, and b_2 is the coefficient.

The elasticity of marketed surplus in relation to average price is determined using the following formula:

$$\mathcal{E}_p = b_2 \frac{\bar{X}}{\bar{\bar{Y}}} \quad (4)$$

Here, $\bar{X}$ and $\bar{Y}$ represent the mean value of market arrival and price, respectively.

To investigate the size and magnitude of the price elasticity of marketed surplus of a subsistence crop, the famous Raj Krishnan model is generally used.

Raj Krishnan model (1962) [10]:

M = Q − C

e = rb − (r − 1) (g + mkh) When M = Marketed surplus,

Q = total production of the crop

C = on farm consumption of the crop

P = Price of the produce

I = Total/net income of the producer

e = elasticity of marketed surplus with respect to the price of the crop

r = reciprocal sales ratio (μ/Θ)

b = output elasticity of the crop

g = price elasticity of consumption of the crop

m = sales ratio (M/Q)

h = income elasticity of consumption of the crop

k = (PQ/I) = ratio of the total value of production to the total/ net income of the producer.

But here, a modified version of the Raj Krishna model as proposed by Janvry and Kumar (1981) [20] has also been used in a study conducted by A. A Reddy (2009) [21], is applied to estimate the price elasticity of marketed surplus, represented by the equation:

$$\text{Price elasticity of marketed surplus} = \left[\left(\frac{C}{M}\right) \times \text{Price elasticity of consumption} - \left(\frac{C}{M}\right) \times \left(\frac{PQ}{I}\right) \times \text{Income elasticity of demand}\right] \quad (5)$$

Here, 'I' denotes the total income of the family from all sources and Data from all sources is applied with consistent notation, as previously noted. C = Family consumption of the crop; M = Marketed surplus, (PQ/I) = ratio of the total value of production to the total net income of the producer.

In this analysis, the average monthly per capita consumption expenditure (MPCE) for each crop serves as a proxy for income, which is used to estimate the income elasticity of quantity demanded. A study in Odisha has shown that the income elasticity of expenditure, as a proxy for the income elasticity of demand for food and non-food items, tends to be higher for various income and occupational groups when examined through the Engel ratio analysis [22]. Additionally, research by Chatterjee et al. (2016) [23] on consumption inequality concluded that increasing per capita consumption (a reliable proxy for per capita income) leads to heightened inequality. Data on rural household income and expenditure were obtained from various reports titled "Household Consumption of Various Goods and Services" published by the National Sample Survey Organization (NSSO), Government of India.

3. Results and Discussion

This section presents the estimated marketed and marketable surplus for selected food grain crops, specifically rice, lentil, and gram, based on data from sample farmers as well as the socio-economic status of the sample farmers.

3.1. Socio-Economic Overview of the Farmers

A region's socioeconomic profile of farm households can give one a thorough understanding of some key characteristics of farm households that may influence choices about which businesses to pursue, how to use technology, marketing strategies, and consumption habits. Different farm households' employment, consumption patterns, and enterprise combinations may be impacted by their unique traits and other socioeconomic elements of the farm household, like gender, age distribution, and educational attainment [24]. Understanding farmers' attitudes toward the ability to retain produce, as well as the marketed and marketable surplus, is another benefit of the demographic profile research. The socio-economic data for the sample farmers is shown in Table 1. Based on their age, the sample farmers from the Nadia district are divided into three groups for this study. The findings reveal that 51% of farmers are aged between 31 and 50, while 37% are over 50. Just 12% of farmers (24 individuals) are aged 30 or younger. The lowest percentage of farmer's involvement in farming can be attributed to the fact that the new generation of young, educated people are not interested in agriculture [25].

Table 1. Socioeconomic Characteristics of sampled farmers.

