

Cropping pattern and intensity in the lower belt of Sarpang District, Bhutan

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Abstract. Tashi T, Tobgay T, Wangmo T, Kinley R, Gyeltsen S. 2023. *Cropping pattern and intensity in the lower belt of Sarpang District, Bhutan. Asian J Agric 7: 1-6.* Information on cropping and farming land use is vital for increasing crop production and identifying production gaps, including planning and investment. Increasing cropping intensity through adopting multiple approaches increases crop production rather than pressure on cropland expansion in many countries. In the case of Bhutan, there is a shortage of information on cropping and its intensity in Bhutan. This study presents the status of cropping patterns and cropping intensity at the household level in the Sarpang District using a multistage random sampling technique. Different forms of multiple cropping practices were recorded in the district but were mostly practiced on a small scale and were intermittent. The rice-based cropping pattern was popular in wetlands, while the maize or vegetable-based cropping pattern predominated in dryland. With an average cropping intensity of 112%, the district had a cropping intensity of 97% and 126% for dryland and wetland, respectively. The landholding size revealed a significant inverse relationship with cropping intensity among farmer characteristics. The district's most serious farming problems were a lack of irrigation water and wildlife crop predation. The study recommends a similar study at the national level and developing appropriate intensification of agricultural land use strategy to minimize pressure on cropland expansion in the future. Similarly, agricultural planning and investment merit assessment of crop diversity, crop production resources, cropping intensity gap, and crop mapping.

Keywords: Cropping intensity, cropping pattern, dryland, land use, wetland

INTRODUCTION

Food demand is expected to increase by more than 70% globally by 2050 when the world's population is expected to reach 9 billion people (Godfray et al. 2010; Alexandratos and Bruinsma 2012; Ray et al. 2013). Similarly, Bhutan's population is anticipated to increase by 21.6% in 2047 from 735,553 in 2017 (National Statistics Bureau of Bhutan 2019), so the absolute rise in food demand is rising. The country's most important commodity, cereal, and vegetable self-sufficiency rates were 77.30% and 84%, respectively (Department of Agriculture 2021). The rice self-sufficiency rate was 47% despite being the main food grain. Additionally, the self-sufficiency of essential commodities such as oil, bulb onion, and tomato is 28.8, 18, and 22%, respectively (Department of Agriculture, 2021; Tashi et al. 2022). Almost all agriculture products are worth Nu. 12.7 billion were imported in 2020, accounting for 19% of the total imported value (Department of Revenues and Customs 2020). Given the current status of food supply and consumer demand, it is wise to identify possible solutions for food production growth.

Unlike many other countries, the rugged terrain nature of the Bhutanese landscape favors only about 2.83% of its area suitable for farming, of which lion's share (70.66%) has been brought under cultivation (Ministry of Agriculture and Forests 2019). In addition, the constitution mandates

safeguarding a minimum of 60% of the total area under forest cover all the time (Royal Government of Bhutan 2008). The loss of arable land to non-agriculture uses through urbanization and development, and land degradation is another grave concern. That implies the rising food demand will put even more strain on limited arable land, necessitating more food production through intensive farming but through the negotiation of natural resources sustainably. The future will be more challenging as the country's pressure on limited arable land continues to increase due to development, population growth, and natural land degradation. In response to these challenges, solutions such as cropland expansion, yield increase, intensive cropping, and alteration of the natural growing environment must be evaluated and adopted. On the other hand, ensuring minimum adverse environmental and ecological destruction is critical.

