Research Article

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Productivity and profitability of organic and conventional potato (*Solanum tuberosum* L.) production in West-Central Bhutan

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Abstract: Bhutan aspires to be an entirely organic nation. Food self-sufficiency and increasing farm household income are critical priorities in the country. Realising these priorities necessitates assessing the country's current organic agriculture performance. The objectives of this study were to investigate the productivity and profitability of organic and conventional potato and farmers' constraints in producing organic potato in West-Central Bhutan. Multistage and purposive sampling techniques were used to select the study sample. A semi-structured questionnaire and face-to-face interviews were employed to gather primary data for the 2019 cropping cycle from 93 potato farmers: 43 organic farmers in the Gasa District and 50 conventional farmers in Wangdue Phodrang District. Descriptive statistics, cost and return analysis, and independent sample *t*-test were applied for data analysis. The results revealed that the conventional potato's productivity (tuber yield) and profitability were significantly higher ($p < 0.001$) than organic potatoes. The average productivities for organic and conventional potatoes were 7.48 and 19.22 t/ha, respectively. Organic potato farmers incurred a loss of –202,708.47 Ngultrum (Nu)/ha, while conventional potato farmers incurred a profit of 83,832.85 Nu/ha. The benefit-cost ratios of organic and conventional potato stood at 0.40 and 1.27, respectively. Lack of premium price, pest and disease problems, low crop productivity, and climate change were the constraints faced by organic potato farmers. The study found that the productivity and profitability of the conventional potatoes were higher than the organic potatoes in West-Central Bhutan in the current scenario. Further, the critical information will contribute to guiding Bhutan's vision for its organic agriculture development.

Keywords: cost and return analysis, constraints, farm household income, farm-gate price, organic agriculture's performance, potato production

1 Introduction

Organic farming is considered a viable choice for small farmers seeking to improve food security and farm income performance in the long term [1]. It is also viewed as a sustainable farming method that has been shown to help accomplish the Sustainable Development Goals [2]. In 2017, 181 countries were involved in organic operations, with the organic market valued at 90 billion euros. The global organic portion of total agricultural land was 1.4%, with 2.9 million organic growers around the globe. Asia has 40% of the world's organic producers [3].

The Kingdom of Bhutan shares similarities with these global trends; therefore, the Royal Government of Bhutan (RGoB) launched the National Framework for Organic Farming in 2006 [4]. The National Organic Programme (NOP) [5] reported that Bhutan has around 10,391.86 ha of land, with a production of 2,599.7 metric tonnes (t) under organic management in 2017, which included areas under agriculture, livestock, and wild collections. Bhutan is characterised predominantly by smallholder farmers engaged mainly in subsistence farming, holding an average of 1.16 ha [6]. The RGoB faces a difficult challenge in attaining food and nutritional security and poverty alleviation; around 2.8% of the Bhutanese population suffer from food poverty [7]. To promote sustainability and meet its Gross National Happiness goals, Bhutan pledged to be

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100% organic by 2020 [8]; however, Bhutan's current government has clarified that the plan to become one by 2023 is quite vague [9]. Nevertheless, the country has been pursuing its organic vision, as evidenced by the initiation of the National Organic Flagship Programme in its 12th Five Year Plan (2018–2023) [9]. The RGoB has prioritised household food security, alleviating poverty, substituting or reducing imports through increased domestic production, generating a marketable surplus, and enhancing farm household income and employment opportunities [10]. However, Bhutan's pledge to be 100% organic by 2020 seems not to favour the country's self-sufficiency and food security goals [8]. Food security is attained when all people have physical and economic access to adequate, safe, and nutritious food that fits their dietary needs and food choices for an active and healthy life at all times [11]. Therefore, to meet the government's priorities on food self-sufficiency and farm income generation, there is an absolute necessity to assess Bhutan's organic agriculture performance.

The potato is the fourth most significant crop in calories, following rice, maize, and wheat. Bajgai [12] reported that the potato is a widely cultivated, consumed, and traded crop in Bhutan, mainly due to the country's suitable agro-ecological conditions. It is grown as a non-cereal food and cash crop and a vegetable by around 22% of Bhutan's rural households. In 2019, there was a total potato production of 43,560 t, in a total area of 4,187 ha, with national average productivity of 10.40 t/ha in the country [13]. Potato productivity is one of the lowest in the South Asian region; however, generally, potato production is a profitable venture in Bhutan, with an average profit of 36.02% [14]. Bhutan exported 24,983.4 t and earned 511.06 Nu[1] million in 2018 [15]. In Bhutan, potato is one of the cash crops mainly cultivated through conventional farming practices [16]. According to the International Centre for Integrated Mountain Development [7], conventional agrochemicals like fertilisers and insecticides are used relatively in small amounts in Bhutan and are restricted to essential cereals and cash crops. However, conventional potato farmers also use some farmyard manure (FYM) and other organic amendments along with chemical fertilisers. Conventional farmers also use herbicides to control weeds in potatoes besides some manual weeding. Conventional farming in Bhutan is basically an integrated approach, and it is as good as the Good Agricultural Practices. In 2019, around 1.08% of the total potato area in the country was under organic potato production with a total of 45.15 ha [17]. Since 2016, around 20.34 ha or 0.50% of the total potato area in the country was certified organic in Gasa District by a competent government institution in Bhutan. All the organic certification cost in Gasa was borne by the government [17]. Certified organic farmers comply with Bhutan Organic Standards, strictly refrain from using any chemical fertilisers and agrochemicals in their fields and resort to using locally available organic inputs, such as the FYM and biopesticides.

One critical issue in accepting organic agriculture remains in its productivity [18]. Productivity increases are a critical precondition for attaining long-term food security in the face of rising demand for agricultural products [19]. Productivity is a performance metric for determining the quantity of output produced from a current resource base; it can be a strong indicator of long-term sustainability [20]. Conway [21] specified that productivity is also a measure of annual *crop yield* per hectare of land. The FAO [22] defined that land productivity measures the quantity of output produced by a given amount of land. There is a close relationship between agricultural productivity and farm income, influencing food security and rural livelihoods [20]. On the other hand, profitability is concerned as an economic concept in analysing the agriculture sector's performance [23]. Profit is gross revenue less total production costs, whereas profitability is a term that is obtained from it [24]. The farmer makes a profit if the difference is positive, but the farmer is at a loss if it is negative [25]. A measure of profitability performance demonstrates how efficiently the farmer's resources are utilised to generate income and profit [26]. The profitability study will be helpful to measure the household income for organic and conventional potato farmers. Similar studies were undertaken and reported in refs [27–31]. Therefore, it is crucial to apply the economic indicators to measure the performance of organic potato production.

