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Economic Analysis of Winter Chili Subsidy Program in Bhutan: A case study of Dagana and Sarpang Districts

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Abstract

Chili plays a significant role in Bhutanese cuisine and is the most commonly consumed vegetable. While Bhutan produces an excess of chilies from April to November, production declines during the colder months from December to March (off-season). Previously, until 2016, the country relied on importing fresh chilies from India. However, due to concerns about chemical residue, the government imposed a ban on chili imports and introduced the winter chili subsidy program in 2017. This program aimed to promote self-sufficiency in chili production during the off-season and was implemented in the southern districts of Bhutan, situated between 200 and 1200 meters above sea level. By providing free inputs such as hybrid seeds, mulching plastic, greenhouses, water storage and conveyance equipment, the program successfully stimulated the domestic production of hybrid chili, which was previously non-existent. However, no studies have been conducted thus far to assess the effectiveness of the program. Therefore, the focus is on evaluating the program's impact at the household level, utilizing both descriptive and econometric methods with data from the Dagana and Sarpang districts. The findings indicate a positive trend in the quantity of subsidized inputs and an increase in the number of chili growers. Nonetheless, it is important to note that farmers do not receive sufficient quantities of these inputs. Statistical analysis using t-test reveals that male-headed households receive significantly higher quantities of certain inputs compared to their female counterparts. Furthermore, the regression analyses suggest that the program contributed to increased chili productivity, especially when farms receive enough quantity of seeds and mulching plastic, yields increased by 36-49% and 30-90%, respectively. Additionally, farmers reported that the subsidy program played an important part in expanding their cultivated areas.

Keywords: Winter Chili; Subsidy; Inputs; Productivity; Area; Gender

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1 Introduction

Agricultural input subsidies are provided to increase crop productivity and household income and create jobs. It is also expected to keep the price of agricultural produce at a reasonable range for the benefit of customers. Agricultural subsidies are vital in developing countries where the majority of the population is dependent on agriculture as the source of livelihood (Hassan Danish et al., 2017).

Schwartz & Clements (1999) defines subsidy as any government assistance that (i) allows consumers to purchase goods and services at prices lower than those offered by a perfectly competitive private sector, or (ii) raises producers' incomes beyond those that would be earned without this intervention. Subsidies are termed differently like assistance, support, transfer, payments, and aids. Subsidies are given in cash or kind or both.

The authors state three important reasons to assess subsidies. The first, subsidy forms one of the major policy instruments of government expenditure. Secondly, at micro level, it affects the farm decisions, income distribution and reduce the flexibility of economy. Thirdly, on a global scale, it distorts the resource allocation by affecting competitiveness. There are evidences of existence of different form of subsidies in countries like India, China, Kenya, Zambia and Malawi to name few.

Subsidies in Bhutan's agriculture sector started with planned development in 1961 as a means to improve farm production and productivity. The farmers were given free seeds, farm tools, plant protection chemicals and fertilizers. These subsidies were gradually phased out with the development pace of the country. From 1998 onwards (beginning of 8th Five Year Plan), the subsidy was given only for producing improved planting materials and transportation of agriculture inputs. Commission of 10% on sales value for seeds and fertilizers is still given to Agriculture Sales and Service Representatives (Ministry of Agriculture and Forests [MoAF], 2021). Subsidy on transportation of seeds and fertilizers is still provided to maintain the same price of these inputs throughout the country. As of now, the majority of subsidies are free supply of inputs. Farmers receive various production input materials which are procured by the government, transported and distributed to them at their sub-districts/villages.

In Bhutan, subsidies are not explicitly termed as subsidy in the book of accounts, as in most countries. It is embedded in various developmental programs in the annual budgets across the governmental agencies at central, district and sub-district levels. So, it is difficult to get a complete picture of how much budget is spent on subsidy programs

Among food crops, chili occupies a uniquely important position in Bhutanese agriculture and food systems. It is consumed in almost every meal and is used primarily as a vegetable rather than a spice. Reflecting its cultural and nutritional significance, chili has been prioritized as one of the seven vegetables under the national food and nutrition security program (Department of Agriculture [DoA], 2022). Ueda & Samdup (n.d.) equated chili with household food security, given its indispensable role in Bhutanese cuisine. It is grown throughout the country, including Dagana and Sarpang districts. It is most commonly traded produce domestically and even exported during summer months. It is consumed as fresh, dried, blanched and dried, powdered, and pickled. It has remained as one of the highest produced vegetables till 2021 (Department of Agriculture [DoA], 2011-2016; Renewable Natural Resources Statistical Division [RNR-SD], 2017-2020). The most commonly grown landraces are suited for warm temperature and cultivated during the months of March to November.

Though chili in other forms is abundantly available year-round, the fresh produce becomes scarce during months of December to March as domestic production is constrained by cold temperature. Thus, December-March are termed as off-season. Until 2016, the demand for fresh chilies was met through imports from India. However, this changed after high pesticide level beyond maximum allowable limit was detected in it and two other vegetables during the routine inspection conducted by the erstwhile Bhutan Agriculture and Food Regulatory Authority, Ministry of Agriculture and Forests. It resulted in ban of these vegetables due to concern for public health safety (Department of Agriculture [DoA], 2018). Thus, the winter chili subsidy program was initiated as an urgent need to meet the domestic demand and secure self-sufficiency during the off season. Winter chilies in Bhutan are those that are produced between December to June next year. The varieties being produced are hybrids imported from India as the landraces cannot yield well during cold months. Though substantial government support has been provided for production of winter chili, no study has been carried out yet to assess the effect of the input subsidies on the chili productivity and area expansion at farm household level. While some literatures have investigated the impact of agricultural input subsidies, empirical evidence has largely focused on Sub-Saharan Africa, particularly Malawi (e.g. Arndt et al., 2016). Studies examining input subsidy programs for import substitution remain limited. Furthermore, in contrast to staple grains, the effectiveness of such programs for high-value vegetable crops has received little attention. This study addresses these gaps by evaluating the winter chili subsidy program in Bhutan.

