Original Research Article

RICE SELF-SUFFICIENCY IN BHUTAN; AN ASSESSMENT

ABSTRACT

Aims: Rice is the essential food grain in Bhutan and its availability directly translates to national food security and stability. Although there are several previous studies on production technologies, varietal adaptabilities and ecology-based information on rice in Bhutan, there is a dearth of information on rice self-sufficiency based on historical production and consumption data. Therefore, objectives of this study are to: i) evaluate rice production and consumption trends; ii) assess current and future rice self-sufficiency, and iii) identify appropriate policy and technical interventions required to enhance rice self-sufficiency.

Methodology: Rice production and consumption data of past fifteen years (2005-2019) was gathered from secondary sources and analysed using descriptive statistics, linear equations, and linear regressions.

Results: The study found that the ratio of rice self-sufficiency had declined due to increase in consumption and decrease in production over the past one and half decades. The rice cultivated area reduced to 30314 acres in 2019

Key Words: Self-sufficiency, Food Security, Per Capita Consumption, Import Dependency Ratio, Trade Deficient, Rice Demand, Projection, Crop Intensification, Crop Extensification

1. INTRODUCTION

Rice is a major dietary grain throughout the world, particularly in Asia, where it is consumed by more than half of the population[1], [2]. Rice consumption in 2018 was 490 million tonnes, with projections of 550 million tonnes and 590 million tonnes by 2030 and 2040, respectively[2]. In Bhutan, rice is the primary source of daily calories; thus, rice self-sufficiency has been a top priority in the country's food policy. Its sufficiency equates to national food security[3], [4]. Rice is also an indispensable food grain among the nine essential grains (*Dru Na Ghu*) since it is so intertwined with Bhutanese civilization and culture. In addition to its energy value, rice is used for religious offerings, ceremonies, gifts, and mediums of exchange and has other intangible values [5]. Therefore, it is vital to secure enough rice for the Bhutanese in all times to come.

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Rice is grown in all districts of Bhutan, including regions as high as 2700 meters above sea level, such as Bumthang [6]–[8]. However, according to the 12th Five Year Plan[FYP], rice production in the country meets the needs of less than half of the population [9]. The balance deficit was met through a huge volume import of rice annually. In 2019, 32466.23 tonnes of domestic rice were supplemented by 61031.85 tonnes of import, particularly from India [9], [10]. The rice consumption per capita was reported at 140 kg [9] compared to 100 kg and 64 kg in Asia and world, respectively[2]. This indicates that Bhutan's per capita rice consumption is much higher both at the regional and global levels. According to the Food and Agriculture Organization [FAO], low-income countries' average diets will continue to rely mainly on staples, which will provide 70% of daily calories [11]. Hence, achieving rice self-sufficiency in Bhutan could signify a degree of food self-sufficiency as well.

The Department of Agriculture has set the aim of increasing rice self-sufficiency at various scales and times over the years, but it has been criticized for not pursuing the goal more actively and realistically[3]. This is substantiated by attempting to increase rice self-sufficiency to 65% in the 10th FYP[12], but remaining at 46.7% even at the end of the 11th FYP[13]. Again, 12th FYP has a target of increasing rice self-sufficiency to 60%[13]. Such discrepancies and inconsistent targets in plans have called forth criticism. Therefore, it is imperative to calibrate rice self-sufficiency using past trends and anticipated future changes.

Pursuing rice self-sufficiency may remain an integral part of Bhutan’s food policy. In recent years, the food crisis and the general rise in food prices have ushered in a renewed interest in food self-sufficiency as every country seeks to insulate themselves from unpredictable global markets and price volatility[14]. It is high time for Bhutan to look for sustainable measures to curb the import given the increasing trend of demand for rice. Moreover, rice imports are heavily dependent on India, which in turn imports food grains to meet growing population demand[1], [9]. This demonstrates that, in addition to internal changes in production and consumption patterns, the future of Bhutan's food security, particularly rice, will be influenced by the degree of grain self-sufficiency in India and neighbouring countries. Therefore, food security is critical to Bhutan's national security and societal stability.