Characteristics	Frequency	Percentage
Age group (in years)		
≤30	24	12
31 to 50	102	51
>50	74	37
Family size group		
≤3	37	18.50
4–5	144	72.00
>5	19	9.50
Education level		
Illiterate	32	16.00
<8	35	17.50
8 to 10	52	26.00
10 to 12	60	30.00
>12	21	10.50
Landholding size		
<1	145	72.50
1 to 2	42	21.00
2 to 4	13	6.50

The majority of the sample farmers, accounting for 72% of the total, have a family size ranging from 3–5 persons, and 18.5% of the total respondents have a family size less than equal to 3 persons. The lowest percentage of sample farmers, measuring 9.5% of the total, has family members exceeding 5 persons. An increase in family size would lead to an increase in the family status of the households, *i.e.*, an increase in the family size will increase the household's farm and non-farm income, which may improve the marketable surplus [26]. Level of education is also important as it helps a farmer to adapt according to the conditions that arise. The data indicate that about 30% of sampled farmers have formal education between 10 and 12 years, while 26% belong to the group with 4 to 10 years of schooling. Farmers with fewer than 4 years of schooling comprise 17.5% of the total, while those with more than 12 years of schooling constitute 10.5% of the total. Farmers with fewer than 4 years of schooling make up 17.5% of the total, while those with more than 12 years of schooling account for 10.5% of the total. A sizeable proportion of farmers, measuring 16%, are found to be illiterate without having any formal education. It is expected that the last group of farmers with the highest level of education will be more likely to adopt modern technology faster than their counterparts at the lower level. Low earnings from farms are partly the result of their relatively lower human capital endowment and partly of labour market discrimination [27]). The size of the landholding also positively affects the total produce, as well as the marketable and marketed surplus [28]. In the present study, it is observed that 72.5% of farmers have a landholding size of less than 1 hectare, while 21% and 6.05% of the land are held by small and semi-medium farmers, respectively.

3.2. Rice Retention and Sales

The total retention of rice by farmers, categorized by farm size, is provided in Table 2. The average production across all farm sizes is 12.09 quintals. Of this, the largest portion, 2.47 quintals, is retained for self-consumption, while 0.60 quintals are reserved for seed purposes, and 0.48 and 0.12 quintals are allocated for feed and other needs, respectively. Farmers with smaller landholdings (less than 1 hectare) retain the least amount for self-consumption, averaging 1.47 quintals, whereas those with larger holdings (over 2 hectares) retain an average of 10.92 quintals. This trend suggests that the amount retained for household consumption increases with farm size. Overall, the total retention averages 3.68 quintals, of which the majority (2.47 quintals) is used for family consumption. These results indicate that retention increases as farm size grows.

Table 2. Total Retention of Rice by Farm Size.

Serial No.	Farm Size (ha*)	Production (q*)	Seed (q*)	Feed (q*)	Other (q*)	Self-Consumption (q*)	Total Retention (q*)	Quantity Sold (q*)
1.	<1	9.03	0.45	0.36	0.09	1.47	2.37	6.65
2.	1–2	15.17	0.76	0.61	0.15	3.18	4.69	10.48
3.	>2	34.92	1.75	1.40	0.35	10.92	14.42	20.51
Total/Average		12.09	0.60	0.48	0.12	2.47	3.68	8.42

[*ha—Hectare and *q—Quintal].

3.3. Marketed and Marketable Surplus Ratio (In Percentage) of Rice

Table 3 presents the gross, net, and marketable surplus for rice. The average gross marketed surplus for all farmers is 69.59%, meaning that most of the production is sold, especially among smaller farmers. Marginal farmers with less than 1 hectare of land have the highest gross marketed surplus (73.72%). In contrast, farmers with over 2 hectares of land have the lowest (58.72%), which implies that an inverse correlation is present between the farm size and marketed surplus [29,30]. The net marketed surplus follows a different pattern, with larger farmers (>2 hectares) exhibiting the highest net marketed surplus (58.72%) due to lower levels of repurchase during the year. This demonstrates a positive relationship between farm size and net marketed surplus. Overall, the average net marketed surplus for all farm sizes is 55.46%. The marketable surplus, which excludes retention for family needs, is much smaller. On average, the marketable surplus across all sample farmers is 16.27%, with the lowest ratio (6.31%) among farmers with less than 1 hectare and the highest (41.28%) among those with over 2 hectares. This increase in marketable surplus with larger farm sizes can be attributed to higher production and relatively stable retention levels across all groups.

Table 3. Marketed and Marketable Surplus of Rice by Farm Size.