A comparative assessment on organic and conventional rice farming in Bhutan was studied previously [29]; however, no such research has been carried out on potatoes, one of the critical horticultural crops in the country. Therefore, this study has focused on comparing the productivity and profitability of potatoes in these two farming systems in two representative districts in West-Central Bhutan. The data were collected for the 2019 production cycle and marketing year. The study's objectives were to assess the organic and conventional potatoes' productivity and profitability and examine different constraints faced by organic potato farmers in West-Central Bhutan. Furthermore, because different potato varieties can influence productivity and profitability, the study focused on the country's popular red potato variety, the *Desiree*. The study is expected to be helpful as a guide for policymakers, receive further support from agriculture officials and researchers, and help

1 Ngultrum (Nu) is a Bhutanese currency, 1 Nu = 0.014 USD.

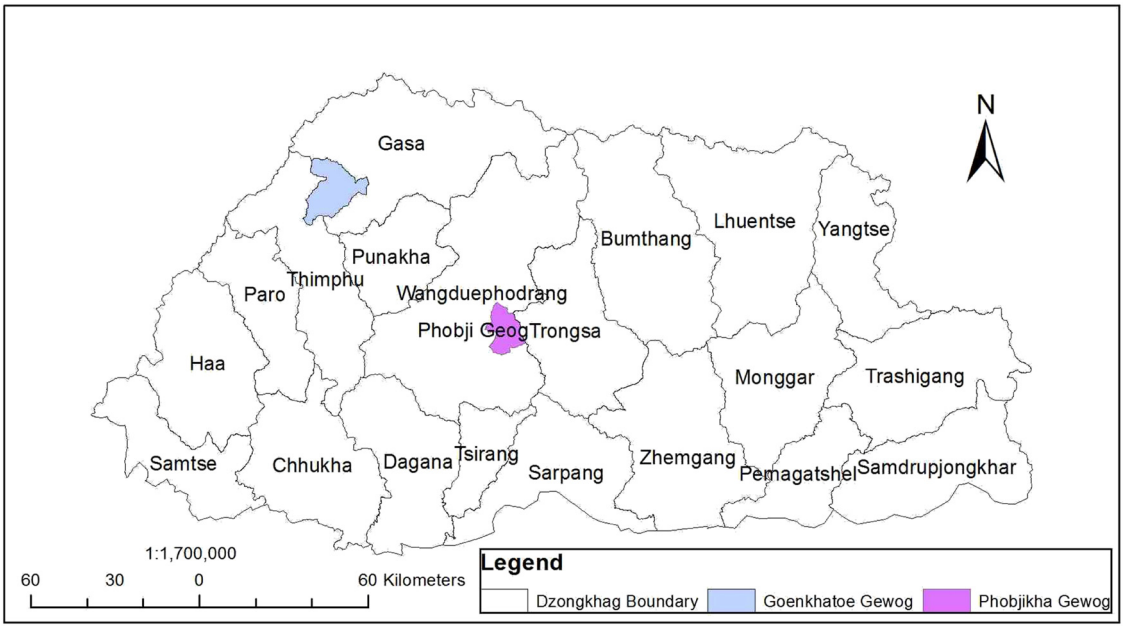

Figure 1: The map of Bhutan showing study areas (Source: National Soil Service Centre-2020).

farmers in their decision-making to adopt a better farming system in potato production.

2 Materials and methods

2.1 Study area

West-Central Bhutan, among the four regions in Bhutan, was purposively selected for the study because it is one of the largest potato producers in the country. The region produced 16,478 t in 2019, comprising 38% of the total potato production in the country [32]. It was also due to the availability of both the commercial organic and conventional potato farmers. Therefore, two potato-producing and neighbouring representative districts in West-Central Bhutan, namely Gasa and Wangdue Phodrang districts, were selected for the study. Bhutan's West-Central region comprises five districts: Gasa, Wangdue Phodrang, Punakha, Dagana, and Tsirang [33].

Gasa District has a potato farming area of 30.08 ha with an annual production of 185.24 t [32]. Goenkhatoe *Gewog*[2] within the district located at 27°50′N 89°38′E, altitude ranging from 2,100 to 2,800 metres above mean sea level (masl) was selected as a research site for the organic potato assessment. The soil in the region is ferralsols type which is identified by low fertility, macro and micro-nutrient deficits, and soil acidity [29]. Soil textures in the *Gewog* are loam and silty clay loam as reported by the National Soil Service Centre (NSSC), Thimphu, in 2020. In 2019, the country as a whole received near-normal temperature and rainfall [34]. The annual national average maximum and minimum temperature were 22.4 and 11.8°C, respectively, and the annual national average precipitation was 1,825.2 mm.

Wangdue Phodrang District has a potato area of 882.62 ha with an annual production of 15,569.87 t [32]. Phobjikha *Gewog* within the district located at 27°30′N 90°10′E, altitude ranging from 2,300 to 4,000 masl was selected as a research site for the conventional potato assessment. Soil textures in the Phobjikha *Gewog* are comparable to Goenkhatoe *Gewog*, consisting of loam and silty clay loam, as reported by the NSSC. Both places fall under the same agroecological zone, that is, the temperate zone (Agroecological Zone 3) of Bhutan, located above 1,800 masl [35]. Figure 1 shows the study areas in West-Central Bhutan.

2.2 Cropping sequences in study areas

The annual sequences of different crops planted on the same plot of land in the study areas are depicted in Table 1. The cropping sequences of organic and conventional potato farmers were comparable, except some conventional farmers grow mustard after potato harvest. It was adopted from the study of Bajracharya and Sapkota [31].

2 A group of villages in Bhutan.

Table 1: Cropping sequences in study areas

Gasa (Goenkhatoe *Gewog*)	Wangdue Phodrang (Phobjikha *Gewog*)
Potato–Sweet or bitter buckwheat	Potato–Sweet or bitter buckwheat
Potato–Turnip	Potato–Turnip
Potato–Garlic	Potato–Mustard

2.3 Sampling procedure

Multistage and purposive sampling techniques were used to select the research sample. In the first stage, two neighbouring representative districts out of five districts in West-Central Bhutan were selected. Multistage and purposive sampling techniques were also applied [36,37]. Gasa District was chosen for the organic potato assessment because it was declared the first fully organic district in 2004 by its local government [38]. Wangdue Phodrang District was selected as the conventional potato research site because the district is the largest producer of potatoes in West-Central Bhutan [39]. Potatoes in Wangdue Phodrang are produced mainly through conventional farming practices.

In the second stage, Goenkhatoe *Gewog*, among four *Gewogs* in Gasa, was purposively selected for the organic potato assessment. Goenkhatoe *Gewog* was primarily selected because the *Gewog* has an organic farmers' group known as *Gasa Rangshin Sonam Detshen*, which has produced certified organic potatoes and other crops since 2016. The group is certified by the Bhutan Agriculture and Food Regulatory Authority [40]. Potatoes are the main cash crop grown in the *Gewog*.

Similarly, Phobjikha *Gewog*, among 15 *Gewogs* in Wangdue Phodrang, was purposively selected for conventional potato research due to the availability of commercial conventional potato farmers. Moreover, potato cultivation is the primary income source for almost all the households in Phobjikha *Gewog* [41], and they have been cultivating potatoes for decades.

2.4 Data collection

Data were collected from 43 organic potato farmers randomly spread across 17 villages in Goenkhatoe *Gewog* under the Gasa District. The conventional potato's data were collected from 50 farmers randomly spread across 13 villages in Phobjikha *Gewog* under Wangdue Phodrang District. The data were collected from mid-September to October end of 2020 for the previous year's potato cropping cycle (2019). These farmers cultivated potatoes in 58.49 ha with a total production of 1,068.54 t.

