Original Research Article

Exploring the nexus between Extension Agents' extension approaches, training, and the challenges of cereal production

ABSTRACT

~~Agricultural extension services play a critical role in increasing the knowledge, skills, and technology transfer of farmers to promote agricultural productivity, achieve food security,and alleviate poverty. In this regard, extension agents are the main actors for the services, advice, and information delivery to the farmers.~~ This study evaluated the linkages between the approaches adopted by extension agents in providing agricultural extension services to farmers, the capacity building of the extension personnel, and the challenges for cereal production. Using purposive sampling, 62 extension personnel were interviewed through a semi-structured questionnaire. The data were analyzed using the deductive approach of qualitative content analysis. The study found that a participatory approach is not fully decentralized in planning and evaluation of the agricultural extension programs to meet the demand-driven services of the farmers. Moreover, there is a discrepancy between the capacity building of the extension personnel and the challenges incurred in cereal production— the training is mostly focused on production and post-harvest of cereal production, while having multitude of challenges in marketing as well. Therefore, it is recommended that a participatory approach must be fully promoted and the training of extension personnel must be melded with the demand-driven needs of farmers in approaching the cereal production issues. The study might be helpful for extension agents and policymakers to understand ways to increase the quality and effectiveness of agricultural extension services to foster agricultural production.

Keywords: Participatory approach, challenges, extension personnel, extension services, cereals

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1. INTRODUCTION

Agricultural extension programs are essential in providing agricultural services to farmers in order to achieve food security and reduce poverty. In a rapidly growing commercialization of agriculture, the adoption of new techniques, practices, and technological advancement must be the main conduit of increasing productivity and income. In this regard, extension agents play a critical role in diffusing technological transfer and agricultural techniques among farmers. Agricultural extension influences farmer attitudes, technical knowledge, and farm management skills regarding crop production through education and effective communication [1]. Moreover, the agricultural extension provider is responsible

for disseminating information, building the capacity of farmers, and assisting farmers in making informed decisions to improve food security [2]. Accordingly, the extension personnel must be trained and equipped with their knowledge and skills in due consideration of farmers' situations to sufficiently disseminate information to scale up the adoption of new innovations and diffusion of technology [3]. Training, refresher courses, and educational up-gradation are essential for extension workers to enhance their knowledge and technical capacity.

There are a host of challenges that developing countries face with regard to the delivery of agricultural extension services, arising both from the extension agents' institutional mechanisms and the farmers' situations on receiving the services. The bureaucratic structure of extension administration contributes to a general lack of motivation by providing few perks, insufficient facilities, limited opportunities for performance-based promotion, and low recognition for extension agents [4]. Moreover, an incentive failure of extension services to respond to customers' demands and be accountable to them is one of the fundamental problems of public extension services in developing nations [5]. In this context, extension agents have realized the need to strengthen agricultural extension services on structural, budgetary, institutional, and other approaches, leading to more effective service delivery. Farmers face challenges due to a low literacy rate, their lack of knowledge of farm machinery, poor service delivery, and the practice of inappropriate service delivery methods and approaches [6,7]. When extension agents lack the skill of effective communication in convincing farmers about the new practices and innovations, farmers restrain from adopting technology and continue to embrace traditional practices [8]. Therefore, reliable and appropriate extension approaches are essential to address the farmer's responsiveness to technology transfer.

Previously, most extension programs were supply-driven with a linear and unidirectional flow of information where clients were the passive receivers of the services [9]. This type of provision of services was often linked to the conventional top-down approach, which does not fully take account of farmers' situations and needs [6, 1, 10]. This has hindered the early technology diffusion and transfer of new techniques due to forced extension of services as driven by supply inputs, resulting in ineffective delivery of services. Against this backdrop, a participatory approach has been promoted as an important element in disseminating extension services and prompting responsiveness according to the needs of the farmers. The participatory approach is helpful in understanding farmers' socioeconomic and agro-ecological situations as well as their potential and limits, acknowledging the effectiveness and quality of the extension services [11]. The bottom-up approach in planning, for instance, is critical to identifying which plans are necessary and appropriate to address agricultural challenges concerning the socio-economic status of the farmers. The interlinkages among the sectors including extension agents, governments, researchers, private sectors, funders, development partners, and farmers critically improve input supply and meet the demand-driven extension services and enhance decision making, address multidimensional problems and improve information sharing [12, 13]. The participatory approach—a decentralized

approach—involves all the stakeholders in the decision-making process by understanding actual problems and needs [14, 10].