Serial. No.	Farm Size	Gross Marketed Surplus (%)	Net Marketed Surplus (%)	Marketable Surplus (%)
1.	<1	73.72	53.76	6.31
2.	1–2	69.07	56.48	18.33
3.	>2	58.72	58.72	41.28
Total/Average		69.59	55.46	16.27

3.4. Lentil Retention and Sales

The retention and sales data for lentils are presented in Table 4. On average, the total production is 1.62 quintals, of which 0.54 quintals are retained, primarily for self-consumption (0.38 quintals). The retention for other purposes, such as seed and feed, is minimal (0.08 and 0.07 quintals, respectively). Farmers with less than 1 hectare of land retain the least (0.45 quintals), while those with larger farms retain more (1.18 quintals). Notably, about 50% of the lentils produced are retained for domestic use, reflecting for domestic use, reflecting the crop's dietary importance locally.

Table 4. Total Retention of Lentil by Farm Size.

Serial No.	Farm Size (ha*)	Production (q*)	Seed (q*)	Feed (q*)	Other (q*)	Self-Consumption(q*)	Total Retention (q*)	Quantity Sold (q*)
1.	<1	1.50	0.8	0.06	0.02	0.30	0.45	1.05
2.	1–2	1.75	0.9	0.07	0.03	0.49	0.66	1.08
3.	>2	2.41	0.12	0.10	0.05	0.83	1.18	1.31
Total/Average		1.62	0.08	0.07	0.02	0.38	0.54	1.08

[*ha—Hectare and *q—Quintal].

The gross marketed surplus for lentils is estimated at 66.64% across all farm sizes, with the highest ratio (70%) found in the smallest farms (Table 5). As farm size increases, this ratio decreases, reaching 55.41% for the largest farms. Similarly, the net marketed surplus ratio shows a decline from 68.38% among the smallest farmers to 55.41% for the largest. The marketable surplus follows a similar pattern, with an average of 32.30% across all farm sizes. Smaller farms retain less for consumption and sell more, while larger farms can retain more for domestic use, resulting in comparatively higher marketable surplus ratios.

Table 5. Marketed and Marketable Surplus of Lentil by Farm Size.

Serial No.	Farm Size (ha)	Gross Marketed Surplus (%)	Net Marketed Surplus (%)	Marketable Surplus Ratio (%)
1.	<1	70.00	68.38	28.38
2.	1–2	62.00	62.00	38.00
3.	>2	55.41	55.41	44.59
Total/average		66.64	65.57	32.30

3.5. Gram Retention and Sales

For grams, the average retention is 0.23 quintals out of a total production of 1.22 quintals per household. As with lentils, the proportion of the crop retained is relatively small, reflecting the greater reliance on marketing for this crop.

The retention of gram for self-consumption among different farm sizes, as illustrated in Table 6, reveals that marginal farmers (<1 ha) have the lowest retention at 0.21 quintals, which increases progressively with farm size, reaching a maximum of 0.29 quintals for those with more than 2 ha of land. On average, farmers retain about 0.23 quintals of gram for personal use, with total retention accounting for roughly one-fifth of overall production, as gram is consumed less frequently than other pulses like lentils. The quantity of gram sold is highest for larger farm size groups (>2 ha), averaging 1.42 quintals, while marginal farmers sell 0.86 quintals. Overall, the average quantity sold across all farm sizes stands at 0.99 quintals per household.

Table 6. Estimation of Total retention (q) of Gram by sample farmers classified according to the size of holding.

Serial No.	Farm Size (ha*)	Production (q*)	Seed (q*)	Feed (q*)	Other (q*)	Self-Consumption(q*)	Total Retention (q*)	Quantity Sold (q*)
1.	<1	1.08	0.5	0.04	0.01	0.10	0.21	0.86
2.	1–2	1.54	0.8	0.06	0.02	0.12	0.27	1.26
3.	>2	1.70	0.9	0.07	0.02	0.12	0.29	1.42
Total/Average		1.27	0.06	0.05	0.01	0.11	0.23	0.99

[*ha—Hectare and *q—Quintal].

Figure 2 displays the comparative retention capacity of the farmers for all these three crops. It is clear that rice (green bar) has the highest retention capacity among all these three crops, as the primary objective of rice cultivation is home consumption.