2 Materials and Methods

2.1 Study Site

The study was conducted in two major winter chili-producing dzongkhags of Sarpang and Dagana districts (Figure 1). A total of 18 sub-districts were covered with nine sub-districts each, to get a representative of the whole districts as they differ in their location, accessibility and the development status. The sub-districts under Dagana were Dorona, Drujeygang, Karmaling, Karna, Larjab, Lhamoizingkha, Nichula, Tsangkha and Tsendagang. Under Sarpang, sub-districts of Chuzanggang, Dekiling, Gakidling, Gelephu, Samtenling, Senggye, Shompangkha, Tareythang and Umling were covered.

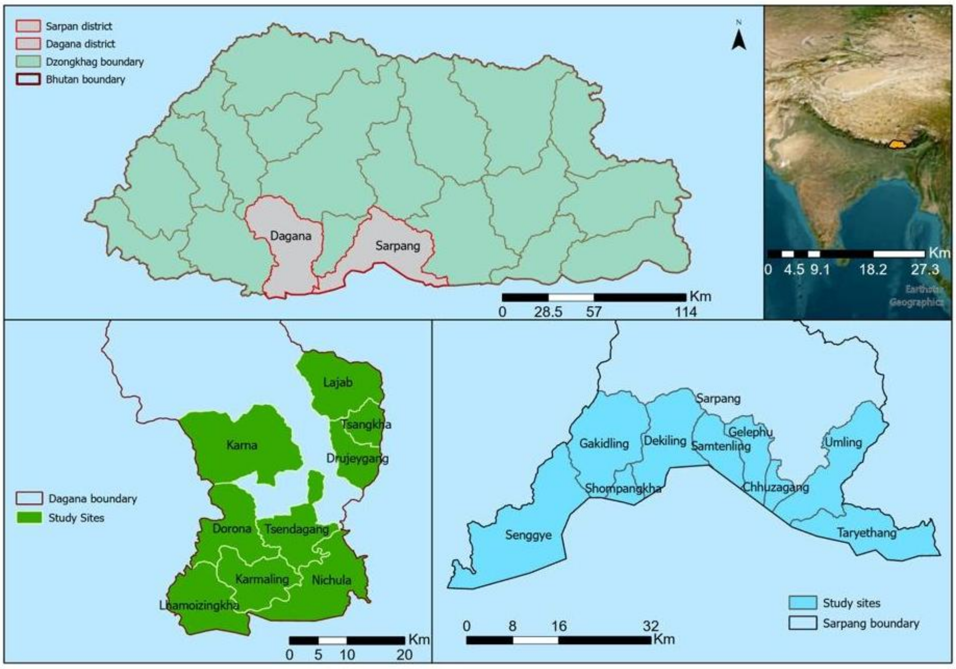

Figure 1. Study area showing Dagana and Sarpang and the sub-districts

Dagana lies between the altitude of 100-4000 meters above sea level (masl) and the main crop of the farmers are maize, vegetables and citrus. It consists of 14 sub-districts and only 11 sub-districts grew winter chili in 2021 as per the records maintained with the district agriculture office. There were 419 chili growers cultivating a total area of 216.2 acres.

Sarpang district lies within an altitude range of 100-1800 masl. It consists of 12 sub-districts, out of which 11 sub-districts grew winter chilies in 2021 except for Chudzom gewog, as per the records maintained with the district agriculture office. There were 678 farmers in total cultivating a total area of 264.55 acres. The main crop of Sarpang farmers is rice, vegetables and areca nut.

2.2 **Sampling method**

Within two districts, the sub-district and villages were selected purposively based on availability of the winter chili growers. As in the study by Huang et al., (2011), a probability proportional sampling was done to select total sample from the sub-districts as per the total chili growing households. Random sampling was done to select the chili growers within these sub-districts. The administrative data maintained with two districts of the chili growers' list was used as sampling frame. There were 419 households in Dagana and 678 households in Sarpang totaling to 1097 households. Yamane (1967:886) formula was used to calculate sample size at 95% confidence interval and 10% precision level as follows:

$$n = \frac{N}{1+N(e)^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

n= Sample size, N= Population, e= Precision level

Therefore,

$$n = \frac{1097}{1+1097(0.1)^2} = 91.6 \ldots\ldots\ldots\ldots\ldots (2)$$

So, 92 households were selected randomly in total, among which 34 farmers and 58 farmers were from Dagana and Sarpang districts, respectively.

2.3 **Data collection**

A total of 92 households were surveyed from the two districts using Google forms by the author in the months of September and October, 2022 for a period of 51 days. A semi-structured English questionnaire was used to interview the farmers by visiting their houses. The interview was conducted in the local dialects of *Dzongkha, Sharchop* and *Nepali* and answers were recorded in Google forms which were submitted by the end of each interview to the server. The responses were cross-checked later in the evening and clarification was sought in case of wrong or unusual entry via phone call to the respondents. Information on farm characteristics, land area, production and sale of chilies were collected. Detailed information on the input subsidies received from 2017 until 2020 was also collected.

In addition, nine Agriculture Extension Supervisors were also interviewed using semi-structured questionnaire to get their views regarding the program. Information on trend of inputs subsidy, the benefit and disadvantages of the subsidy and their views on crop replaced by chili were collected. The officials play a critical role in operationalization of the program as they are the closest representative of the government. Besides their other responsibilities, they also play a major role in the implementation of subsidy programs. In most cases, they make decisions regarding who would receive the subsidy.