Many recent studies have used a variety of approaches to investigate cereal self-sufficiency and its projections[1], [14]–[17]. Such information is, however,

quite scarce for Bhutan. A few scattered studies on rice self-sufficiency have been undertaken for Bhutan, including a study on food security and food self-sufficiency through simulation of scenarios by the Policy and Planning Division, Ministry of Agriculture and Forests[3]. Different estimates of rice self-sufficiency varying from 40% to 65% were also reported by[6]. To identify thrust areas for policy decisions and to scientifically evaluate the rice supply-demand balance for resource allocation, it may be required to have a thorough grasp of historical production and consumption patterns. This paper aims to assess the rice self-sufficiency trend using past production and consumption data. The study provides basic information on the status of rice self-sufficiency, projects future trends and recommends appropriate policy strategies and technological interventions for securing rice for Bhutan.

2. DATA AND METHODS

2.1. Data

Analysis was performed using the secondary data gathered from various sources concerning rice for the period of 2005-2019. Information on rice production and area cultivated were collected from annual agriculture statistics, and rice import and export data were extracted from the yearbook of Bhutan trade statistics. Population data was used from the Bhutan Population and Housing Census reports of 2005 and 2017 published by the National Statistics Bureau[18][19]. Since total rice consumption requirement are generally expressed in kilograms of milled rice, this study assumed a milling recovery of 65% based on the methods used by[4], [20]–[22].

2.2. Methods:

2.2.1. Rice self Sufficiency Ratio (SSR)

The study employed the widely known formula provided by the FAO to calculate rice self-sufficiency[23]. Self-sufficiency ratio (SSR) is defined as the percentage of food consumed that is produced domestically and is calculated as below. The similar concept was also employed to study cereal sufficiency and food security in Bangladesh, India, Myanmar[16], Afghanistan[24] and Africa[17].:

$$SSR = \frac{DRP}{TRC} x\ 100$$

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Where, DRP is the domestic rice production and TRC is the total rice consumption, i.e., domestic rice production (DRP) plus rice import (RI) minus rice export (RE). Thus, SSR can be also calculated as:

$$SSR = \frac{DRP}{(DRP + RI) - RE} x\ 100$$

2.2.2. Trend analysis and forecasting

Linear trend model was selected for trend analysis and forecasting because it has resulted minimum values of Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD) and Mean Squared Deviation (MSD) over quadratic model and exponential growth model. Linear trend model was also used by[15] and, [25]. Using slope and the intercept, linear trends were analysed as follows:

$$p = k + qY$$

Where p refers to parameter used for analysis, k is the intercept, and q is slope and Y denotes year.

In addition to the above methods, other descriptive statistics measures such as percentages, growth rates and multiple regression analysis were applied in the study.

3. RESULTS

3.1. Area, Production and Yield

Data presented in (Fig 1) show that the ~~on~~ rice cultivated area and production in Bhutan showed periodic variability during the last 15 years. Between 2005 and 2019, the total rice area was decreased by about 35%, resulting to 30314 acres from 62458 acres. Similarly, production was decreased by 8%, falling from 35312 to 32466 tonnes. Surprisingly, both the area and the production fell by 41% and 42% respectively between 2017 and 2019. ~~The productivity of milled rice yield, .~~ ~~on~~ On the other hand, ~~increased~~ increased of productivity milled rice yield from 0.76 to 1.07 tonnes with a 41.3% increase in the same period. Similar findings on the decrease in the area and the rise in production were also reported in other studies[6], [26]. The increase in productivity could be due to the increase in adoption of scientific technologies especially improved variety, as reported by[6], [7], [27]. However, yield remained lower than in Asian major rice-growing countries such as India, Vietnam, Thailand, Myanmar, Indonesia, and particularly Cambodia where rice production increased by 7.45 times between 1984 and 2013[28].

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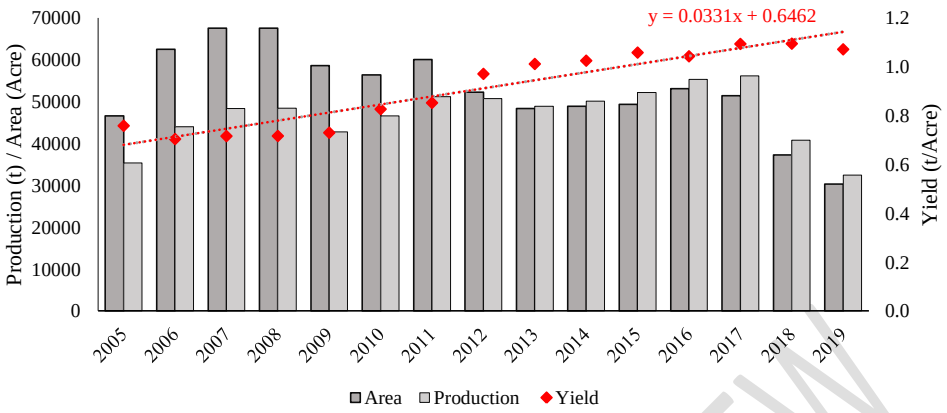