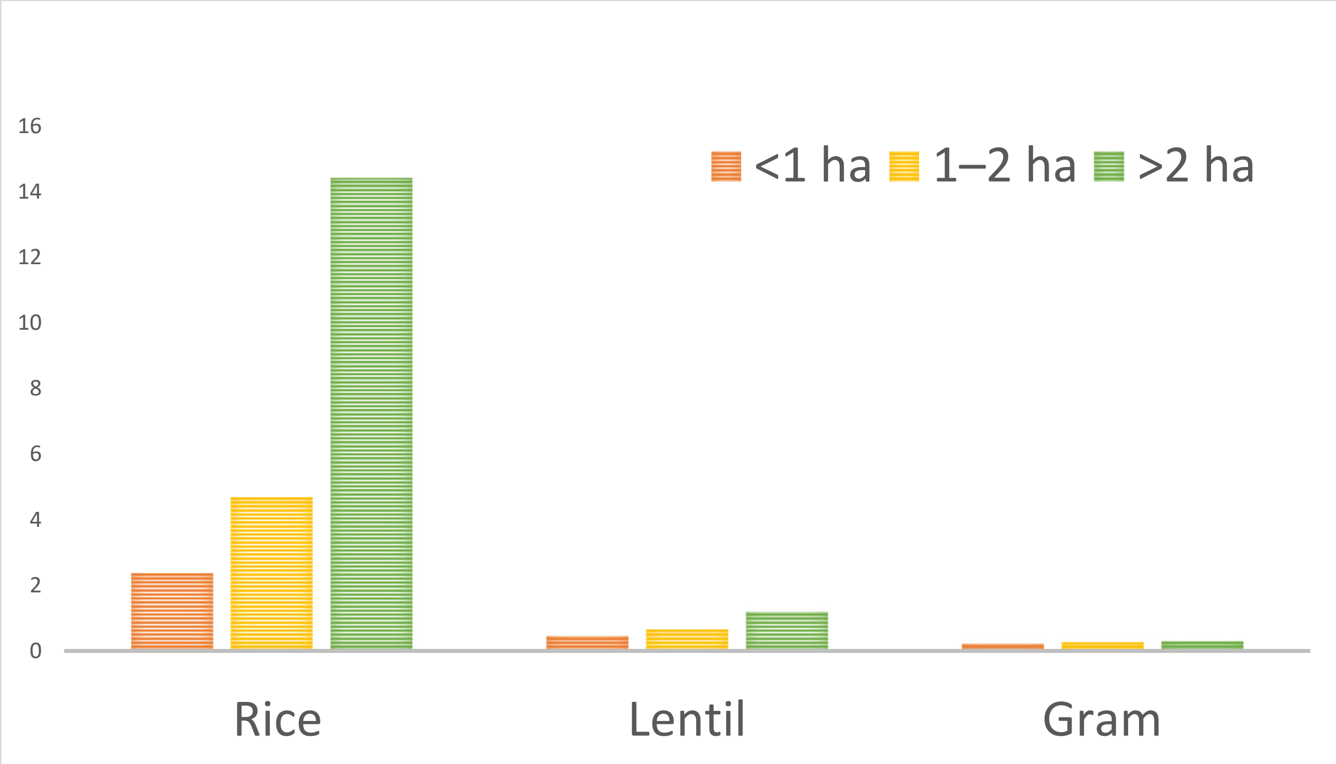

Figure 2. Comparative retention capacity of farmers of different crops.

Table 7 highlights the gross marketed surplus, net marketed surplus, and marketable surplus (Shah M, 2018; Sharma.V. P, 2016) [31,32] across different farm size categories. Marginal farmers (<1 ha) exhibit a slightly lower gross marketed surplus (80.33%) compared to the average (81.12%), while small and large farmers report higher surpluses of 82.19% and 83.18%, respectively. The trend holds true for both net marketed and marketable surpluses. Marginal farmers retain the lowest marketable surplus at 75.98%, whereas larger farms have a higher surplus of 82.15%. The average marketable surplus across all farm sizes is 77.53%, showing a positive relationship with farm size. There is minimal variation between gross and net marketed surpluses, indicating that repurchases are rare, except among marginal farmers, who may need to sell crops under duress to meet cash needs. Similar studies in Madhya Pradesh have reported higher marketed surpluses than marketable surpluses, suggesting that some farmers may have resorted to distress selling [32,33].

Table 7. Estimation of gross marketed, net marketed and marketable surplus of the sample farmers classified according to size of holdings.