Primary data were collected through face-to-face interviews with individual farmers. During each farmer's interview, the head of the family, or any family member actively engaged in potato farming, was interviewed. The semi-structured questionnaire was applied to collect data from farmers. It consisted of three parts: the first part contained the socio-demographic characteristics, the second part gathered productivity and profitability data, and the last part comprised constraints. The constraints opined by farmers were recorded using the five-point Likert scale, ranging from strongly disagree = 1 to strongly agree = 5 [42].

Informed consent: Informed consent has been obtained from all individuals included in this study.

Ethical approval: The research related to human use has been complied with all the relevant national regulations, institutional policies and in accordance with the tenets of the Helsinki Declaration, and has been approved by the Ministry of Agriculture and Forests. Then, selected districts, *Gewogs* administrations and agriculture extension officials were approached, who readily provided consent to collect data.

2.4.1 Assessment of content validity

To assess the content validity of the items in the questionnaires, the item objective congruence (IOC) rating, interpretation, and decision as provided by Rovinelli and Hambleton [43] were applied, wherein each question item with an IOC rating of 0.5 and above was retained in the questionnaire. A draft of the semi-structured questionnaire was sent for review and feedback to three experts relevant to the study field to ensure that each of the questionnaire's items captured the intended objectives. The pre-testing of the questionnaire designed for an individual farmer's interview was carried out with at least 30 potato farmers who did not belong to the sample research farmers. The pre-testing was carried out in Geney *Gewog* under the Thimphu District in Bhutan on the 1st week of September 2020.

2.5 Data analysis

2.5.1 Socio-demographic characteristics

Descriptive statistics, namely, frequencies, arithmetic means, standard deviations, percentages, and maximum and

minimum, were used to analyse the socio-demographic characteristics using the SPSS.

2.5.2 Productivity analysis

Productivity was calculated using the following formula [22]:

$$\text{Land productivity} = \text{Volume of output/planted area}, \quad (1)$$

where the volume of output was measured in metric tonnes (t) and the planted area was measured in hectares (ha).

2.5.3 Profitability measure using cost and return analysis (CRA)

The CRA is a form of economic assessment that takes into account both the implicit and explicit expenses borne by farmers [44,45]. Actual expenditures incurred fall under the explicit cost, while imputed or implied costs, which are not related to the actual expenditure payments, fall under implicit cost [44]. Thus, the costs can be categorised into explicit and implicit costs, which are cash and non-cash costs, respectively [28,46]. The CRA was computed using Microsoft Excel.

2.5.4 Total cost (TC)

TC was computed using the following equation [28,36]:

$$\text{TC} = \text{TVC} + \text{TFC}, \quad (2)$$

where, TC is the total cost, TVC is the total variable cost, and TFC is the total fixed cost.

The TVCs are the costs incurred by the variable inputs, such as raw materials, labour, and other variable overhead expenses [47]. While TFCs are those production costs that do not change with production volume, such as land rent [48]. Non-cash costs were estimated based on the farm inputs' prevailing market prices. The labour costs were computed for the hired, exchange, and family labourers [25]. Hired labourers' cash costs were based on the prevailing farm labour wage, whereas exchange and family labourers' costs were based on the farmers' actual food and refreshments expenditures [29].

The TFCs also include the depreciation of farm tools and equipment [49]. The straight-line method shows the same value of depreciation cost in each period [50].

$$\text{Depreciation expense} = (\text{Asset cost} - \text{Salvage value})/\text{Useful life of the asset}. \quad (3)$$

2.5.5 Gross return (GR)

GR was calculated with the following equation [28,29]:

$$\text{GR} = Q \times P, \quad (4)$$

where, Q is the productivity (yield) and P is the selling price (farm-gate price considered in this study).

2.5.6 Profitability

The following equation determined the profit or gross margin (GM) [30,51]:

$$\text{Profit or GM} = \text{GR} - \text{TC}, \quad (5)$$

where, GR is the gross return and TC is the total cost.

2.5.7 The benefit cost (B:C) ratio (BCR)

The BCR was calculated using the following equation [29,52]:

$$\text{B:C ratio} = \text{GR/TC}. \quad (6)$$

2.5.8 Return on investment (ROI) [36]

$$\text{ROI} = \text{GM/TC expressed in \%}. \quad (7)$$

2.5.9 Break-even price and break-even productivity (*yield*) analysis using break-even analysis

Alongside other parameters, the break-even price (P) and productivity (Y) were computed, which were adopted from the study of Dillon [53] as indicated in the equations below:

$$\text{Price } (P_i) = (\text{VC}_i + \text{FC}_i + \pi_i)/Y_i, \quad (8)$$

$$\text{Productivity } (Y_i) = (\text{VC}_i + \text{FC}_i + \pi_i)/P_i, \quad (9)$$

where P_i is the output price of commodity i, Y_i is the productivity of commodity i, VC_i is the variable cost incurred to produce commodity i, and FC_i represents the fixed costs to produce commodity i; break-even price or productivity can be inspected by setting profits (π_i) equal to zero.

2.6 Comparison of productivity and profitability statistically (mean differences)

The productivity and profitability mean differences were compared using the independent sample *t*-test, using the SPSS. Before the statistical analysis, the requirements of normal distribution and variance homogeneity were verified. All tests were performed at a significance level of 5% [54].

2.7 Constraints faced by organic potato farmers

Constraints encountered by organic potato farmers in the region were analysed using the descriptive analysis of the five-point Likert scale [42]. The various constraints were ranked following their mean values. The mean values were interpreted as follows: the ranges of 1.00–1.80, Strongly disagree; 1.81–2.60, Disagree; 2.61–3.40, Undecided; 3.41–4.20, Agree; and 4.21–5.00, Strongly agree [54]. It was adopted from a similar study on the barriers encountered in converting to organic farming [55].

3 Results

3.1 Socio-demographic profile of farmers

Details of the socio-demographic profile of farmers are presented in Table 2. Organic potato farmers had a higher female population (69.77%) than the male population (30.23%), but the conventional potato farmers had about equal distribution of male (48%) and female population (52%). In addition, organic farmers' average family labour was lower than the conventional farmers with two and three numbers, respectively.

Overall, the average year of farming experience was higher for organic farmers (31 years) than the conventional farmers (26 years). Organic farmers attended more technical training than conventional farmers, with two training sessions per year. Most organic farmers (83.7%) depended purely on farming for their income, while 40% of the conventional farmers had off-farm income. The conventional farmers cultivated potato in a larger area than the organic farmers, with a mean cultivated area of 1.08 and 0.11 ha, respectively. Interestingly, organic potato farmers owned larger landholding than conventional farmers; the conventional farmers leased in more land for potato cultivation. The average farm size of the organic farmers was comparable with the national average of 1.16 ha, but the conventional farmers had lesser than the national average.

3.2 Productivity and profitability analysis of organic potatoes

The details of the productivity and profitability analysis with the CRA are provided in Table 3. The TC of organic potato production was 340,771.17 Nu/ha. The TVC was 338,211.89 Nu/ha, which accounted for 99.63% of the total production cost. The TFC was 2,559.28 Nu/ha, and its share of total production cost was only 0.75%. The total cash cost was 135,671.90 Nu/ha, and the total non-cash cost was 203,790.90 Nu/ha. The government provided input support with seeds and bio-pesticides, amounting to an average of 1,308.37 Nu/ha. Therefore, the actual cost of organic potato production to a farmer with this input support was 339,462.80 Nu/ha. Under the variable costs (VCs), the labour cost was higher than the input cost. The total input cost accounted for 41.96% of the total production cost. The highest input cost was incurred on purchasing potato seeds comprising 18.43%, while the lowest input cost incurred was for the use of bio-pesticides comprising only 0.04% of the total production cost.