Several types of research have demonstrated that increasing cropping intensity could be a viable option for improving food production among numerous strategies (Siebert et al. 2010; Wu et al. 2015; Dias et al. 2016; Meng et al. 2017). That is accomplished by increasing the number of harvests yearly, resulting in higher food supplies without cropland expansion needs. In the next 40 years, Bruinsma (2009) estimated that more than 90% of crop production growth would result from intensification, indicating that cropland expansion may account for only 10% of

production increase. Cropping intensity is a commonly and broadly discussed term that refers to the ratio of the sum of the annual harvested area to total cropland (Bezbaruah and Roy 2002; Siebert et al. 2010; Wu et al. 2015). Wu et al. (2015) suggested that intensive use of existing croplands through increased cropping intensity by increasing the number of cropping cycles or adopting multiple cropping or intercropping can increase food supplies without additional land clearing. This approach may provide an opportunity for Bhutanese farmers to increase the frequency of harvests each year, thereby increasing the food supplies. Unfortunately, agriculture research in Bhutan has mostly focused on increasing yield per unit area of specific crops by screening and adopting high-yielding varieties, applying fertilizer and pesticides, evaluating improved irrigation technologies, and developing value chains. Therefore, increasing food production by cropping intensity has received very little attention in Bhutan. Therefore, it is imperative to explore the potential of cropping intensity in augmenting food production and calibrate its scope in the Bhutanese food production system. Furthermore, while recognizing the limited scope for horizontal expansion, increasing cropping intensity may give a credible strategic opportunity to increase food production.

The present study attempted to assess cropping patterns and determine cropping intensity at the household level in the Sarpang District, as this subject has been less studied in Bhutan. The study area was purposely selected due to the long growing season and similar agroclimatic and geographical conditions representing the large arable land of southern Bhutan. The study reported farming challenges that could be key hurdles to increasing crop production.

Understanding cropping intensity at the local level may usher policymakers, researchers, and extension personnel to develop food production strategies and plan initiatives to respond to sustainability challenges and increase food production. In addition, understanding cropping intensity would aid in identifying land-use opportunities in the regions to increase food production.

MATERIALS AND METHODS

Description of the study area

The study was carried out in the Sarpang District, located between 26°42'N and 89°46'E to 26°47'N and 90°54' E in the subtropical agroecological zone of Bhutan (Figure 1). The district's elevation ranges from less than 200 m to 4,200 m above sea level, where 74% of the district's total area falls below 1,800 m altitude (Department of Forests and Park Services 2016). It experiences hot and humid summer and dry and warm winter, with annual temperatures ranging from 6°C in winter to 35°C in summer. The average annual rainfall in the district is about 5,100 mm (NCHM 2018). Soils are generally sandy loam to loam with a pH of less than 6 with low organic carbon and nitrogen (National Soil Services Center 2001). Approximately 76.5% of total arable land (19,744.54 acres) was cultivated in the district (Ministry of Agriculture and Forests 2020). The estimated population of the district was about 22,000, with 71% living in rural areas (National Statistics Bureau 2017). Crop cultivation and livestock rearing were the predominant economic activities in the district.