Serial No.	Farm Size (ha)	Gross Marketed Surplus (%)	Net Marketed Surplus (%)	Marketable Surplus (%)
1.	<1	80.33	78.65	75.98
2.	1–2	82.19	82.19	80.81
3.	>2	83.18	83.18	82.15
Total		81.12	80.06	77.53

The elasticity of marketed surplus in response to changes in output is presented in Figure 3 and Table 8. For paddy, the elasticities are above unity for marginal (<1 ha) and large (>2 ha) farmers, with values of 1.03 and 1.45, respectively, while small farmers (1–2 ha) exhibit a lower elasticity of 0.85. The overall elasticity for paddy is 1.12, indicating a proportional increase in marketed surplus as production rises. For lentils, the elasticity is positive and exceeds unity for marginal (1.0) and large farmers (1.07) but is slightly below unity (0.78) for small farms, with an overall average of 0.91. Gram shows positive elasticities for all farm sizes, averaging 1.09, underscoring the importance of marketed surplus in contributing to farmers' income and the agricultural economy [34].

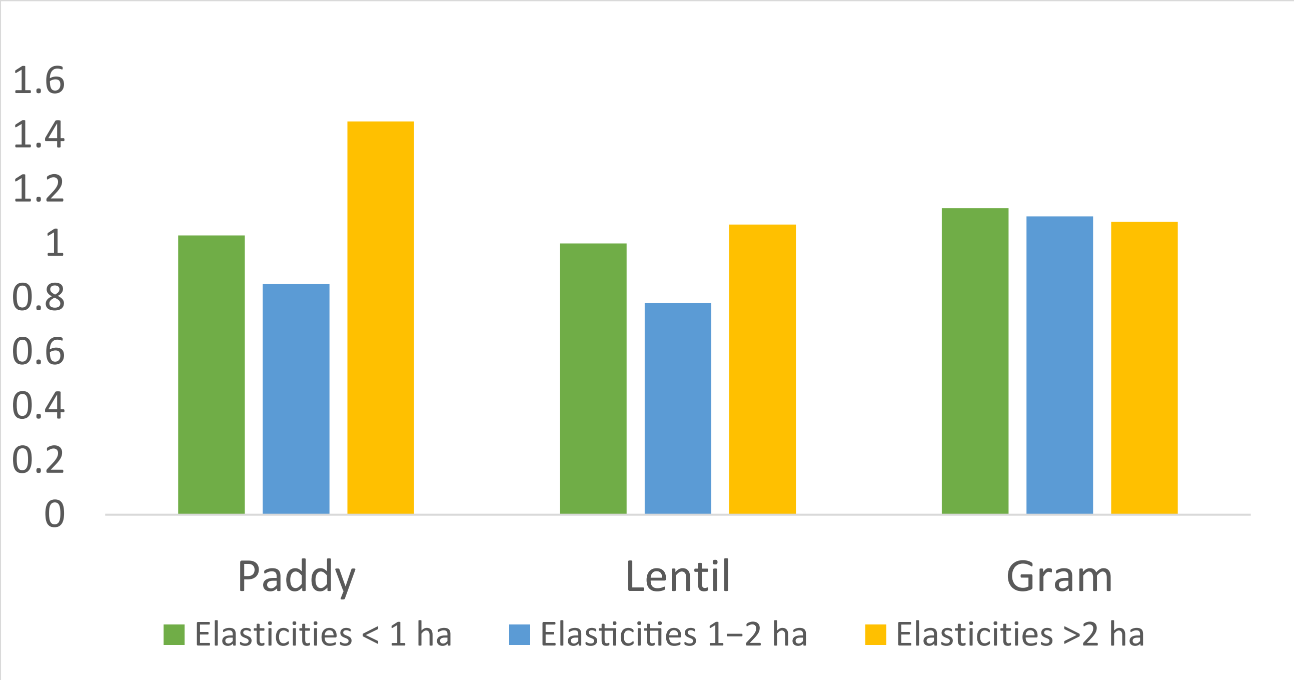

Figure 3. Elasticities of marketed surplus with respect to output.

Table 8. Estimation of elasticities of marketed surplus with respect to output for various farm size groups of sample farmers.