Two officials involved in the winter chili program at Agriculture Research and Development Center (ARDC) of Yusipang in Thimphu and Smartening in Sarpang were also interviewed through open ended questions as expert interviews are known to generate huge and high-quality data (Wang et al., 2019). The objective was to find out the policies and directives for subsidy program implementation process. Huang et al., (2013) found that though there are set of criteria for the allocation of subsidies, the government however doesn't document the allocation process of the subsidies at grassroots level, which can have an impact on the achievement of the intended objective. Interviewing farmers and government officials working at different levels gave an insight into the views of the subsidy recipients and those of experts.

2.4 **Data Analysis**

Ideally, we should compare farms that received subsidies (the treated group) with those that did not (the control group) to estimate policy impacts. However, this approach is not feasible in our study region because all chili farms receive some form of subsidy, leaving no valid control group. Instead, we exploit variation in the type of input subsidy received. For instance, some farms received seed subsidies, while others received mulch subsidies. Focusing on this variation allows us to identify the differential impacts of alternative subsidy instruments.

Additionally, the households ventured into winter chili cultivation only because of the subsidy program and all those farms received some form of subsidy annually, throughout the cultivation period. So, there were no farms to compare the before and after subsidy scenario.

When the outcome variable is cultivated area, we use the change in area before and after subsidy receipt for each farm. This within-farm comparison helps control for time-invariant unobserved heterogeneity and yields more precise estimates of policy impacts. We do not apply the same before and after strategy to yield outcomes, as yields fluctuate substantially over time due to weather and other shocks, making such differences unstable and less informative.

The data cleaning, visualization and analysis was done using stata MP, version 17 and excel. During the analysis, it was found that one of the winter chilies growing farmers residing in the Sarpang district has leased in 30 acres of land. He was a former civil servant turned chili entrepreneur, taking opportunity of the subsidy program and the good price fetched by the produce. However, he was not a representative of typical farm household as he was a transient farmer. Due to his huge cultivated area, which is not usual, the influence on means of data was substantial. So, the outlier was removed and analysis was done for the rest of the 91 households. In addition to data analysis of the farm households, the views shared by the farmers and agriculture experts were used to validate the findings.

The data analysis was done using both descriptive and regression method as follows:

2.4.1 Descriptive analysis

The first part presents a descriptive analysis. We provide an overview of farm characteristics, land holdings, trends in input subsidies, gender, farmers' perceptions of input subsidies, and chili yields, using simple tables, figures, and mean comparisons based on *t*-tests.

2.4.2 Regression analysis

In the regression analysis, the Ordinary Least Square (OLS) was employed to estimate the determinants of area expansion and yield. Specifically, we will estimate the following model:

$$Y_i = c_0 + bX_i + u_i$$

where Y_i is an outcome variable of farm i, c_0 is the constant term, **b** is a vector of coefficients, **X** is a vector of explanatory variables, and u is the error term. We will use the heteroskedasticity-robust standard errors.

We consider two types of outcomes, which are, average yield in 2020 and 2021, and the area expansion of chili from 2020 to 2021. Yield is measured in logarithm to achieve better fit.

X includes input subsidies and farm characteristics. Input subsidies are the amount received in 2019, not 2020 or 2021. The year 2019 is selected for several reasons: First, some inputs, such as mulch and water tank, can be used for several years. Thus, 2019 input subsidy can affect yield or area expansion in 2020 or 2021. Second, there is an endogeneity concern if we use inputs received in 2020 or 2021. Farms who plan to expand area of cultivation will likely request more inputs, which result in reverse causality. Actually, we could not find meaningful results if we use input subsidies in 2020 or 2021.

Some input subsidies are classified into three groups based on the amount of received. For seed, it is classified as "below recommended rate", "within recommended rate", and "above recommended rate" if the amount of subsidy is less than 8 packets per acre, from 8 to 12 packets, and above 12 packets, respectively. For mulch, it is classified as "below recommended rate", "within recommended rate", and "above recommended rate" if the amount of subsidy is less than 4 rolls per acre, from 4 to 8 rolls per acre and above 8 rolls per acre, respectively.

3 Results and Discussion

3.1 Farm households' characteristics

From the total of 91 households, 59 households were headed by male (64.84%) and the rest 32 were female headed households. The main occupation of the majority of the household heads was farming (95.65%). The average age of farmers was 44.24 years, with youngest farmers age at 22 years and the oldest farmer being 73 years. The average family size was 2.48, which is less compared to the national average size of 4 people (Renewable Natural Resources Statistics Division, 2019). The smallest family had just one person, and the largest