The participatory approaches, therefore, ease service providers and receivers in terms of what services are essential according to the challenges and ensure more equitable access to the extension services to achieve sustainable agriculture development [15]. Thus, the objectives of this study were to identify the approaches practiced by extension personnel in agricultural extension services, assess their capacity-building opportunities, and determine the nexus between extension workers' training, extension approaches, and the challenges in promoting extension services. The findings of our research could be critical in addressing the need for an appropriate approach to improve public extension services, based on real requirements, farmer skills, and farming systems.

2. METHODS AND MATERIALS

2.1 STUDY AREA

Bhutan is situated in the eastern Himalayas, saddled between China in the north and India in the south. The altitude of the country ranges from as low as 100 masl in the southern foothills to more than 7500 masl in the north. Its total area of 38,394 Km^2 hosted a population of 735, 553 people in 2017 [16]. The country is covered with 70% forest, with year-round snow and glaciers covering 7%, arable areas accounting for about 3%, and meadows and pastures accounting for 4%, while the rest is barren, rocky, or scrubland [17]. Bhutan is divided into six agro-ecological zones: wet sub-tropical zone (100 to 600 m), humid subtropical zone (600-1,200 m); dry sub-tropical zone (1,200-1,800 m), warm temperate zone (1800-2600m); cool temperate (2600-3600m); and alpine (3600-7500m). The temperature ranges from as low as -5°C in the north in winter and as high as 35°C in the south in summer. The annual average rainfall exceeds 3000mm with little or no rainfall during the dry season. The 3% of arable land is essential to employing 57% of the population in the agriculture sector, one major revenue source for the Bhutanese economy. The other economic sources of the country include tourism, hydropower, the mining sector, and small and cottage industries. The study was conducted in 11 districts out of 20 districts and 53 gewogs (blocks) out of 205 gewogs in Bhutan.