The total labour cost was the highest contributor (57.67%) to the total production cost. The highest labour cost incurred was in weeding and earthing up activities, comprising 25.53%, while the lowest labour cost incurred was on applying bio-pesticides, which consisted of only 0.02% of the total production cost. The depreciation cost contributed the highest under the fixed costs, comprising only 0.74% of the total production cost.

Farmers received an average farm-gate price of 18.29 Nu/kg, and the GM or the profit was negative at −202,708.47 Nu/ha. The GM over cash cost and variable cost were 1,082.43 Nu/ha and −201,457.56 Nu/ha, respectively. The average productivity of organic potatoes was 7.48 t/ha. The break-even productivity and break-even prices were 18.63 t/ha and 45.58 Nu/kg, respectively, while the BCR stood at 0.40, and the ROI was −59.71%.

3.3 Productivity and profitability analysis of conventional potatoes

The details of productivity and profitability analysis with the CRA are presented in Table 4. The TC of conventional

Table 2: Socio-demographic profile of farmers

Items	Organic farmers (n = 43)		Conventional farmers (n = 50)	
	Frequency	Percentage	Frequency	Percentage
Gender				
Male	13	30.23	24	48.00
Female	30	69.77	26	52.00
Age				
Average age (years)	52		43	
<40 years	10	23.26	23	46.00
40–50 years	10	23.26	16	32.00
51–60 years	13	30.23	7	14.00
>60 years	10	23.26	4	8.00
Education level				
Illiterate	27	62.79	26	52.00
Non-formal education	4	9.30	4	8.00
Primary School	9	20.93	17	34.00
Middle School	1	2.33	2	4.00
Lower secondary	2	4.65	0	0.00
Upper secondary	0	0.00	1	2.00
Marital status				
Single	0	0.00	1	2.00
Married	38	88.37	46	92.00
Household members				
Average member(s)	4		6	
≤3	18	41.86	10	20.00
4–5	13	30.23	16	32.00
≥6	12	27.91	24	48.00
Family labour				
Average persons	2		3	
1–2	35	81.40	22	44.00
3–4	7	16.28	21	42.00
≥5	1	2.33	7	14.00
Experience in farming				
Average years	31		26	
1–10 years	9	20.93	5	10.00
11–20 years	9	20.93	12	24.00
>20 years	25	58.14	33	66.00
Attend farmers' training				
Average per year	2		1	
No training	6	13.95	22	44.00
1 to 2 times per year	30	69.77	28	56.00
3 times per year	7	16.28	0	0.00
Off-farm income				
None	36	83.7	30	60
Yes	7	16.3	20	40
Average farm size (ha)	1.17		0.84	
Potato cultivated area (ha)				
Mean	0.11		1.08	
Std. Dev	0.14		0.49	
Minimum	0.02		0.20	
Maximum	0.92		2.12	

potato production was 309,012.30 Nu/ha, with a TVC of 290,591.79 Nu/ha and a TFC of 18,420.51 Nu/ha. The total variable and fixed costs accounted for 94.04 and 5.96% of the total production cost, respectively. The total cash cost was 108,133.20 Nu/ha, and the total non-cash was 200,879.10 Nu/ha. Under the VCs, the input cost was higher than the labour cost. The total input cost comprised 60.10% of the total production cost. The cost

Table 3: Cost and return analysis of organic potatoes

Item	Quantity	Cash (Nu)	Non-cash (Nu)	Total (Nu)	%
(A) Variable costs (VCs) (Nu/ha)					
(1) Input cost					
(i) Seed	2.39 t	9,321.90	53,243.60	62,565.50	18.43
(ii) FYM and other organic fertilisers	41.34 t	1,550.39	56,792.70	58,343.09	17.19
(iii) Bio-pesticides	0.002 L	0	145.38	145.38	0.04
(iv) Fuel & rental		21,374.03	0	21,374.03	6.30
Total input cost (Nu/ha)		32,246.32	110,181.68	142,427.99	41.96
(2) Labour cost (man-days/ha)					
(i) Land preparation	133.42	8,681.41	14,998.68	23,680.09	6.98
(ii) Compost/FYM application	46.89	6,570.37	6,801.57	13,371.94	3.94
(iii) Planting	84.41	13,814.76	8,338.41	22,153.17	6.53
(iv) Weeding & earthing up	297.17	43,861.92	42,793.78	86,655.70	25.53
(v) Bio-pesticides application	1.01	0	83.73	83.73	0.02
(vi) Harvesting/curing	196.93	30,466.60	19,372.67	49,839.27	14.68
Total labour cost (Nu/ha)		103,395.05	92,388.84	195,783.89	57.67
TVC (Nu/ha)		135,641.37	202,570.52	338,211.89	99.63
(B) Fixed costs (FCs) (Nu/ha)					
(1) Land tax		30.53	0	30.53	0.01
(2) Land rent		0	0	0	0.00
(3) Depreciation cost		0	2,528.75	2,528.75	0.74
TFC (Nu/ha)		30.53	2,528.75	2,559.28	0.75
TC = (TVC + TFC) (Nu/ha)		135,671.90	205,099.27	340,771.17	
TC with deductions of an average govt. support on seeds & bio-pesticides worth of Nu. 1,308.37/ha (Nu/ha)		135,671.90	203,790.90	339,462.80	
GR (Nu/ha) ($Q \times P$)				136,754.33	
Productivity (kg/ha) (Q)				7,477	
Farm-gate price (Nu/kg) (P)				18.29	
GM (profit) (Nu/ha) (GR-TC)				−202,708.47	
Break-even productivity (kg/ha)				18,631.56	
Break-even price (Nu/ha)				45.58	
BCR (GR/TC)				0.40	
ROI (GM/TC × 100) (%)				−59.71	
Gross margin over cash cost (Nu/ha) (GR-Total cash cost)				1,082.43	
Gross margin over variable cost (Nu/ha) (GR-TVC)				−201,457.56	

Nu = Ngultrum (Bhutanese currency); 1 Nu = 0.014 USD.

incurred on the seed purchase was the highest input cost comprising 29.03%, and the lowest input cost was on purchasing insecticides, which constituted 0.01% of the total production cost. The total labour cost made up 33.94% of the total production cost. The highest labour cost was on the harvesting/curing, comprising 22.07%, and the lowest labour cost was on applying pesticides, which made up only 0.37% of the total production cost. The depreciation cost was the highest cost within the fixed costs, which comprised 3.79% of the total production cost. Many conventional farmers also leased the land, which made up 2.17% of the total production cost.

The conventional potato farmers received an average farm-gate price of 20.44 Nu/kg, and the GM or profit was 83,832.85 Nu/ha. The GM over cash and variable costs stood at 284,711.95 and 102,253.36 Nu/ha, respectively. The average conventional potato productivity was 19.22 t/ha. The break-even productivity and break-even prices were 15.12 t/ha and 16.08 Nu/ha, respectively, while the BCR was 1.27 and the ROI was 27.13%.