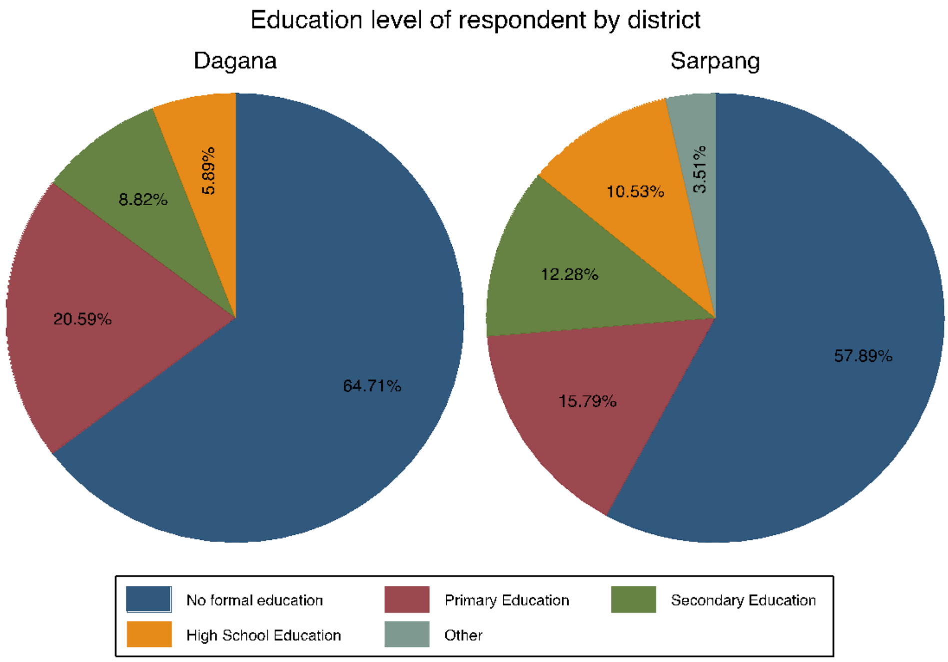

Figure 2. Different education level of the respondents

family had 7 members.

As reflected in the Figure 2, in total 61.3% of the farmers didn't receive any form of education. A total 8.21% of the respondents attended high school, the highest education level achieved in the sample survey. However, none of the female respondents attended high school. Primary education was the most common education received (18.19%) by the respondents. Compared to Dagana, Sarpang had 10.53% respondents who had a high school education which is 4.64% more. Overall, the district also had more respondents receiving some kind of formal education at 43.1% compared to 35.29% in Dagana district. The unique feature of Sarpang respondents was enrollment in non-formal education which constituted 3.51% of the respondents. The proportion of respondents achieving the highest education level as expected, was more in the younger age group at 25.09% to none with high school education above 55 years and above. From 32 female households, 65.63% were uneducated, and the highest level achieved was primary school education. In male households, the percentage of uneducated was lower at 58.63%.

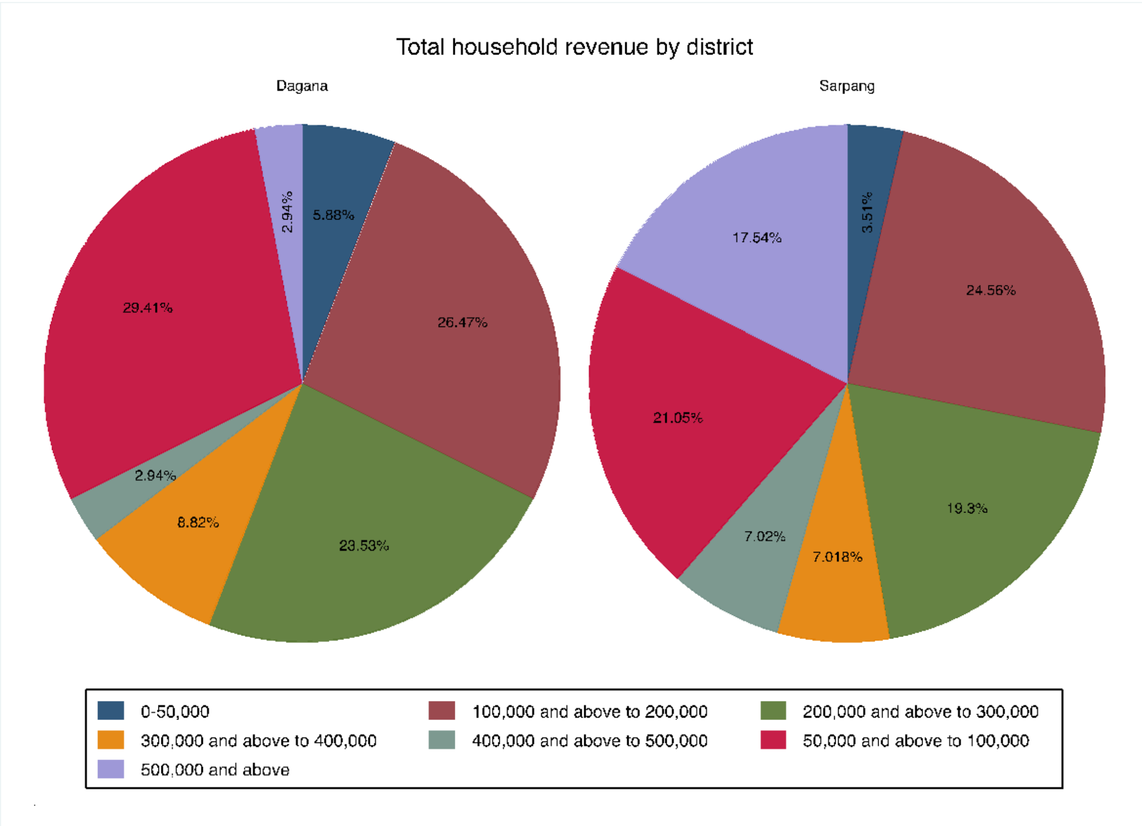

Figure 3. Total household revenue by district

The majority of the household's revenue (25.52%) fell between the range of 100,000 to 200,000 Bhutanese Ngultrum (BTN), followed closely by 25.23% in the range of 50,000-100,000 BTN as depicted in Figure 3. Dagana district had higher percentage of household (5.88%) in lowest revenue range of 0-50,000 BTN in comparison to Sarpang (3.51%). Sarpang district had higher percentage of household (17.54%), having a highest revenue range of 500,000 BTN and above compared to mere 2.94% in the Dagana district. So, households in Sarpang had more proportions of households with higher revenue.

3.2 **Land ownership and cultivation area**

The majority of farmers owned land between 3-5 acres (31 households) followed by 19 households, each owning land area of 1.5-3 acres and above 5 acres. The rest of the households had less than 1.5 acres.