Crops	Elasticities			
	<1 ha	**1–2 ha**	**>2 ha**	**All**
Paddy	1.03	0.85	1.45	1.12
Lentil	1.00	0.78	1.07	0.91
Gram	1.13	1.10	1.08	1.09

In Table 9, the price elasticities of marketed surplus vary significantly among crops and farm sizes [35]. For marginal and large farmers, the elasticities of marketed surplus with respect to price are negative across all crops (Figure 4). In contrast, small farmers show positive elasticities for rice (2.57) and gram (3.42) but a negative elasticity for lentils (−4.91). For all farmers combined, the elasticities are negative for rice (−3.42) and lentil (−1.27), but positive for gram (0.81). Historical studies also found that the relationship between marketed surplus and price tends to be negative for subsistence crops like rice, as higher prices increase farmers' real income, leading to higher consumption and thus reducing marketed surplus [15,36]. The negative price elasticity of paddy may be attributed to its characteristics as a staple food. In some contexts, rice can be categorized as an inferior good, meaning that as incomes rise, the demand for rice may decrease because consumers may shift towards purchasing more expensive alternatives (like meat or processed foods) [37]. This behaviour reinforces the negative price elasticity; if rice prices rise significantly, poorer households may still buy it out of necessity, while wealthier households might reduce their consumption in favour of other options.

Table 9. Estimation of elasticities of marketed surplus with respect to selling price of foodgrains for various farm size groups of sample farmers.

Crops	Elasticities			
	<1 ha	**1–2 ha**	**>2 ha**	**All**
Paddy	−0.35	2.57	−4.12	−3.42
Lentil	−3.07	−4.91	−1.64	−1.27
Gram	−1.81	3.42	−1.25	0.81

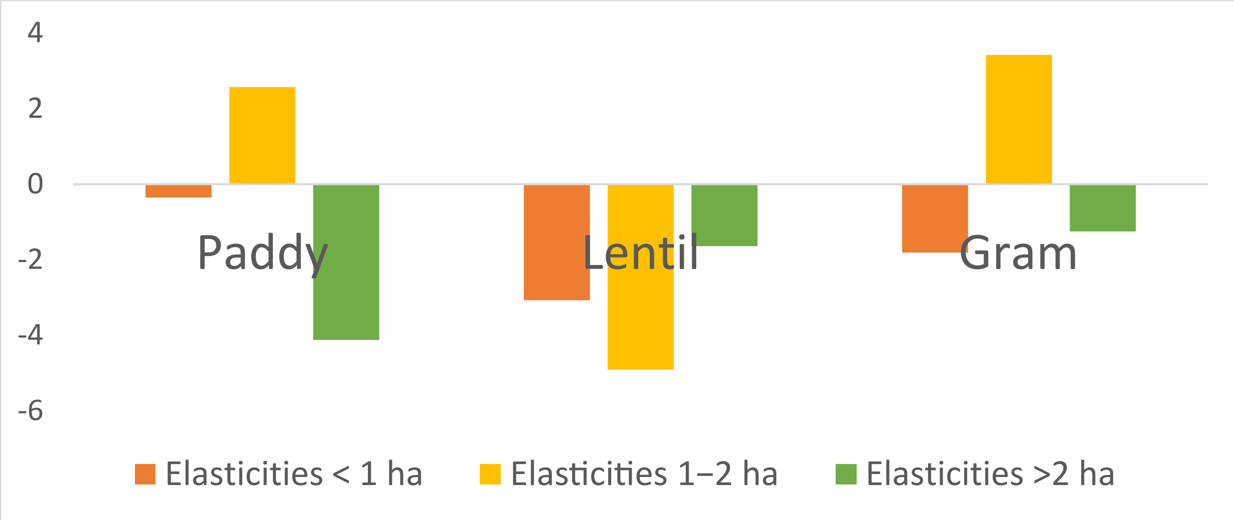

Figure 4. Elasticities of marketed surplus with respect to selling price.

Table 10 examines the price elasticities of marketed surplus for rice, lentil, and gram. The consumption-to-marketed surplus ratio (C/M) is highest for rice (0.82), followed by lentil (0.51) and gram (0.38). The share of crop revenue in total net income is also greatest for rice (0.66), while lentil and gram contribute 0.19 and 0.15, respectively. The price elasticity of consumption is negative for rice (−0.38) and lentil (−0.52) but positive for gram (3.49). Income elasticities are negative for rice (−0.36) and gram (−0.81) but positive for lentil (0.746). The overall price elasticity of marketed surplus is positive for rice (0.915) and lentil (0.03) but negative for gram (−0.874). These results suggest that price changes significantly affect the marketed surplus of subsistence crops like rice, with price elasticity exhibiting an inverse relationship [15,38]. Similar patterns have been observed in other regions, where crops like jute display positive price elasticities, while others like urad and sesame tend to show negative price elasticities [21].