Figure 1: Rice production, area and yield from 2005-2019

3.2. Per Capita Production and Consumption

Data presented in (Fig 2) indicated that ~~Per~~ per capita refers to the volume of rice production available for each member of the population[29]. Rice annual per capita production fell from 52.5 kg in 2005 to 43.8 kg in 2019 ~~from 52.5 kg in 2005~~, with an 83% per capita production index. This means that rice production per capita in 2019 was 17% lower than that in 2005. Per capita rice production varied less between 2006 and 2017, but a sharp fall was recorded between 2017 and 2019, with the lowest value of 43.8 kg in 2019. Rice consumption per capita was found 172 kg in 2013[7]. Though annual per capita rice consumption varied from year to year, the average annual per capita consumption in the last 15 years was 147.7 kg, compared to 103 kg in Asia [30] and 27 kg in Africa[17]. This ~~shows that~~revealed that Bhutan's per capita rice consumption was higher than the rest of Asian countries. Further per capita rice consumption in Bhutan shows an increasing trend which is in contrast to major rice consuming Asian countries like Thailand, Vietnam, and Malaysia where per capita consumption was found declining as reported by[30]. Analysis shows that per capita consumption was positively correlated with per capita production (r = 0.78) which shows that the rice consumption was proportional to the rice production. Per capita consumption analysis had shown a substantial drop from 160.8 kg in 2017 to 126 kg in 2019 corresponding to the sharp decline in production in the same period.

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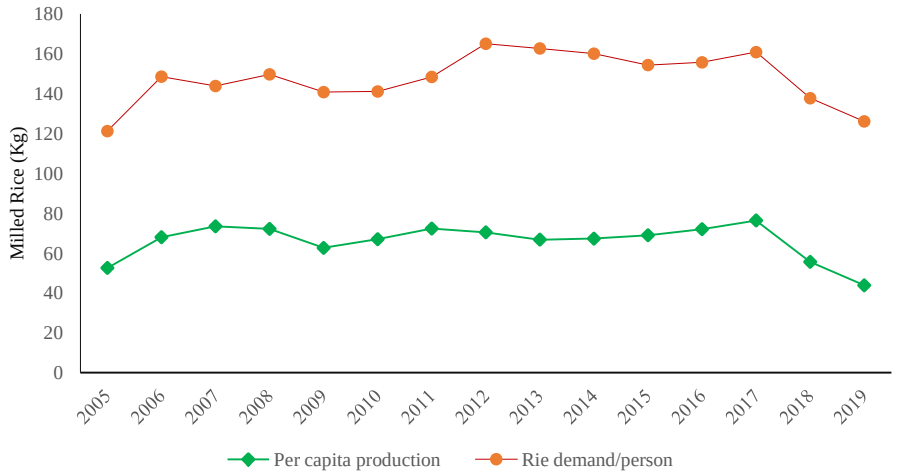

Figure 2: Per capita rice production from 2005-2019

3.3. Rice Import and Expenditure

Except for 2012, rice had been among the top 10 imported commodities during the study period. Rice imports were ranked fifth among the top ten imported commodities in 2019, after gasoline and petroleum[10]. Data in Table 1. Suggested that ~~T~~the import had doubled within two decades, from 33,000 tonnes in 2000[6] to 61031.85 tonnes in 2019.. Astonishingly, import values in Ngultrum increased by 297% while imports increased by 32.2%, indicating that the price of imported rice had risen significantly over time. Despite a 7.7-tonne increase in rice exports in 2019, the rice trade deficit increased by 298% in 2019 compared to 2005. On the orther hand , the average, Nu. 1676 million was spent on rice every year from 2017 to 2019. While India remained the major (> 95%) source of imported rice, minor sources included Thailand, Japan and Malaysia.