3.4 Comparison of productivity and profitability statistically (mean difference)

Detailed results with the p-value and significance level of mean differences are provided in Table 5. The independent sample t-tests results showed that the conventional potato had significantly higher values in both the productivity and profitability parameters at $p < 0.001$ than the

Table 4: Cost and return analysis of conventional potatoes

Item	Quantity	Cash (Nu)	Non-cash (Nu)	Total (Nu)	%
(A) Variable costs (VCs) (Nu/ha)					
(1) Input cost					
(i) Seed	3.06 t	2,198.25	87,522.03	89,720.28	29.03
(ii) Chemical fertilisers	0.97 t	32,458.18	0	32,458.18	10.50
(iii) Agrochemicals					
(a) Insecticide	0.07 L	20.4	0	20.4	0.01
(b) Fungicide	0.004 t	1,050.75	0	1,050.75	0.34
(c) Herbicide	0.0073 t	5,785.26	0	5,785.26	1.87
(d) Sticker	0.10 L	24.39	0	24.39	0.01
(iv) FYM and other organic fertilisers	16.08 t	1,759.98	43,873.20	45,633.18	14.77
(v) Fuel & rental		11,024.77	0	11,024.77	3.57
Total input cost (Nu/ha)		54,321.98	131,395.23	185,717.22	60.10
(2) Labour cost (man-days/ha)					
(i) Land preparation	10.21	956.68	1,655.03	2,611.71	0.85
(ii) Compost/FYM application	20.27	3,879.78	3,760.38	7,640.16	2.47
(iii) Planting/fertilising	42.35	8,106.79	7,893.78	16,000.57	5.18
(iv) Weeding & earthing up	28.62	3,492.76	5,790.46	9,283.22	3.00
(v) Pesticide application	5.15	575.78	569.74	1,145.52	0.37
(vi) Harvesting/curing	195.70	30,075.72	38,117.67	68,193.40	22.07
Total labour cost (Nu/ha)		47,087.52	57,787.05	104,874.58	33.94
TVC (Nu/ha)		101,409.51	189,182.28	290,591.79	94.04
(B) Fixed costs (FCs) (Nu/ha)					
(1) Land tax		21.11	0	21.11	0.01
(2) Land rent		6,702.58	0	6,702.58	2.17
(3) Depreciation cost		0	11,696.82	11,696.82	3.79
TFC (Nu/ha)		6,723.69	11,696.82	18,420.51	5.96
TC = (TVC + TFC) (Nu/ha)		108,133.20	200,879.10	309,012.30	
GR (Nu/ha) ($Q \times P$)				392,845.15	
Productivity (kg/ha) (Q)				19,220.00	
Farm-gate price (Nu/kg) (P)				20.44	
GM (profit) (Nu/ha) (GR-TC)				83,832.85	
Break-even productivity (yield) (kg/ha)				15,118.47	
Break-even price (Nu/ha)				16.08	
BCR (GR/TC)				1.27	
ROI (GM/TC × 100) (%)				27.13	
Gross margin over cash cost (Nu/ha) (GR-Total cash cost)				284,711.95	
Gross margin over variable cost (Nu/ha) (GR-TVC)				102,253.36	

Nu = Ngultrum (Bhutanese currency); 1 Nu = 0.014 USD.

organic potato. Furthermore, the BCR was also significantly higher in conventional farming.

Regarding input cost, the costs of seed, fertiliser and manure, pesticide/bio-pesticide, and total input cost were significantly higher in conventional potato production than organic production. But the fuel and farm machinery rental cost was significantly higher in organic potato production.

In labour cost, land preparation, compost/FYM application, weeding and earthing up, and total labour cost were significantly higher in organic potato production than in conventional potato production. However, the labour cost for pesticide/bio-pesticide application was significantly higher in conventional potato production. There were no significant differences observed in both the farming systems on the labour cost on planting and harvesting/curing activities. No significant differences were observed in the TC of production.

The productivity of the organic potatoes was also significantly lower than the national average (10.40t/ha), while it was significantly higher for the conventional potato, both at $p < 0.001$. It was statistically compared using one-sample t-tests with the SPSS; between organic potato and national average, the t-test value was −6.818 with d.f. of 42; between conventional potato and the national average, the t-test value was 11.961, d.f. of 49.

Table 5: Independent sample *t*-test results on productivity and profitability ($N = 93$)

Item	Mean		*t*-test	*p*-value
	Organic	Conventional		
Productivity (t/ha)	7.48	19.22	−13.767	0.000***
Profit (Nu/ha)	−202,708.47	860,31.02	−7.669	0.000***
BCR	0.52	1.39	12.640	0.000***
Input cost (Nu/ha)				
Seed	62,565.49	89,720.28	−6.119	0.000***
Fertiliser/manure	58,169.07	78,091.37	−2.281	0.025*
Pesticide/bio-pesticide	145.39	6,880.79	−13.440	0.000***
Fuel & rental	21,374.03	11,024.78	2.923	0.006**
Total input cost	120,879.95	174,692.45	−5.039	0.000***
Labour cost (Nu/ha)				
Land preparation	23,680.09	2,611.71	5.231	0.000***
Compost/FYM application	13,371.94	7,640.17	2.387	0.019*
Planting & fertilizing	22,153.17	16,000.57	1.496	0.138
Weeding & earthing up	86,655.70	9,283.22	3.274	0.002**
Pesticide/bio-pesticide application	83.73	1,145.52	−3.525	0.001**
Harvesting/curing	49,839.27	68,193.39	−1.526	0.131
Total labour cost	146,141.55	89,428.34	2.076	0.043*
Total production cost (Nu/ha)	339,462.79	306,814.13	0.867	0.390

N = sample size; organic farmers (n_1) = 43; conventional farmers (n_2) = 50; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

3.5 Constraints encountered by organic potato farmers

Constraints of the organic potato farmers are shown in Table 6. As determined by the mean analysis, the first four constraints are main constraints, namely: no price premium for organic produce, pest and disease problems, low crop productivity, and climate change affects production. Other undecided constraints are the unavailability of farm labour and the inadequate supply of bio-pesticides in their place.

4 Discussion

Bhutan envisages becoming a fully organic nation. However, there is a prior need to assess organic

Table 6: Constraints faced by organic potato farmers ($N = 43$)

Constraint	Mean	Interpretation
1. No premium price for organic potato	4.84	Strongly agree
2. Pest and disease problems	4.02	Agree
3. Low potato productivity	4.00	Agree
4. Climate change affects the production	3.69	Agree
5. Labour unavailability	3.14	Undecided
6. Bio-pesticide supply is inadequate	2.65	Undecided
7. Bio-pesticides are not accessible on time	2.50	Disagree
8. Imported potato competes with local	2.09	Disagree
9. Fertiliser supply is inadequate	2.02	Disagree
10. Inadequate knowledge of potato production	2.02	Disagree
11. Damage of potato by wild animals	1.77	Strongly disagree
12. Fertilisers are not accessible on time	1.51	Strongly disagree
13. Seed supply is inadequate	1.49	Strongly disagree
14. Seeds are not accessible on time	1.39	Strongly disagree
15. Unavailability of farm machinery for hire	1.07	Strongly disagree
16. Irrigation problem	1.00	Strongly disagree

N = sample size (number of respondents).

agriculture's performance in the country [38,56]. It was found that conventional potato farming was more productive and profitable than organic farming in West-Central Bhutan.