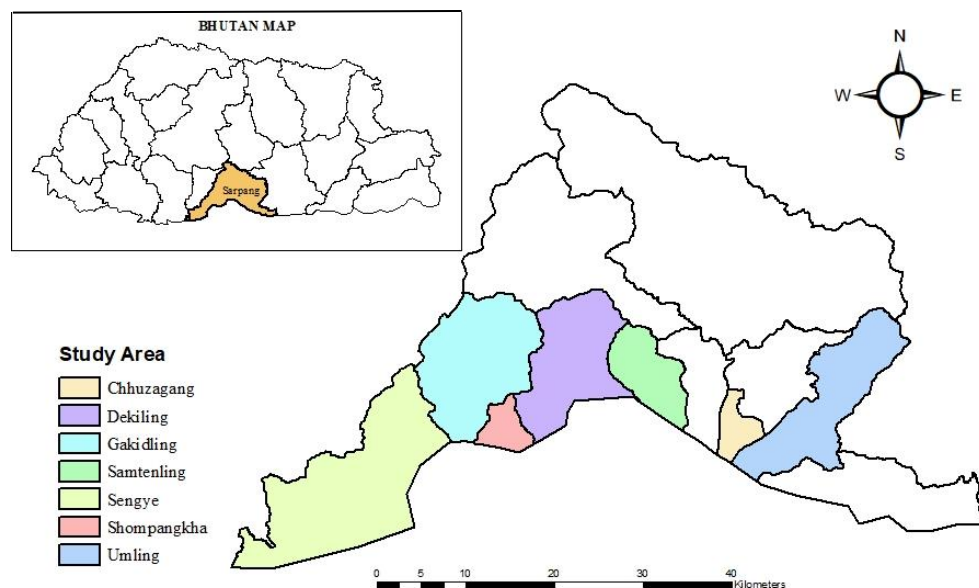


Figure 1. Study area in the Sarpang District, Bhutan

Sampling, data collection, and analysis

The study adopted a multistage sampling technique. The first stage involved sampling six blocks based on altitude (<1,500 m), cultivation area, and farming population. Two villages from each block were randomly chosen in the second stage. In the third stage, samples were drawn at random from all farming households. Next, using pre-tested semi-structured questionnaires, data were collected from 100 households and analyzed using SPSS. Descriptive statistics were mostly used to facilitate the presentation of the findings. Regression analysis examined the relationship between cropping intensity and respondent characteristics. Cropping intensity was calculated as the ratio of total cropped area to net area sown as employed by Siebert et al. (2010), Wu et al. (2015), Atsumi (2016), Gogoi (2016), Rashid et al. (2017), Wu et al. (2018), Waha et al. (2020).

RESULTS AND DISCUSSION

Characteristics of the respondents

More than two-thirds of the respondents (69%) were females. The average age of the respondents was 46 (SD=11.7), representing the age range of 36 to 55. Only 2% of respondents had completed tertiary education, while 76% had no formal education; in rural literacy, 63.6% was reported by the National Statistics Bureau (2017). Most responders (83%) had been farming for more than ten years, indicating a high experience level. There was a significant frequency of relatively small family sizes in the district, with about 65% of respondents having less than six family members and only 4% having more than eight. Annual farming income ranged from Nu. 4,000 to 480,000 with an average annual farming income of Nu. 80,660, and 77% of the respondents earn less than Nu. 100,000. Livestock was an integral part of the farming system, as 72% of respondents had livestock components. The average landholding size was 3.26 acres, with 43% owning more than 4 acres and 20% owning less than 2 acres (Table 1). The dryland (*Kamzhing*) size ranges from 0 to 5.5 acres, with an average landholding of 1.75 acres. In comparison, the wetland (*Chuzhing*) size ranges from 0 to 4 acres, with an average landholding size of 1.43 acres (Figure 2).

Cropping information

Almost all subtropical cereals, vegetables, fruits, and other food plants were grown by farmers in the lower belt of Sarpang. Paddy was the most dominant annual crop in the wetland, while vegetables and maize were the most dominant crops in the dryland. Major growing cereals include: paddy, maize millet, mustard, and wheat, while vegetables include: chili, tomato, beans, cole crops, brinjal, pea, cucumber, potato, onion, and leafy vegetables. In addition, garlic, ginger, and turmeric were commonly grown spices, as were fruits such as areca nut, litchi, banana, mango, pineapple, jackfruit, and mandarin. The long growing season allows crops like beans, maize,

tomato, and cucumber to be grown twice or thrice in a year as multiple cropping. Although paddy can be grown twice a year as multiple crops, spring paddy cultivation was not very prevalent in farmers' fields.