The average cultivated area was 3.72 acres. On average, households in the Sarpang district cultivated 3.92 acres and Dagana cultivated 3.37 acres. In Sarpang, the highest cultivated area was 13 acres, and in case of Dagana, it was 10 acres. There was not much difference in average cultivated area between male and female headed households.

The average chili cultivated area was 0.37 acres in 2020 and 0.49 acres in 2021. The minimum cultivated area was 0.01 acres and the maximum was 4.2 acres in 2020. In 2021, the cultivated area ranged from 0.03 to 6 acres.

3.3 **Input subsidy trend and household coverage**

The subsidized input has been increasing for all inputs from 2017 to 2020, as shown in Figure 4. In 2017, households received 52.8 packet of seeds in total compared to 344.8 packets in 2020. Likewise, a total of 123.75 rolls of mulching plastic was received by the households in 2020 compared to 60.8 rolls in 2019. The trend is similar for other inputs. This can be due to increased awareness among farmers and improved planning and execution of the subsidy program. Interviews with sub-district officials also confirmed that there had been an increasing trend. The most common inputs among the households are hybrid seeds and mulching plastic. The least is water harvesting silpaulin sheet. Seeds and mulches are seen as essential and fundamental inputs. Constructing a water harvesting structure entails costs and labor from the farmers and this could be the reason for its unpopularity. It may also be because most farms have access to continuous water sources for irrigation, thus not requiring its storage.

The trend in increase of input subsidy kept pace with the increase in number of chili growers. The plausible reason could be increase in government budget for the subsidy program and also increased awareness among the farmers leading to more demand for subsidy. A similar trend was found in China whereby, the subsidy amount increased to 51.4 billion yuan compared to 100 million yuan in 2002 in an effort of the government to secure food and reduce income gap (Huang et al., 2011). However, in contradiction Hassan Danish et al. (2017) found the decrease in fertilizer subsidy trend in Pakistan after some period.

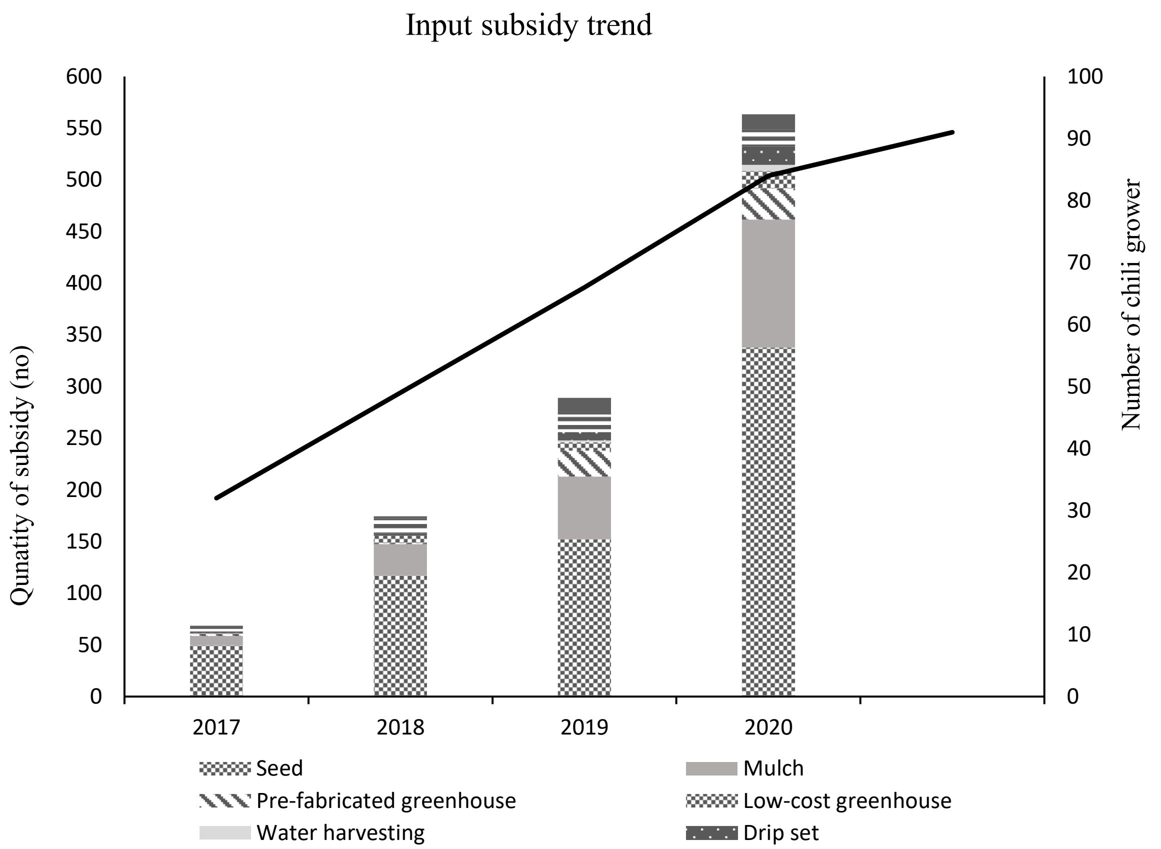

Figure 4. Input subsidy trend and number of chili growers

Note: The line represents input subsidy trend. The left y-axis shows quantity of input subsidy received, while the right y-axis number of farmers who received the subsidy.