Table 10. Estimation of price elasticities of marketed surplus food grains.

Sl. No.	Parameters	Rice	Lentil	Gram
1	Consumption marketed surplus ratio	0.82	0.51	0.38
2	Share of crop revenue in the total net revenue	0.66	0.19	0.15
3	Price elasticity of consumption	−0.38	−0.52	3.49
4	Income elasticity of rice/lentil/gram	−0.36	0.746	−0.81
5	Elasticities	0.915	0.03	−0.874

4. Conclusions

This research examines the supply response and market behavior of food grain crops—rice, lentil, and gram—in the Nadia district of West Bengal. The study offers key insights into farmers' tendencies regarding crop retention and the sale of surplus produce. It was observed that smaller farms retain a smaller portion of their harvest for household consumption compared to larger farms, which leads to higher gross marketed surplus ratios among smaller farmers. This is largely due to the immediate financial needs of marginal farmers, compelling them to sell a significant portion of their produce post-harvest. The elasticity of the marketed surplus for rice, relative to output, was found to be generally positive and above unity, indicating a proportional rise in the marketed surplus as production increases. The elasticity varies across different farm sizes, highlighting distinct economic behaviours among small, medium, and large-scale farmers. Similarly, lentils and gram demonstrate a positive supply response, with lentil showing significant retention for domestic use, reflecting their dietary importance. The study provides insights into how economic factors shape market participation. In conclusion, the study suggests that the responsiveness of marketed surplus to changes in output highlights the need for targeted policy interventions.

This study has some limitations. It does not include global market fluctuation of commodities and climate change impacts. It also does not consider the impact of advanced technology used by farmers.

The higher marketed surplus ratios among smaller farms call for policies that address their financial challenges. Decentralized procurement involving local institutions such as co-operatives, farmer producer organisations, facilitating credit access for storage, flexible and farmers' supportive e-NAM facility, more investment in local and regional storage with low-cost transport facility and robust market information system on prices and demand trends in the market could be helpful policy strategies that can reduce the forced sale of small and marginal farmers.

Appendix A

Schedule for Marketed and Marketable Surplus of Rice, Lentil, and Gram
Name of the respondent:
Village: Block:
District: Age:
Education: Sex:
Occupation: a. Primary b. Secondary:

1. Family details:

Sl. No.	Name	Sex	Age	Education	Occupation	
					Primary	Secondary

2. Land Holding Pattern:
   a. Owned land (in acre/ha):
   b. Leased in Land:
   c. Leased-out Land:
   d. Total operational holding (a+b+c):

3. Land Use Pattern:

Crop	Area		Crop Season
	Irrigated	Un-Irrigated	
Rice			
Lentil			
Gram			

4. Cost Structure:

Sl. No.	Crop	Inputs	Quantity (Kg)	Price (Rs/kg)	Value (Rs)
1	Rice				
2	Lentil				
3	Gram				

5. Return Structure (Rs/ha):

Sl. No.	Crop	Production (q)	Quantity Retained for Home Consumption	Quantity Sold (q)	Price (Rs/ha)	Total Revenue
1	Rice					
2	Lentil					
3	Gram					

6. Total Income of the Household (Rs/ha):

Sl. No.	Crop	Total Cost	Total Return	Net Revenue
1	Rice			
2	Lentil			
3	Gram			
4	Other Crops			
5	Off-farm Sources (Rs/yr)			

7. Marketed or Marketable Surplus:

Sl. No.	Crop	Total Production (q)	Total Requirement for Family Consumption	Excess or Deficit Quantity (Repurchased)
1	Rice			
2	Lentil			
3	Gram			

Acknowledgments

Authors acknowledge the help and support of the administration of Bidhan Chnadra Krishi Viswavidyalaya for allowing to carry out the research and the sampled farmers for spend their valuable times.

Author Contributions

M.M.: Conceptualization, Surveying, Formal Analysis, Software Validation, Writing—Original draft; S.S.: Conceptualization, Visualization, Software Validation, Writing—review and editing; B.B.: Conceptualization, Supervision, Writing—Review and editing; S.D.: Writing—review & editing; S.G.: Conceptualization, Supervision, Writing—review & editing. A.P.: Supervision, Writing—review & editing.

Ethics Statement

Not applicable.

Informed Consent Statement

Not applicable.

Funding

This research received no external funding.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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