Table 1. Characteristics of the respondents

Variable	Age	Average
Sex	Male	31
	Female	69
Age	25-35	17
	36-45	34
	46-55	30
	56-65	19
	>65	6
Education	Tertiary	2
	Secondary	2
	Primary	20
	Uneducated	76
Farming experience	0-5	4
	6-10	13
	>10	83
Household size	1-5	65
	6-10	31
	>10	4
Income from farming	0-50000	44
	50001-100000	33
	100001-200000	8
	200001-400000	11
	>400000	3
Livestock	Yes	72
	No	28
Landholding	0-0.9	7
	1-1.9	13
	2-2.9	24
	3-3.9	14
	>4	43

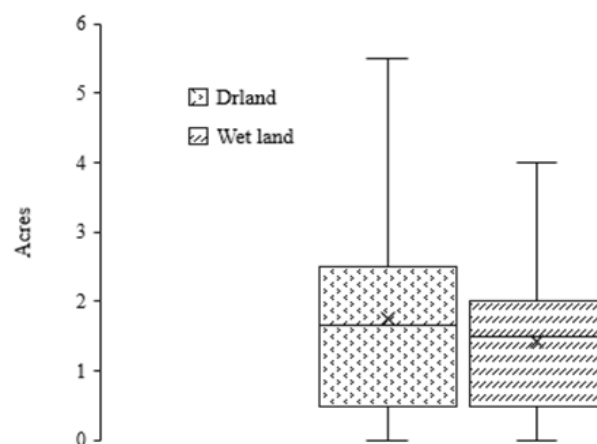


Figure 2. Box plot of landholding

Sequential cropping

Numerous cropping sequences were observed in the studied area; however, only a few significant cropping patterns are reported in Table 2. The most common cropping sequence in dryland was vegetables-maize, practiced by 43% of the respondents. That was followed by maize-chili, vegetables-maize, and vegetables-onion, all used by 39, 23, and 15% of respondents. Maize-gram, vegetables-mustard, and vegetables-fallow were a few of the area's minor cropping sequences. In the maize-vegetables-maize pattern, about 12% of respondents cultivate crops three times a year, and 22% grow crops only once a year. On the other hand, nine paddy-based cropping sequences were recorded in the wetland along with the other two cropping cycles. The paddy occupies the wetland from June-November and is mostly grown as rainfed. After the paddy harvest, various vegetables and other crops were grown until the next paddy season. About 49% of the respondents exclusively use wetlands for paddy cultivation, while 5% do not use wetlands for paddy cultivation. Paddy-vegetables, paddy-chili, and paddy-maize were the most popular wetland cropping sequences, with 34%, 32%, and 25% of respondents, respectively. Minor cropping patterns included maize vegetables and ginger vegetables. Although spring paddy cultivation (February-June) as double cropping was also reported in the district, it was insignificant and limited to governmental initiatives. The district observed appreciable areca nut plantation in wetlands due to irrigation shortage, human-wildlife conflict, and higher economic returns; however, a

wetland is exclusively meant for paddy-based cropping farmland in Bhutan (The Land Act of Bhutan, National Land Commission 1 2007).

Multiple cropping

Different forms of multiple cropping practices were common in the Sarpang, but most were sporadic and small-scale (Table 3). Aside from food crops, the plantation of seasonal and annual flowers, shrubs, avenue trees, and other ornamental plants around the residence was popular in the district for aesthetic and religious purposes.

Table 2. Cropping pattern

Dryland		Wetland	
Crops	Resp. (%)	Crops	Resp. (%)
Maize-Vegetables	43	Paddy-Fallow	49
Maize-Chilli	39	Paddy-Vegetables	34
Maize-Maize	23	Paddy-Chilli	32
Vegetables-Onion	15	Paddy-Maize	25
Ginger-Vegetables	13	Paddy-Wheat	12
Potato-Maize	12	Paddy-Mustard	13
Maize-Millet	12	Paddy-Onion	8
Maize-Vegetables-Maize	12	Paddy-potato	6
Maize-Fallow	12	Paddy Lentil	3
Vegetables-Fallow	10	Maize-Vegetables	3
Vegetables-Mustard	9	Ginger-Maize	2
Maize-Gram	3		