3.4 **Difference in inputs by gender of household head**

Table 1 compares the amounts of input subsidies received by gender. With the exception of seeds, male-headed households receive larger quantities of subsidies than female-headed households. For instance, male-headed households received 3.6 rolls per acre of mulching plastic in 2019 compared to 1.8 rolls per acre by female-headed households. Likewise, male-headed households received 5.5 numbers of protected structures per acre compared to 1.8

numbers received by female headed households in the year 2020. *t*-tests indicate that these differences are marginally significant, with *p*-values at 0.1 and $p < 0.05$ respectively.

A similar pattern is observed for micro-irrigation, fencing net, water storage tanks, and prefabricated greenhouses. Although the differences are not always statistically significant, likely due to the small sample size, the consistency of these patterns suggests the presence of gender inequality in the selection of subsidy recipients.

Table 1. Comparison of inputs per acre between different gendered households

Variables	Female			Male			P_value	Star
	Mean	SD	n	Mean	SD	n		
Seed/acre (2020)	10.117	8.248	30	12.236	9.015	54	0.291	
Seed/acre (20)19	6.406	6.261	30	5.386	6.324	54	0.479	
Mulch/acre (2020)	5.317	5.109	30	7.576	7.212	54	0.133	
Mulch/acre (2019)	1.847	2.224	30	3.553	5.353	54	0.100	*
Drip/acre (2020)	0.217	0.806	30	1.542	4.729	54	0.133	
Drip/acre (2019)	0.067	0.365	30	0.356	1.170	54	0.191	
Green net/acre (2020)	0.728	2.030	30	1.589	4.898	53	0.362	
Green net/acre (2019)	0.622	2.172	30	1.129	4.609	53	0.572	
Water harvesting/acre (2020)	1.111	2.290	30	4.317	14.935	54	0.247	
Water harvesting/acre (2019)	0.778	2.109	30	3.542	14.830	54	0.314	
Greenhouse/acre (2020)	1.828	1.984	30	4.142	5.550	54	0.030	**
Greenhouse/acre (2019)	1.228	1.867	30	2.732	5.479	54	0.150	

*** p<0.01, ** p<0.05, * p<0.1

3.5 **Farmers' perception of input subsidy**

Farmers were asked to choose the most crucial subsidy for chili crop cultivation among various input options, including seed, animal protection structures, protected structures, mulching plastic, training, and water conveyance equipment. Among these options, 29 farmers chose seed as the most vital input subsidy. One of the reasons given for this choice was the difficulty in accessing quality seeds. Mulching plastic was considered important by 18 farmers, while 16 farmers highlighted the significance of protected structures. Surprisingly, capacity-building training was considered the least important among the respondents, with only five farmers identifying it as a valuable support for chili cultivation, as indicated in Table 2. This could be attributed to the widespread diffusion of knowledge and skills among farmers within their own communities.

Table 2. Farmers choice of input subsidy

Important subsidy	Freq.	Percent
Animal protection structures	10	10.99
Protected structures	16	17.58
Mulching plastics	18	19.78
Not sure	1	1.1
Seed	29	31.87
Trainings	5	5.49
Water conveyance equipment	12	13.19
Total	91	100

3.6 Yield

As per the descriptive statistics, the average yield of 2020 and 2021 was 1098.01 kg/acre. The average yield was less in 2021 at 957.35 kg/acre compared to 1243.72 kg/acre in 2020. Nonetheless, the average yield in both the years in the two districts was above the national average of 900 kg/acre as shown in Figure 5. The average yield of Dagana was 1568.04 kg/acre and that of Sarpang was 891.86 kg/acre. So, the average yield of Sarpang was less by 75.82%.

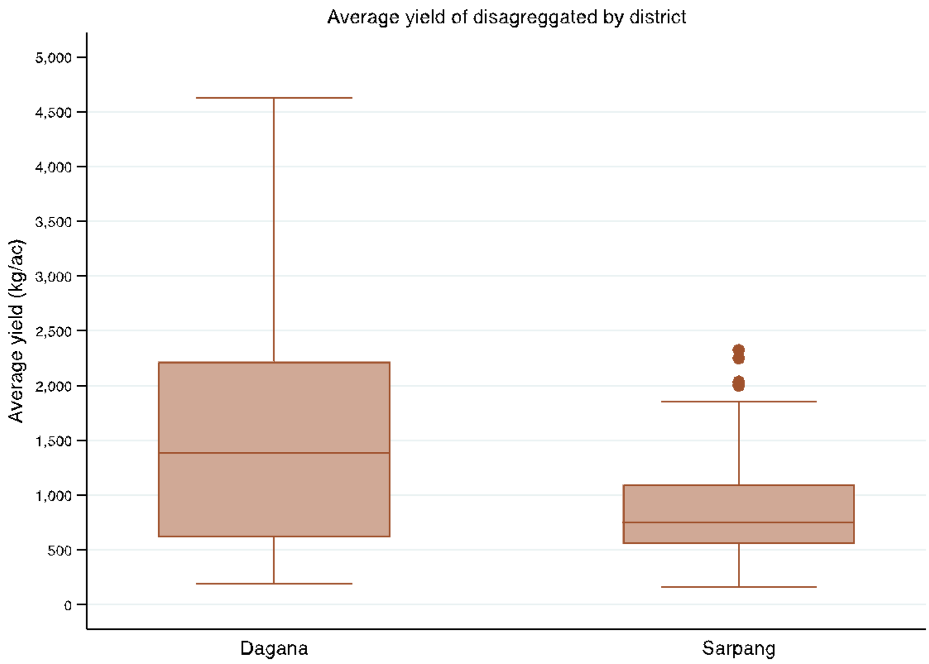

Figure 5. Difference of chili yield between two districts

The data presented in Figure 5 illustrates the distribution of household yields in Dagana and Sarpang. In Dagana, approximately 50% of households had yields ranging from 600 to 2200 kg/acre, while in Sarpang, the range was narrower, from 500 to 1100 kg/acre. The median yield in Dagana was around 1400 kg/acre, whereas in Sarpang, it was approximately 700 kg/acre. In Dagana, the upper quartile yield, representing the top 25% of households, ranged from 2200 kg/acre to a maximum of 4623.33 kg/acre. On the other hand, in Sarpang, the upper quartile yield ranged from 1100 kg/acre to a maximum of 1800 kg/acre.