Organic farmers, having attended more technical training, received farm input support and organic certification free of charges from the RGoB indicated the government's effort to promote organic farming in the Gasa District and the country. Both organic and conventional potato farmers were well experienced in potato farming. Most organic farmers depended purely on farming for their income, while some conventional farmers had off-farm income. Despite conventional farmers having lesser farm size than organic farmers, they cultivated potatoes in larger areas by leasing in more land.

The study found that the conventional potato's productivity was significantly higher than the organic potato at $p < 0.001$; on average, it was 2.57 times higher. Similar findings on organic potatoes were reported by Ierna and Parisi [57] and Maggio et al. [58]. This finding contradicts the report of Tashi and Wangchuk [29], where rice grain yields between organic and conventional rice were not significantly different in Bhutan. Interestingly, the productivity of the organic potatoes was also significantly lower than the national average, while it was significantly higher for the conventional potato. The cost of organic potato production per hectare was higher than the conventional potato, on average by 30,450.50 Nu/ha, but it was not significantly different. On the other hand, Tashi and Wangchuk [29] found that the total production cost for organic rice was significantly higher than the conventional rice in Bhutan.

The total labour cost was significantly higher in organic potato production than the conventional production at $p < 0.05$. The weeding/earthing up activity was the largest contributor to the labour cost for organic farmers. The higher cost incurred on the weeding and earthing-up operation by the organic farmers was due to the need for more farm labourers (297.17 man-days/ha) to control the weeds in the absence of synthetic herbicides, unlike conventional farmers (28.62 man-days/ha). Similar findings were reported in organic rice [29,46] and in organic maize [27]. The total input cost was significantly higher in conventional potato production than in organic production at $p < 0.001$. The costs to purchase external inputs is reduced in organic farming [1]. The input costs for seed, fertiliser/manure, and pesticide/bio-pesticide were also significantly higher in conventional potato production. Such observation agrees with report of Tashi and Wangchuk [29], where conventional rice farmers incurred significantly higher agrochemical costs in Bhutan. The seed cost was the highest under the conventional farmers' input cost, contributing to 29.03% of the total production cost. The TFC accounted for 5.96% of the total production cost to conventional farmers, while only 0.75% to organic farmers. The higher fixed cost in the conventional farms was mainly due to paying the rent for leased lands, and the farm machinery's higher depreciation cost. The profitability of the conventional potato was significantly higher than the organic potato at $p < 0.001$. On average, it was higher by 286,541.32 Nu/ha than the organic potato. This result is supported by significantly higher BCR in conventional potatoes. Coppola et al. [59] and Tashi and Wangchuk [29] also reported similar findings in hazelnut and rice, respectively. However, it contradicts the findings reported by Turhan et al. [60] in organic tomatoes. The BCR of organic production was <1 at 0.40 and the ROI was negative at −59.71%, which indicated that organic potato production was not profitable. The BCR of the conventional potato was >1 at 1.27 and ROI was positive at 27.13%, showing that conventional potato production was profitable. This implies that the conventional farmers earned an average of 1.27 Nu for every 1 Nu of their investment. Conventional potato farmers also received higher farm-gate prices than organic farmers by 2.15 Nu/kg. The important reason for receiving lower farm-gate prices or the market price for organic potatoes, as opined by some organic farmers, was the overall poor appearance of organic potato tubers compared to the conventional counterpart. They pointed out that organic potato tubers are generally small-sized, and tubers are also not as smooth and attractive as the conventional potatoes, partly due to pest and disease infestations. Bhutanese traders and local customers are willing to give higher price according to the size and better appearance of potato tubers, and generally did not bother if it is organically or conventionally produced. However, they said there are a few educated customers in the market who really seek organic potatoes.

The unprofitability of the organic potato was mainly due to low productivity and lower farm-gate price. The organic potato had a 45.40 Nu/kg break-even price in the current productivity level but received only 18.29 Nu/kg. Higher price and premium price above the break-even price would ensure profitability to the organic farmers. Sgroi et al. [61] realised higher profitability in organic lemon farming due to premium price. The unprofitability of organic potato cultivation also explains why organic farmers cultivated the potato in a smaller area in 2019, despite having larger farmable land than conventional farmers. According to Kahan [25], farmers may choose to cultivate more of a particular crop because of its potential for higher profits.

The study also observed that organic potato farmers engaged in group marketing. Most of their harvests were

sold to a prior identified common middleman who purchased directly from the farmers, but the farmers receive the payment separately. The farm-gate price offered by the middleman was not profitable to the organic farmers. Likewise, in Bhutan, studies also reported that there was no premium price for organic rice [29]. The scale of organic farming adoption would be determined by customers' limited market size and willingness to pay a price premium [62]. Because price disparities occur across different business channels, exploring better marketing channels would be helpful [28]. Due to the global economy, farm products can be sold anywhere in the globe, giving farmers greater opportunities to earn more money and profit [25]. The profitability of farm production should be maintained by boosting marketability [23].

A prevalence of pest and disease problems, another major constraint, and subsequent constraints on climate change, could have contributed to lower crop productivity of organic potatoes. Wheeler [62] reported that the second most vital obstacle to organic farming adoption is production difficulties and pest and disease problems. Crop yields are influenced by diseases and weather [25]. The primary cause of yield loss in organic potato cultivation is insufficient disease and pest management [63]. Late blight infection was one of the causes for lower potato productivity in organic farming than the conventional production method [57]. An adverse impact of climate change on potato production has also been reported by many researchers [64–66]. As a result, more research needs to be conducted to address pest and disease issues, lower crop productivity, and climate change issues. Increasing the productivity of organic potatoes in the Gasa District will entail improving farming practices in line with the International Federation of Organic Agriculture Movement's (IFOAM) principles. Farm labour unavailability could have been due to lesser family labour with the organic farmers. The farm labour shortage is a growing problem in Bhutan, mainly resulting from an increasing rural to urban migration [67]. Regarding inadequate supply of bio-pesticides, many imported bio-pesticides in the country have a shorter shelf life, are relatively expensive, and their efficacy trials are still underway [68]. Considering the adverse impact of pesticides on the environment and human health, the supply of pesticides and bio-pesticides is centralised by the government and accessible only through limited government agencies.

5 Conclusion

The study revealed that the productivity and profitability of conventional potatoes were significantly higher than organic potatoes. It was also found that the productivity of the organic potatoes was also significantly lower than the national average. The total input cost was significantly higher in conventional potato farming, while the total labour cost was significantly higher in organic potato farming. The lower BCR of the organic potato and unfavourable ROI indicated that it was not profitable. A higher BCR of the conventional potato and a favourable ROI revealed a profitable venture. The unprofitability of organic potatoes was mainly due to lower crop productivity and lower farm-gate price.

The researchers hope that the empirical data generated will contribute to guiding policymakers on the development of Bhutan's vision for its organic agriculture. In addition, it will further instigate support from agriculture officials in the country to address the constraints of organic potato farmers. It will also help farmers in the decision-making process, while adopting a suitable farming system of potato production. Furthermore, long-term scientific field research on the performance of organic, conventional, and Good Agriculture Practices potatoes needs to be carried out in Bhutan, also considering their contributions to environmental pollutions. Research and technology generation to increase the productivity of organic potato considering pest and disease, climate change constraints, and market research will be crucial for organic potato development in the country.