Note: Resp.: Respondents

Table 3. Multiple cropping practices in Sarpang, Bhutan

Crops	Type of multiple cropping	Description
Paddy+ Urd beans	Intercropping/Stripe cropping	Common in the district where black gram (urd beans) was planted on terrace bunds of paddy fields as intercrop.
Ginger + Maize	Intercropping	Ginger was planted as the main crop on ridges, while maize was planted in between furrows as an intercrop.
Maize + Potato	Inter/mixed cropping	Sporadic and practiced on a small scale. Mainly potato-based cropping where maize was planted either in furrows or along the border.
Maize+ Bean	Inter/mixed cropping	The beans are sown in the maize field, and the maize plant serves as a stake.
Maize + gram	Inter/mixed cropping	Grams were grown in the maize field as intercrop
Vegetables	Stripe/intercropping	A common practice in the district. For example, beans, chili, cole crops, tomato, leafy vegetables, etc.
Paddy+Lentil	Relay cropping	Lentil was sown before the harvested paddy or after the harvest of the paddy.
Mango, Litchi, Avocado, banana, jackfruit, lime, guava, etc.	Mixed cropping	Mixed fruit planting around the house plot was very common in the district.
Areca nut + beetle leaves	Intercropping	The beetle leave was intercropped with the areca nut plant, which provides support for climbing
Areca nut + banana+ fodder /pineapples	Multi-storied	Very common in areca nut plantations. Fodder/pineapple was grown as a ground crop
Fodder trees	Alley cropping	Random planting of fodder trees such as <i>Ficus</i> , <i>Gmelina</i> , <i>Leucaena</i> , <i>Bauhinia</i> , <i>Morus</i> , etc., along the periphery of the field

Cropping intensity and land use

Cropping intensity refers to the number of crops grown in the same field over a single agricultural year. Table 4 shows cropping intensity by land type, farm size, and season for 292.85 acres of net cultivated area. Cropping intensity in the district was 112%, which is lower than that of Asia (130%) and the world (126%) (Wu et al. 2018). Wetland cropping intensity was 23% higher than that of dryland. Paddy alone accounts for 75.4% of wetland cropping intensity. Almost half of the farmers left the wetland idle after the rice harvest, implying that most of the wetland remained underutilized for almost half of the year. Thus, taking advantage of this period can boost cropping intensity while supplying temperate regions with winter vegetables. Moreover, oil and legumes were among Bhutan's most commonly imported agricultural commodities, which can be easily integrated into paddy cropping systems (Department of Revenues and Customs 2020). Maize and vegetable-based cropping patterns were found popular in dryland. The average cropping intensity between June and November was 39 and 95%, while November to June was 58 and 31% for dry and wetlands, respectively. The cropping intensity in the dryland from November-June was higher than that of June-November by about 50%. On the contrary, the wetland's November-June cropping intensity was 67% lower than June-November.

Therefore, cropping intensity was approximately 50% higher in June-November than in November-June.

It is important to assess the potential cropping intensity based on the availability of resources and local climatic factors and determine the cropping intensity gap. However, it is also important to examine increased cropping intensity's negative environmental and ecological repercussions (Wu et al. 2015). Increasing cropping intensity in the district demands appropriate solutions to major challenges reported by farmers, such as irrigation water shortages, wildlife depredation, high pest and disease incidences, and hot and humid summer, as well as sustainable soil and plant health management. Similarly, improved technology, such as heat and water-logging tolerant crop varieties, pest-disease-resistant crops, short-duration crops, rain shelters, and protected agriculture, are recommended to increase cropping. In addition, socio-economic issues such as the farmers' income, investment, return, profit, and risk-bearing ability must be considered. On the other hand, 4,647.49 acres of uncultivated arable land (23.5%), including 3,351.48 acres of fallow land in the district, could be easily brought under cultivation (Ministry of Agriculture and Forests 2020). Therefore, a comprehensive study on fallow land could provide insights into developing appropriate interventions and using Bhutan's scarce arable land.