3.7 Economic analysis of input subsidy under different levels of seed and mulch use

The economic analysis focuses only on seed and plastic mulch, as these subsidized inputs have a short economic life and require replacement within one to two production cycles. In contrast, other subsidized inputs (protected structure, drip and water harvesting tank) have a useful life of three years or more. So, restricting the analysis to annually replaceable subsidized inputs allow for a more accurate estimation of recurring production costs and returns attributable to the input subsidy.

The input use levels are defined solely by the quantity of subsidized inputs received and subsequently used by the households and are categorized as below recommended rate (benchmark), within recommended rate, and above recommended rate.

Incremental yield gains associated with higher levels of subsidized input use are derived from the regression analysis results, which estimate the marginal yield response to seed and mulch application while accounting for other independent variables too. These estimated yield differentials are used to compute gross revenue, additional returns, and benefit cost ratios under different subsidy use scenarios.

The results show that when production costs increased by Nu. 1260 for increasing the seed use from under the recommended level to within the recommended level, the additional revenue generated was Nu. 95,305.33 and generated a benefit cost ratio of 75.6 indicating that for every one ngultrum spent, it generated a revenue of Nu. 76. However, the benefit cost ratio decreases to 59.2 when the seed use increased above the recommended level, indicating lower return to cost compared to when seeds are used at recommended level though there is increase in yield. This is similar to the findings by Panhwar et al. (2011), of increase in the yield of sunflower with increasing seed rate. Likewise for the use of mulch within the recommended rate from that of below the recommended rate, the benefit cost ratio was 12.9. And unlike the seed use, the benefit cost ratio increased to 19.5 when used above the recommended level. The increase in benefit is due to the gain in productivity with increasing input use. So, this analysis indicates that benefit cost ratios improve consistently as farmers move from below to within and above recommended input levels of both seed and mulch, indicating strong economic efficiency of the winter chili subsidy program. Farmers utilizing subsidized inputs below recommended rates forgo significant potential income despite the availability of inputs at zero cost.

Table 3. Cost benefit analysis of subsidized seed and mulch under different levels of use

Cost						Benefit					
Input type	Quantity (gm/roll per acre)	Level	Input price (Nu/gm)	Cost (Nu/acre)	Additional cost (Nu/acre)	Yield (kg/acre)	Yield (% change)	Output price (Nu/kg)	Revenue (Nu/acre)	Additional revenue (Nu/acre)	Benefit Cost Ratio
Seed	42	Below RR	45	1890	0 (Benchmark)	1244	(average yield)	214	266216	0 (Benchmark)	(Benchmark)
	70	Within RR	45	3150	1260	1689.35	35.80%	214	361521.3	95305.33	75.6
	91	Above RR	45	4095	2205	1853.56	49%	214	396661.8	130445.84	59.2
Mulch	3	Below RR	2070	6210	0 (Benchmark)	1244	(average yield)	214	266216	0 (Benchmark)	(Benchmark)
	6	Within RR	2070	12420	6210	1617.2	30.40%	214	346080.8	79865	12.9
	9	Above RR	2070	18630	12420	2376.04	91.10%	214	508472.6	242257	19.5

3.8 Regression analysis

The regression results are presented in Table 4. The number of observations was 91 after dropping missing observations. It should be noted that, in the sample used in this study, all farmers received some form of subsidy. Therefore, the results of the analysis do not represent the effects of subsidies compared to receiving no subsidy, but rather the relative effects across different types of subsidies. Consequently, an insignificant coefficient should not be interpreted as indicating that a subsidy has no effect; instead, it should be interpreted as indicating no differential effect compared with other types of subsidies.

For area expansion, none of the variables are statistically significant, likely due to the small sample size though the farmers reported a total area expansion of 24.07 acres due to the subsidies. Nevertheless, the t-statistics for male-headed households and distance to the market are relatively large, suggesting that these variables are marginally insignificant. The signs of the coefficients indicate that male farmers are more likely to expand the cultivated area of chili, whereas farmers located in more remote villages are less likely to do so. Among the subsidy variables, the t-statistics for seed provision are relatively large, indicating that farmers who receive more seeds are more likely to expand their cultivated area, compared to farms who receive other types of subsidies. Thus, it is comparable to findings of significant positive effect of subsidies on allocation of land to targeted crops (Chibwana et al., 2012; Demirdogen et al., 2022; Yi et al., 2015). In contrast, Huang et al. (2011) found that there was no change in the area under grain cultivation though farmers received grain subsidies. Smale & Thériault (2022) also found that subsidy didn't have any effect of area under cowpea when it was planted as main crop and it reduced the area under crop when it was gown as intercrop.

In the yield regression, many input subsidy variables are significant. First, both seed variables are positive and statistically significant. This is similar to the findings of significant positive impact of subsidy on crop yield (Ali et al., 2019; Chibwana et al., 2010; Denning et al., 2009; Karamba & Winters, 2015; Shively, G. E., & Ricker-Gilbert, J, 2013). The positive impact of seed for increase in productivity can be attributed to the higher quality of hybrid seeds, which are pure and has high germination ability and produces true to its type plants. Since yield is measured in logarithmic form, the coefficients can be interpreted as percentage changes. The yield increased by 36% and 49% when farms use the recommended rate and above the recommended rate, respectively. Similarly, mulch increased the yield by 30% to 90%, depending on the amount received. Protected structures, such as greenhouse also increased yield by 3.6%. The coefficient on the number of water storage tanks is negative, which is counterintuitive. This negative sign likely reflects underlying water scarcity. When water availability is insufficient, yields decline and farmers are more likely to request water storage tanks.