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stretch from the study's inception to submitting the paper. She contributed to the research methodologies, provided relevant references, formatting, data interpretation and overall guidance in paper writing.

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References

[1] Morshedi L, Lashgarara F, Hosseini SJF, Najafabadi M. The role of organic farming for improving food security from the perspective of farmers. Sustainability. 2017;9(11):2086. doi: 10.3390/su9112086.

[2] Willer H, Lernoud J. The world of organic agriculture. Statistics and emerging trends 2019: Research institute of organic agriculture FiBL and IFOAM organics international; 2019.

[3] IFOAM. Consolidated annual report of IFOAM – Organics international & its action group; 2018. Retrieved from https://www.ifoam.bio/sites/default/files/annualreport_2018.pdf

[4] Department of Agriculture [DoA]. National framework for organic farming in Bhutan. In agriculture Do, editor. Thimphu, Bhutan: Department of agriculture, Royal Government of Bhutan (RGoB); 2006. p. 44.

[5] National Organic Programme [NOP]. National organic program (NOP): Major achievements 2016-2017 (Annual report). In Agriculture Do, editor. Thimphu: Department of Agriculture, Royal Government of Bhutan; 2017. p. 7.

[6] National Statistical Bureau [NSB]. Bhutan living standards survey report 2017. Bhutan: National Statistics Bureau (NSB), Royal Government of Bhutan; 2017. p. 1–210, i–xvi.

[7] ICIMOD. Organic agriculture development strategies: roadmap for 12th five year plan and beyond. International Centre for Integrated Mountain Development (ICIMOD); 2018. p. 34.

[8] McCrae-Hokenson M. Organic agriculture in Bhutan: barriers going to 100%. Independent Study Project (ISP) collection, 1827; 2014.

[9] Seldon P. Nu 1 billion flagship program for organic farming with Sikkim in mind. The Bhutanese; 2019. Retrieved from https://thebhutanese.bt/nu-1-billion-flagship-program-for-organic-farming-with-sikkim-in-mind/.

[10] Ghimiray M, Katwal TB, Tshering K, Dorjee, Dukpa W, Lakey, et al. Agriculture research strategy 2018–2028. In Agriculture Do, editor. Thimphu, Bhutan: Agriculture Research and Extension Division (ARED), Department of Agriculture; 2019. p. 56.

[11] Pieters H, Guariso A, Vandeplas A. Conceptual framework for the analysis of the determinants of food and nutrition security. Foodsec Proj. 2013;45.

[12] Bajgai Y. In Lakey, editor. Standard evaluation guidelines for field & horticultural crops. Thimphu, agriculture research & extension division (ARED). Thimphu: Department of Agriculture, Ministry of Agriculture & Forests; 2018. p. 27–39.

[13] Ministry of Agriculture and Forests (MoAF). Agriculture Statistics 2019. In Agriculture Do, editor. Thimphu, Bhutan: Renewable Natural Resources Statistics Division (RSD); 2020. p. 1–123, I–VII.

[14] BPV Consultancy & research services. Lot 2: potato value chain analysis. Thimphu, Bhutan: Bhutan Philanthropy Ventures Pvt. Ltd; 2018. p. 98.

[15] Ministry of Agriculture and Forests [MoAF]. Bhutan RNR Statistics 2018. Thimphu: Renewable Natural Resources Statistics Division, Directorate Services, Royal Government of Bhutan; 2019. p. 121.

[16] Lhamo P. In Phobji and Gangtey, farmers compete to use more fertilisers. Kuensel; 2019. Retrieved from https://kuenselonline.com/in-phobji-and-gangtey-farmers-compete-to-use-more-fertilisers/.

[17] Agriculture Research & Development Centre (ARDC)-Yusipang. Annual report (2018–2019), ARDC-Yusipang, Royal Government of Bhutan. In Agriculture Do, editor. Thimphu: Department of Agriculture; 2019. p. 106, i–x.

[18] Connor DJ. Organic agriculture cannot feed the world. Field Crop Res. 2008;106(2):187–90. doi: 10.1016/j.fcr.2007.11.010.

[19] Qaim M, Arjunan S. In Kempken F, Jung C, editors. Genetic modification of plants: agriculture, horticulture and forestry. Heidelberg: Springer; 2010. p. 615–27.

[20] FAO. Guidelines for the measurement of productivity and efficiency in agriculture: Food and Agriculture Organization of the United Nations (FAO); 2018.

[21] Conway GR. Agroecosystem analysis for research and development. Bangkok: Winrock International Institute for Agrcultural Development; 1986.

[22] FAO. Productivity and efficiency measurement in agriculture – literature review and gaps analysis Food and Agriculture Organization of the United Nations (FAO); 2017.

[23] Baležentis T, Galnaitytė A, Kriščiukaitienė I, Namiotko V, Novickytė L, Streimikiene D, et al. Decomposing dynamics in the farm profitability: an application of index decomposition analysis to Lithuanian FADN sample. Sustainability. 2019;11(10):2861. doi: 10.3390/su11102861.

[24] Lipsey RG. An introduction to positive economics. 4th edn. London: Weidenfeld and Nicolson; 1975. p. 214–7.

[25] Kahan D. Economics for farm management extension: food and agriculture organization of the united nations (FAO); 2013.

[26] Kahan D. Farm business analysis using benchmarking. Rome: Food and Agriculture Organization of the United Nations (FAO); 2010.

[27] Adamtey N, Musyoka MW, Zundel C, Cobo JG, Karanja E, Fiaboe KKM, et al. Productivity, profitability and partial nutrient balance in maize-based conventional and organic farming systems in Kenya. Agric Ecosyst Env. 2016;235:61–79. doi: 10.1016/j.agee.2016.10.001.

[28] Suwanmaneepong S, Kerdsriserm C, Lepcha N, Cavite HJ, Llones CA. Cost and return analysis of organic and conventional rice production in Chachoengsao Province, Thailand. Org Agriculture. 2020;10(3):369–78. doi: 10.1007/s13165-020-00280-9.