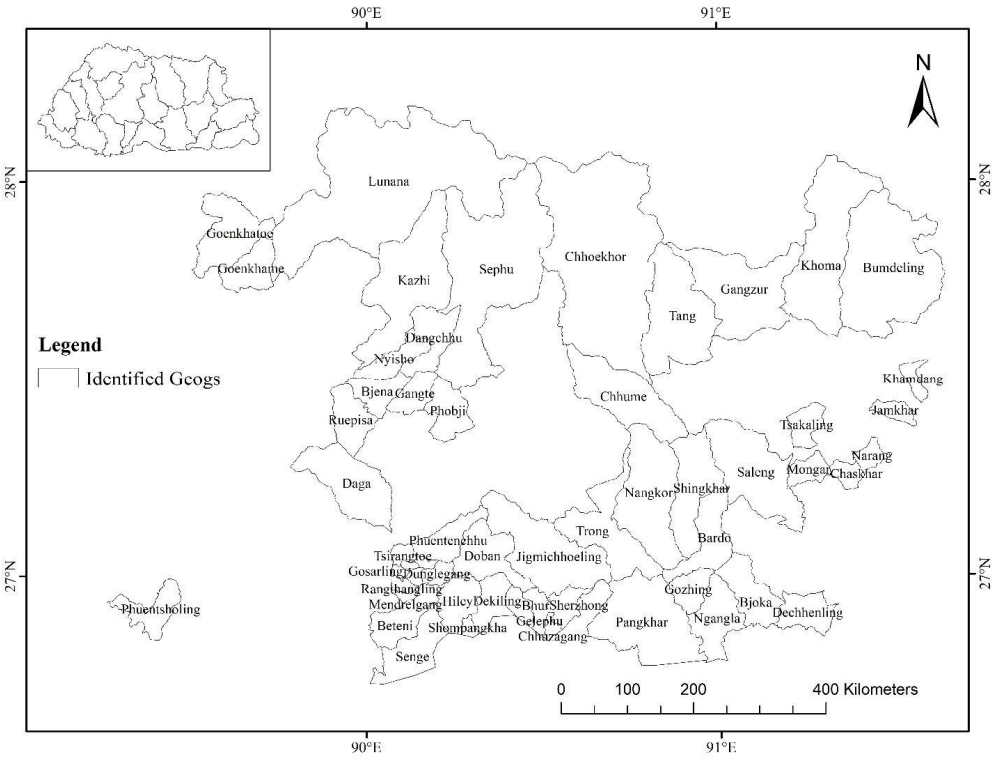

Figure 1. Map showing study sites

2.2 SAMPLING AND DATA COLLECTION

Data were collected using a semi-structured questionnaire. Extension personnel were explained in detail the objectives of the study and the questions that would be asked in the survey prior to the interview. The respondents were interviewed face to face by the lead author of the study and the research assistants. Using purposive sampling, a total of 62 extension officers were interviewed. Purposive sampling was employed as the selection of the key participants was relevant to the purpose of the study [18]. Moreover, purposive sampling is appropriate for qualitative investigations in which the researcher is looking for informants with the most in-depth knowledge of the research issue [19]. At least one questionnaire lasted for one hour.

Table 1. Number of extension personnel from selected gewogs and dzongkhags

District	Gewog	Respondents
Sarpang	10	11

Pemagatshel	1	1
Chhukha	1	1
Lhuentse	2	2
Mongar	5	9
Zhemgang	7	7
Bumthang	2	3
Wangdue	9	10
Tsirang	10	11
Trashiyangtse	3	3
Gasa	3	4
Total	**53**	**62**

The deliverables in the questionnaire were demographic characteristics of the extension officials (gender, age, education, and years of extension experience); the number of farm households growing cereal in their respective regions; the number of activities and projects they carried out; approaches used for the provision of the extension services; extension training; and challenges in promoting the agricultural extension services. The open-ended questions allowed extension officials to provide their stances on challenges in extension services gained from the experiences, occasionally using probes when needed (Table 2).

Table 2. Guiding topics for exploring participants' experiences of extension services.

Questions	**Prompt**
How often do you receive training?	
What agricultural extension training did you attend?	Pest management, seed protection, disease control, product development, etc.
What approaches do you adopt for providing extension services in terms of planning, implementation, evaluation, and reporting in your gewogs?	Top-down, bottom-up, farmers, extension, researchers, etc.
How do you disseminate agricultural services to farmers?	
Is training related to the issues faced by farmers?	
What are the production challenges that you need to address through extension services?	Labor shortages, wildlife conflicts, irrigation, etc.
What are the marketing challenges that you need to address through extension services?	A lack of market, inaccessibility of a market, etc.
What are the post-harvest challenges that you need to address through extension services?	Pest and diseases, value addition, etc.

What are the harvesting challenges that you need to address through extension services?	Pest and diseases, lack of harvesting facilities, etc.
What government support do you think farmers require?	Budget, capacity building, etc.
What supports from development partners do you think farmers require?	

2.3 VALIDITY OF DATA

The quality of the data was ensured by checking the internal, external, and analytical reliability of the data. Internal validity is concerned with eliminating any external variables that may alter data reliability, while external validity is concerned with the generalizability of data. For internal reliability, it was ensured that the research setting for interviews is one where each respondent is not influenced or interfered with by other respondents or people by conducting interviews in a separate place or an isolated place. To ensure external reliability, the respondents from all regions of Bhutan are represented. Furthermore, the qualitative technique was designed to delve deeper into the issues rather than provide broad coverage for generalizability. To maintain analytical reliability, the themes were first developed by one investigator who had a sufficient field experience on the extensions and later, checked, corrected, and agreed upon by the other authors.

2.4 DATA ANALYSIS

Descriptive statistics such as mean, frequency, and percentage were conducted to analyze the data.The qualitative data were analyzed using the MAXQDA 2020 software. The MAXQDA is a program designed for computer-assisted qualitative, quantitative, and mixed methods data, text, and multimedia analysis [20]. The study used qualitative content analysis to analyze the data using a deductive approach. The deductive approach was applied as the data was used to deduce preconceived themes. Qualitative content analysis is the textual analysis of trends and patterns in words through systematic coding and categorizing them related to content [21, 22]. The frequency of occurrence of words, which are presented as codes, is categorized according to the content or categories. The main category is, therefore, developed as per the themes: 1) approach; 2) training; and 3) challenges. The content analysis involves three phases of analyzing qualitative data: preparation, organizing, and reporting [21].