In yield model, farm characteristics are not statistically significant, however, relatively large t-statistics are observed for "Chili is the main crop" and "Sarpang." The former likely captures farming skills, as farms specializing in chili production tend to have greater experience and management capacity, resulting in higher yields. The latter reflects regional differences, as shown in the previous section, chili yields in Sarpang are substantially lower than those in Dagana. The average yield for two years of Sarpang district was 891.86 kg/acre compared to 1568.04 kg/acre in Dagana. The factors cited by the agriculture experts for high productivity in Dagana were raising of chili nurseries in plug trays/plastic cups and inside the greenhouses, ensuring high survival rate and higher productivity as roots don't get disturbed while transplanting. In Sarpang, most farmers kept nurseries on the beds or seeds sown in some boxes and sheltered under the house roofing. Overall, the regression results suggest that providing sufficient input subsidies, particularly seeds and mulch can increase yield and, to some extent, cultivated area, thereby contributing to higher domestic production.

Table 4. Regression results

	Area expansion	log(yield)
Subsidy received in 2019		
Seed: Within recommended rate (dummy)	0.121	0.358
	[1.43]	[2.15]**
Seed: Above recommended rate (dummy)	0.187	0.49
	[1.33]	[2.92]***
Mulch: Within recommended rate (dummy)	0.09194	0.304
	[0.77]	[1.68]*
Mulch: Above recommended rate (dummy)	-0.02221	0.911
	[-0.15]	[2.35]**
Protected structure (number/acre)	-0.01156	0.036
	[-1.31]	[2.33]**
Water storage tank (number/acre)	-0.002	-0.014
	[-1.27]	[-3.61]***
Farm characteristics		
Altitude (m)	0.000	0.000
	[-0.61]	[-0.10]
Male HH head (dummy)	0.196	-0.061
	[1.66]	[-0.31]
Age of respondent	0.003	-0.006
	[0.42]	[-0.82]
Educated (> 7 years) (dummy)	0.015	-0.108
	[0.12]	[-0.72]
Family members engaged in farming	0.001	-0.08
	[0.01]	[-1.03]
Years into chili cultivation	-0.001	-0.002
	[-0.09]	[-0.10]
Chili is main crop (dummy)	0.05	0.299
	[0.21]	[1.49]
Distance from the market: 15 to 20 km (dummy)	-0.189	-0.115
	[-1.66]	[-0.40]
Distance from the market: > 20 km (dummy)	-0.053	0.07
	[-0.50]	[0.40]
Sarpang (dummy)	0.13	-0.301
	[1.04]	[-1.48]
Constant term	**0.248**	**7.03**
	[0.75]	[17.06]***
Observations	82	82
R-squared	0.157	0.351

Note: Robust t-statistics in brackets *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

4 Conclusion

The Subsidy program in chili increased the productivity and simultaneously reduced the cost of inputs. The households cultivating chili as the main crop were able to generate higher revenue. Though there was no difference in effect of different subsidized inputs on chili cultivated area expansion, there are evidences from farmers' report that subsidy did contribute to area expansion. The domestic production has been partially able to fulfill the demand for fresh green chilies during the months of December to March, consistent with the finding by Jayne & Rashid (2013) in ability of the subsidy program to substitute imports and raise food self-sufficiency. So, it can be stated that the program objective of self-sufficiency has been partially achieved. However, there is a need of other supports like effective measures to control pests and diseases and proper nursery management to increase the productivity as the average yield is much lower than the potential yield of 5000 kg/acre achieved in on-station farms. There are still challenges in producing sufficient quantities that need to be addressed through proper research and development (R&D).

There was difference in quantities of subsidized inputs received per acre between the different gendered households. The male households received more quantities of mulch and prefabricated greenhouse compared to the female headed households. Despite the fact that Bhutan has more female farmers than males working in agriculture, the chili subsidy program benefitted male headed households more. It is evident from this study that they were not only able to access more subsidized inputs but also earned more revenue from chili than their female counterparts. So, a better targeted program would contribute to higher total production through enhanced production and productivity of the female farmers. This finding is important for consideration when similar subsidy program is planned in future.

Most studies concluded that public investment effectively raises agricultural productivity compared to subsidies in Asia (Akber & Paltasingh, 2019; Jayne et al., n.d.; Jayne & Rashid, 2013). Thus, it is recommended that spending should shift from that of subsidy to investment in crop R&D and infrastructure development. There is a trade-off between subsidies and investment due to limited resources. Accordingly, Bhutan's government also needs to formulate a proper exit strategy for this program.

Lastly, the study on agricultural input subsidies for cash crops in Asia remains limited, so this study makes a substantial contribution not only to Bhutan's local policy but also to the broader research literature.

There are two main limitations in this study. First, the data collected on yield fell during the pandemic time (2020 and 2021). As also mentioned by the farmers, the yield estimates might be underestimated since portions of the harvest were lost due to complete breakdown of market chain. Second, small sample size could result in imprecise estimates in the regression results. With a small sample, the regression has low power to detect true effects. As a result, variables that truly matter may appear statistically insignificant ("false negative").

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6 Author's contribution statement

Choney Zangmo was responsible for conception and design of the study, implementation of research and data collection, analysis and interpretation of result, while Kentaro Kawasaki and Takeshi Sato provided guidance and support in use of econometric models, verification of result and review of the manuscript.

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