Table 1: Rice Import and Export from 2005-2019

Year	Import (t)	Import (Nu. million)	Export (t)	Export (Nu. million)	Rice Trade Deficit (Nu. million)
2005	46164.06	419.51	18.01	1.59	417.92
2006	52100.00	472.12	0.01	0.00	472.12
2007	46500.00	544.53	109.04	8.61	535.92
2008	52113.96	693.10	89.50	7.05	686.05
2009	53460.49	721.71	46.91	8.52	713.19
2010	51948.09	738.99	375.99	15.19	723.81

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2011	**53964.38**	**851.92**	**80.20**	**5.70**	**846.23**
2012	**68256.23**	**1254.20**	**59.73**	**6.23**	**1247.97**
2013	**70428.51**	**1061.39**	**117.00**	**13.05**	**1048.34**
2014	**69157.54**	**1101.33**	**7.22**	**0.91**	**1100.42**
2015	**64639.67**	**1126.42**	**1.28**	**0.09**	**1126.33**
2016	**64322.24**	**1536.83**	**3.53**	**0.11**	**1536.72**
2017	**62106.54**	**1677.41**	**3.40**	**0.43**	**1676.98**
2018	**60289.81**	**1689.09**	**5.97**	**0.63**	**1688.46**
2019	**61031.85**	**1664.61**	**25.74**	**2.29**	**1662.32**

~~Table 1: Rice Import and Export from 2005-2019~~

3.4. Trend in Rice Self-Sufficiency Ratio

The self-sufficiency ratio measures the magnitude of domestic production in relation to consumption, indicating the extent to which a country's supply of rice is derived from its own domestic production[14], [16], [31]. The ratio of production to consumption indicates the adequacy of rice production to meet the rice ~~requirement which are~~requirement which is directly proportional. The rice self-sufficiency ratio witnessed substantial variability across the study period, ranging from 34.73 to 51.03%. The self-sufficiency ratio remained below 50%, indicating that Bhutan's rice consumption had been heavily reliant on imports except in 2007. Self-sufficiency ratio decreased from 43.35% in 2005 to 34.73% in 2019 which is the lowest self-sufficiency rate for the period considered for this study. The rice self-sufficiency dropped an average of 0.61% annually from 2005 to 2019 in the country.

The degree of variation of self-sufficiency was influenced by the level of production and consumption over the years. Although production and consumption exhibited similar trends, the average consumption growth rate was 61.3 tonnes yearly. It was recorded that an average production fell by 14.52 tonnes, resulting in ~~a decreased~~decreased rice self-sufficiency. From 2005 to 2019, production declined from 35311.9 tonnes to 32466.23 tonnes, while consumption increased from 81457.95 tonnes to 93472.34 tonnes. As a result of the this declines in production and increase in consumption, rice self-sufficiency declined from 43.35% in 2005 to 34.73% in 2019. In 2007, 2008, and 2011, the country achieved nearly 50% rice self-sufficiency. Recent records show that there was a sharp downfall in self-sufficiency from 47.48 in 2018 to 34.73 in 2019.

The demand-supply ratio and import dependency ratio are directly related to self-sufficiency[29]. Data in Table 2. Indicated that ~~T~~the demand-supply ratio ~~shows how~~of much a country's production falls short of demand, while the

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import dependency ratio shows how much of a country's rice supply comes from imports[31]. Both indicators have a negative impact on self-sufficiency. During the study period, both indices showed an increasing trend that impacted self-sufficiency negatively. The demand-supply gap increased from 46146.05 tonnes in 2005 to 61006.11 tonnes in 2019, while the import dependency ratio increased from 56.65% in 2005 to 65.27% in 2019.

Table 2: Rice production and consumption from 2005-2019

Year	Production (t)	Consumption (t)	Self-sufficiency Ratio (%)	Demand-Supply gap (t)	Import Dependency Ratio (%)
2005	35311.90	81457.95	43.35	46146.05	56.65
2006	43944.55	96044.54	45.75	52099.99	54.25
2007	48347.00	94737.96	51.03	46390.96	48.97
2008	48385.35	100409.81	48.19	52024.46	51.81
2009	42747.90	96161.48	44.45	53413.58	55.55
2010	46563.40	98135.50	47.45	51572.10	52.55
2011	51173.85	105058.03	48.71	53884.18	51.29
2012	50710.40	118906.89	42.65	68196.49	57.35
2013	48898.85	119210.36	41.02	70311.51	58.98
2014	50074.70	119225.02	42.00	69150.32	58.00
2015	52170.30	116808.68	44.66	64638.38	55.34
2016	55308.50	119627.21	46.23	64318.71	53.77
2017	56150.90	118254.05	47.48	62103.15	52.52
2018	40798.33	101082.17	40.36	60283.84	59.64
2019	32466.23	93472.34	34.73	61006.11	65.27

~~Table 2: Rice production and consumption from 2005-2019~~

3.5. Projection Analysis

Using linear trends from the data on yields, areas, and consumption as described above, rice production and consumption were forecasted for the next decade. The slope and intercept of the observed trend were used for projection. Similarly, per capita rice availability was calculated using population projection from the National Statistics Bureau[32] to assess Bhutan's ability to achieve rice self-sufficiency.