Table 4. Cropping intensity in Sarpang, Bhutan

Farm size (acres)	Net cultivated area (Acre)		Gross cropped area (Acre)		Cropping intensity (%)		
	Dryland	Wetland	Dryland	Wetland	Dryland	Wetland	Average
0-1	20.96	11.34	25.70	17.26	123	152	137
>1-2	20.05	68.13	23.47	95.35	117	140	129
>2-3	85.90	30.25	77.70	32.95	90	109	100
>3	44.72	11.50	26.20	11.90	59	103	81
June-Nov	171.63	121.22	66.93	115.16	39	95	67
Nov-Jun	171.63	121.22	99.54	37.58	58	31	45
Overall cropping Intensity					097	126	112

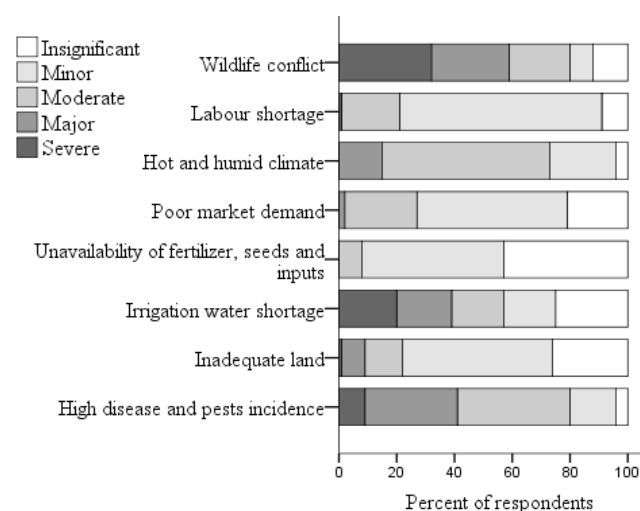


Figure 3. Farming challenges

Cropping intensity and respondents' characteristics

The extent of cropping intensity was studied using the respondents' education, farming experience, income, and landholding size. Multiple regression results demonstrated a significant effect on cropping intensity ($F(4.95) = 8.65$, $p < 0.001$), with $R^2 = 26.7$, implying that the considered factors predict 26.7% of the variation. Income and farming experience positively impacted crop intensity, but education and landholding size had a negative impact. Except for landholding size, none of the variables significantly affected cropping intensity. However, the landholding size has a negative effect at a 1% significant level, demonstrating that cropping intensity decreases significantly as landholding increases.

Farming challenges

The study examined farming challenges to better understand farming in the district and identify challenges to further crop intensification and agricultural development. Furthermore, using the Likert scale, the scoring system was employed to evaluate the challenges in farming that directly impact crop selection and the degree of cropping intensity. Human-wildlife conflict and irrigation water shortages were reported as severe by 32% and 20% of respondents, respectively, and as a major challenge by 27% and 19%. About 70% of respondents rated high insect and disease prevalence as a serious to moderate farming issue. At the same time, land, labor, seeds, fertilizers, and poor market demand, were mentioned as minor farming problems. Similarly, nearly half of the respondents rated hot and humid weather conditions with high rainfall during the monsoon in the district as a moderate challenge (Figure 3).

This study is the first of its kind in the district to study cropping and its intensity. It is critical to clearly understand crop diversity, cropping patterns, and intensity while making food production and land use management decisions. The study recorded a range of cropping patterns, with maize-vegetables predominating in dryland and paddy-fallow and paddy-vegetables dominating wetland. The cropping pattern selection techniques were not based on scientific understanding; rather than crop choices were made according to their consumption needs. Thus, awareness and demonstrations on developing scientific cropping patterns are crucial to transform subsistence farming into commercial agriculture. It is evident from cropping intensity (1.12) that, on average, farmland was cultivated only once a year, which indicates ample scope to increase cropping intensity and maximize land use return. Notwithstanding increasing cropping intensity, the resurrection of fallow and uncultivated land is suggested through policies and technology support to realize a secure food and nutrition nation.

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