[29] Tashi S, Wangchuk K. Organic vs. conventional rice production: comparative assessment under farmers' condition in

Bhutan. Org Agriculture. 2016;6(4):255–65. doi: 10.1007/s13165-015-0132-4.
[30] Lyngbaek AE, Muschler RG. Productivity and profitability of multistrata organic versus conventional coffee farms in Costa Rica. Agrofor Syst. 2001;53(2):205–13. doi: 10.1023/a:1013332722014.
[31] Bajracharya M, Sapkota M. Profitability and productivity of potato (*Solanum tuberosum*) in Baglung district, Nepal. Agriculture & Food Security. 2017;6(1):47. doi: 10.1186/s40066-017-0125-5.
[32] MoAF. Agriculture statistics 2019. In Services D, editor. Thimphu: Renewable Natural Resources Statistics Division (RSD), Royal Government of Bhutan; 2020. p. 1–123, I–VII.
[33] ARDC-Bajo. About ARDC Bajo. Wangduephodrang: Agriculture Research & Development Centre (ARDC)-Bajo; 2020. Retrieved from http://rcbajo.gov.bt/bsws/by-laws/.
[34] National Center for Hydrology and Meteorology. Annual report 2019–2020. Thimphu: Bhutan, National Center for Hydrology and Meteorology, Royal Government of Bhutan; 2020. p. 1–73, i–iii.
[35] Feuerbacher A, Luckmann J, Boysen O, Zikeli S, Grethe H. Is Bhutan destined for 100% organic? Assessing the economy-wide effects of a large-scale conversion policy. PLoS One. 2018;13(6):e0199025.
[36] Chidiebere-Mark N, Ohajianya D, Obasi P, Onyeagocha S. Profitability of rice production in different production systems in Ebonyi State, Nigeria. Open Agriculture. 2019;4(1):237–46. doi: 10.1515/opag-2019-0022.
[37] Anwar M, Zulfiqar F, Ferdous Z, Tsusaka TW, Datta A. Productivity, profitability, efficiency, and land utilization scenarios of rice cultivation: an assessment of hybrid rice in Bangladesh. Sustain Prod Consum. 2020;26:752–8. doi: 10.1016/j.spc.2020.12.035.
[38] Wangmo S, Iwai CB. Performance of organic agriculture (OA) based on emergent properties of agriculture system in Gasa, Bhutan. Khon Kaen Agric J. 2018;1985(1986):1202–10.
[39] Department of Agriculture (DoA). Agriculture statistics 2016. In Agriculture Do, editor. Thimphu, Bhutan: Department of Agriculture, Ministry of Agriculture & Forests (MoAF); 2017. p. 81.
[40] Department of Agricultural Marketing and Cooperatives [DAMC] & DAS Gasa. Gasa Dzongkhag leading the way in organic crop production. Thimphu: MoAF; 2016. Retrieved from http://www.moaf.gov.bt/gasa-dzongkhag-leading-the-way-in-organic-crop-production.
[41] Dorji C. Potato farmers of Gangteng and Phobji use more fertilisers for better yield. Bhutan Broadcasting Service (BBS); 2019. Retrieved from http://www.bbs.bt/news/?p=112250
[42] Likert R. A technique for the measurement of attitudes. Archives of psychology. New York: The Science Press; 1932. p. 140.
[43] Rovinelli R, Hambleton R. The use of content specialists in the assessment of criterion-referenced test item validity: 1977. Dutch J Edu Res. 1977;2:49–60.
[44] Ciaian P, PALOMA S, Delincé J. Literature review on cost of production methodologies. The first scientific advisory committee meeting. Vol. 1; 2013. p. 1–19.
[45] Netayarak P. Agricultural economics. Bangkok: Thammasat University Press; 2007.
[46] Mendoza TC. Evaluating the benefits of organic farming in rice agroecosystems in the Philippines. J Sustain Agric. 2004;24(2):93–115. doi: 10.1300/J064v24n02_09.
[47] Delaney PR, Whittington OR. Wiley CPA examination review, outlines and study guides. Hoboken, New Jersey: John Wiley & Sons; 2011.
[48] Thorpe E, Thorpe S. The Pearson CSAT Manual 2011. New Delhi: Dorling Kindersley (India) Pvt. Ltd; 2011.
[49] Charantimath PM. Entrepreneurship development and small business enterprise. India: Pearson Education; 2005.
[50] Robinson TR, Henry E, Pirie WL, Broihahn MA, Cope AT. International financial statement analysis. 2 edn. Hoboken, New Jersey: Wiley; 2012.
[51] Husin L. Productivity and income peformance comparison of smallholder oil palm plantation at dry land and wet land of South Sumatra Indonesia. APCBEE Procedia. 2012;3:270–5.
[52] Adhikari RK. Economics of organic rice production. J Agric Environ. 2011;12:97–103.
[53] Dillon CR. Microeconomic effects of reduced yield variability cultivars of soybeans and wheat. J Agric Appl Econ. 1992;24(1):121–33.
[54] Best JW, Kahn JV. Research in education. 8 edn. Boston: Allyn and Bacon; 1998.
[55] Sharifi O, Sadati SA, Ghobadi FR, Sadati SA, Mohamadi Y, Del PTT. Barriers to conversion to organic farming: a case study in Babol county in Iran. Afr J Agric Res. 2010;5(16):2260–7.
[56] Neuhoff D, Tashi S, Rahmann G, Denich M. Organic agriculture in Bhutan: potential and challenges. Org Agric. 2014;4(3):209–21. doi: 10.1007/s13165-014-0075-1.
[57] Ierna A, Parisi B. Crop growth and tuber yield of "early" potato crop under organic and conventional farming. Sci Hortic. 2014;165:260–5. doi: 10.1016/j.scienta.2013.11.032.
[58] Maggio A, Carillo P, Bulmetti GS, Fuggi A, Barbieri G, De Pascale S. Potato yield and metabolic profiling under conventional and organic farming. Eur J Agron. 2008;28(3):343–50. doi: 10.1016/j.eja.2007.10.003.
[59] Coppola G, Costantini M, Orsi L, Facchinetti D, Santoro F, Pessina D, et al. A comparative cost-benefit analysis of conventional and organic Hazelnuts production systems in center Italy. Agriculture (Basel). 2020;10(9):409. doi: 10.3390/agriculture10090409.
[60] Turhan S, Ozbag BC, Rehber E. A comparison of energy use in organic and conventional tomato production. J Food Agric Env. 2008;6(3–4):318–21.
[61] Sgroi F, Candela M, Di Trapani AM, Fodera M, Squatrito R, Testa R, et al. Economic and financial comparison between organic and conventional farming in sicilian lemon orchards. Sustainability. 2015;7(1):947–61. doi: 10.3390/su7010947.
[62] Wheeler SA. The barriers to further adoption of organic farming and genetic engineering in Australia: views of agricultural professionals and their information sources. Renew Agr Food Syst. 2008;23(2):161–70. doi: 10.1017/s1742170507002128.
[63] Finckh M, Schulte-Geldermann E, Bruns C. Challenges to organic potato farming: disease and nutrient management. Potato Res. 2006;49(1):27–42.
[64] Bhatnagar A, Dua VK, Chakrawarti SK. Scenario, implications and prospects of climate change on potato (*Solanum*

tuberosum) insect pests: a review. Indian J Agric Sci. 2018;88(9):1331–9.
[65] Julio G, Ruiz I, Cuesta X. Expanding the agricultural frontier of the potato (*Solanum tuberosum* L.) to reduce the effects of climate change. Rev Univ Soc. 2018;10(1):46–51.
[66] Kimathi SM, Ayuya OI, Mutai B. Adoption of climate-resilient potato varieties under partial population exposure and its determinants: case of smallholder farmers in Meru County, Kenya. Cogent Food Agr. 2021;7(1):1860185. doi: 10.1080/23311932.2020.1860185.
[67] Population & Housing Census of Bhutan [PHCB]. Population & Housing Census of Bhutan (PHCB) 2017. Bhutan: National Statistics Bureau, Royal Government of Bhutan; 2017. p. 1–268, i–xvii.
[68] DoA. Implementation framework and guidelines for supply of bio-inputs in the country. In Agriculture Do, editor. Thimphu, Bhutan: Department of Agriculture, Royal Government of Bhutan; 2015. p. 10.