Table 3. Rice self-sufficiency projection from 2020-2030

Year	Area (Acre)	Yield (t)	Production (t)	Per Capita Consumption (Kg)	Population	Consumption (t)	SSR	Per capita production	Rice Balance (population
	a	y	pd = a*y	pcc	p	c= ppc*p	(pd/c)*100	pd/p	(p-[pd/pcc])/p*100
2020	39570.42	1.17584	46528.49	152.57	748931	114261.63	40.72	62.13	59.3
2021	37932.8	1.208945	45858.66	153.18	756129	115822.16	39.59	60.65	60.4
2022	36295.18	1.242049	45080.40	153.79	763249	117379.50	38.41	59.06	61.6
2023	34657.56	1.275154	44193.72	154.40	770276	118931.19	37.16	57.37	62.8
2024	33019.94	1.308258	43198.61	155.01	777224	120479.22	35.86	55.58	64.1
2025	31382.32	1.341363	42095.08	155.62	784043	122015.68	34.50	53.69	65.5
2026	29744.7	1.374468	40883.12	156.24	790718	123537.98	33.09	51.70	66.9
2027	28107.08	1.407572	39562.74	156.85	797264	125048.21	31.64	49.62	68.4
2028	26469.45	1.440677	38133.93	157.46	803626	126537.47	30.14	47.45	69.9
2029	24831.83	1.473781	36596.69	158.07	809785	128002.43	28.59	45.19	71.4
2030	23194.21	1.506886	34951.03	158.68	815755	129444.92	27.00	42.85	73.0

~~Table 3Rice self-sufficiency projection from 2020-2030~~

Overall, the rice production is likely to decrease during the next ten years based on this analysis. Although the yield is expected to increase continuously, overall production is anticipated to fall because of reduced cultivation area. On the other hand, the volume of consumption will increase over the years due to an increase in population and per capita consumption. A similar finding was also reported by[6]. As a consequence, rice self-sufficiency will decline from 40.72% in 2020 to 27% in 2030. The rice balance shows that rice shortages in 2030 will be equal to the amount needed for 73% of the estimated population, against 59.3% in 2020. In 2030, rice per capita production is predicted to be 42.83 kg against a 158.68 kg consumption requirement.

4. DISCUSSION

Analysis shows that Bhutan's rice self-sufficiency ratio had been below 50% for practically every year during the last fifteen years. This means that nearly half of rice requirement was met through imports. Despite the fact that achieving 100% rice self-sufficiency may be practically challenging due to land and resource constraints and a lack of appropriate technologies[3], [3].~~it~~ It is

vital that Bhutan strive to increase its self-sufficiency. The self-sufficiency ratio shows a declining trend especially in most recent years, alarmingly so in the last three years. According to projections, the self-sufficiency ratio will continue to decline in the coming years, owing to a rise in consumption and a decrease in production area. Since self-sufficiency revolves around the volume of production and consumption, any strategy to increase self-sufficiency needs to focus on these two parameters. Rice intensification and extensification could be used to increase production and curb imbalance between rice production and requirement. Though imports could supplement domestic production, they are strongly discouraged from the standpoints of food and nation security[14] hence, Bhutan should gear towards reducing rice imports. India is a key supplier of the rice to Bhutan and, it is critical to consider India's rice production and consumption patterns, as any changes in production or trade policy could have a negative impact on Bhutan[28]. The worrying leap in imports will have a detrimental impact on the economy, as rice imports have been highlighted as a major driver of the trade deficit and currency devaluation[33]. In 2007-2008, a shift in government policies in the worldwide market resulted in a surge in food prices, particularly rice[23]. Similarly, this study recommends investigating the influence of Indian rice imports on domestic rice pricing, output, and import monopoly.

The dwindle in rice cultivation area has a significant impact on self-sufficiency. Apart from the loss of rice fields to developmental activities, fallow land has been identified as a major driving force in the reduction of rice cultivated area[7]. From 1989 to 2009, he estimated that 5-10% of the land was left fallow each year. This study also agrees that a reduction in cultivated area is a major factor of production decline of rice. Between 2015 and 2019, an average of 7586 acres were kept fallow each year[34] which can be reverted. In 2019 alone, 8406 acres of wet land were fallowed[9] which accounted for 28% of the net rice cultivation area. Otherwise, crop extensification is limited due to the fact that approximately 70.7% of arable land is already in use[34]. However, more research is needed to identify the future expansion area and reasons for fallowing to design appropriate technical and policy solutions to encourage more farmers to take up rice crop. Aside from challenges such as lack of irrigation, wildlife damage, and labour shortages, rice growers have cited low economic return as a discouraging factor for rice farming[4], [6], [35]–[37]. This recommends that the government should assist in lowering production costs and increasing net returns through appropriate measures to

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make rice farming as profitable. This may be achieved by instituting or strengthening existing policies on subsidies, incentives and policy support schemes. According to[28] the establishment of rice estates in Malaysia and a rice pledging scheme in Thailand have both contributed to increased rice production.

In order to increase rice self-sufficiency, crop ~~extensification~~intensification must be complemented by intensification, such as promoting high yielding varieties, disease and pest resistant varieties, drought and cold tolerant varieties, improved water and soil management techniques. Chhogyel et al in 2015 reported an increase of rice yield by 1.07 tonnes per hectare using intensified interventions through the commercialization program. Similarly, [6], [8], [27] reported high yielding varieties yield advantage of 27%, 33%, and 37.9% respectively over traditional varieties. The adoption of improved modern varieties was increased from 35% in 2003[6] to 43% in 2013[7] showing an increasing trend but it is still low in Bhutan. So, expansion of areas under improved rice varieties may be pursued along with other strategies like enhancing area under irrigation, efficient location-based soil and plant management to increase rice production. Other viable options for rice intensification such as double cropping in low altitude areas and the expansion of upland rice cultivation also provide arenas to enhance rice production in Bhutan.

Bhutan's per capita consumption of rice stands at 146.7 kg which is much higher than other rice-dependent nations in the world. Given our production status and negative impacts of huge rice imports, it is important to change the role of rice in Bhutanese diets from both the nutrition and food security perspectives. Many Asian countries have reduced rice consumption by changing their diet pattern and diversifying their food. Japan's rice self-sufficiency has benefited from such programs[38]. Importantly, food diversification and modification of our rice-based dietary culture are two aspects that need attention. Policy intervention on this front would not only help reduce our rice import but also help in lowering pressure to our limited rice production capacity. While younger generations are anticipated to embrace new eating habits as a result of modern exposure and lifestyles, it is also critical to educate them about healthy food, nutrition, and food diversity. On the other hand, while developing long-term rice policies, it is critical to consider cross-sectoral issues

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such as climate change, global warming, development and urbanisation, natural disasters, and weather anomalies.

5. Conclusion

From this study, it is apprehensible that Bhutan's rice self-sufficiency has been declining over the years due to a decrease in production and an increase in per capita consumption. Despite an increase in productivity per acre from 0.76 tonnes in 2005 to 1.07 tonnes in 2019, sufficiency remains at 34.73%. The rice consumption has been increasingly reliant on imports, particularly from India. The projection demonstrates that self-sufficiency will continue to decline in the coming years unless suitable interventions are made. Self-sufficiency may be increased through four possible windows; (1) increased yield, (2) increased imports, (3) area expansion, and (4) a decrease in consumption. Other than increasing imports, other three measures may be recommended through crop ~~extensification~~intensification and intensification. While new crop land development is limited, reverting the existing fallow land would help augment production. For crop intensification, adoption of improved modern varieties, expansion of irrigation, adoption of improved plant and soil management techniques, adoption of labour-saving technologies, promotion of upland rice and double cropping are encouraged. On the policy front, subsidies, input support and incentives are necessary to make rice farming economically viable and attractive. Aside from rice self-sufficiency, given Bhutan's current level of rice consumption, a shift in consumption pattern and food diversification are required to achieve balanced diet nutrition. Overall, rice production is dependent on natural and economic resources, policy support, technological innovation, as well as effective agricultural programs. It is, therefore, important to seek a sustainable and achievable path while developing plans and policies. Otherwise, realising rice self-sufficiency may remain a farfetched national dream.

6. Study Limitations

Since this study was carried out using secondary data, limitations include lack of segregated data regarding rice utilization, such as seed, feed, industrial use, etc. Overall, rice production was taken into account while assessing self-sufficiency. In addition, the imported rice included brown rice and semi or wholly milled rice meant for consumption which may include rice imported for seeds, industrial use etc.

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