Table 3. Example of coding the statements concerning challenges in cereal production

Statements from the respondents	**code**	**Sub-themes/subcategories**	**Theme/main category**
The most prominent challenges that we			

are facing today are labor shortages and land fragmentation, most farmers are attracted to working on off-farm projects as they get higher wages. (Respondent 29)	Labor shortage Land fragmentation	Production	
Rice, wheat, maize, and buckwheat are the main cereals in Bhutan. They are produced on a large scale. To improve and increase production, there is an urgent need to promote value addition, such as converting them into flour, chips, juice, etc. (Respondent 26)	Value addition	Post-harvest	Cereal production challenges
Bhutan's agro-ecological condition favors the cereal production to the economy of the scale. Bhutan must venture into large commercial farming. However, a lack of marketing in any form has encouraged farmers to do subsistence farming instead of growing cereals for commercial purposes (Participant 12)	lack of marketing	Marketing	

3. RESULT AND DISCUSSION

3.1 Descriptive characteristics of the respondents

The descriptive variables of the respondents are shown in table 4. The males, with 72.6%, dominated their female counterparts with 27.4%. The mean age of the extension officials was 35 years, with an education level slightly skewed towards diploma qualification at 53.6%. The majority (92%) of the respondents had a medium level of knowledge and skills in cereal production and a mean of 12 years of experience in agricultural extension. The average household growing cereals was 313. On average, 131 days were spent on cereal activities by extension officials per year. While, with a mean of 0.4, most extension officials did not handle projects related to cereal production, 65% of the respondents had attained training in cereal production.

Table 4. Socio-extension attributes of the extension officials

Variable (n = 62)		Frequency	Percentage
Gender	Male	45	72.6

	Female	17	27.4
Age (mean=35.39 years)	20-30	17	27.4
	31-40	28	45.2
	41-50	17	27.4
Education	Diploma	33	53.6
	Bachelor's degree	29	46.8
Knowledge and skills in cereal production	Low	3	4.8
	Medium	57	91.9
	High	2	3.2
Households growing cereal under extension's gewog(mean=312.76)	1-150	7	11.3
	151-300	31	50.0
	301-450	15	24.2
	above 450	9	14.5
Engage in activities related to cereal production in a year (mean=131.11).	1-120 days	40	64.5
	121-240 days	14	22.6
	141-364 days	8	12.9
Projects on cereal production (mean=0.40)	Not at all	48	77.4
	At least one	9	14.5
	More than one	5	8.1
Training (mean = 3.60)	Not at all	22	35.5
	At least one	14	22.6
	More than one	26	41.9
Extension experience (mean=12.32)	1-10 years	26	41.9
	11-20 years	30	48.4
	21-30 years	6	9.7

3.2 Extension approaches tothe provision of extension services

3.2.1 Planning of extension services

The majority of the extension workers applied the bottom-up approach in planning the extension services, while some argued that the adoption of top-down approach was more prevalent. This implies that planning of agricultural programs is not fully executed in decentralization process.

The extensions take account of group dynamics and the participatory approach to understand the interests of the farmers and meet the demand-supply approach of the extension services. The participation of stakeholders in the planning process is acknowledged as an essential element in assessing the needs of farmers, identifying the challenges, understanding the willingness of farmers to adopt new methods and technology, and ultimately increasing agricultural production and income. Furthermore, the collaborative discussion provides appropriate information and knowledge essential for planning and realizing agricultural development goals through decentralization. Therefore, one indicator of effective extension service is the planning of the extension programs [23] by equal participation of extension and farmers in the planning and decision-making process. This process allows the dissemination of extension programs driven by demand-side rather than being a passive provider and receiver of the extension services. The participatory approach eases transfer and promotes faster diffusion of technological adoption and new techniques and provides opportunities for farmers and extension to better tailor the services to specific priorities and needs, thus achieving the goals of both extension agents and farmers.

However, some of the respondents shared that the planning of programs involved authoritative decisions, implying that farmers were not fully involved in decision-making. This could be due to aging and poorly functioning village extension workers, making it difficult to transition from the traditional approach of the top-down method to the bottom-up approach [24]. Similarly, a previous study [2] indicates that while extension workers understand the value of stakeholder analysis, it is not being implemented. The other reason could be due to the fact that the extension agents' plans do not match the interests of the farmers. Moreover, it could be attributed to the farmers' motives being averted by the objectives of the extension, which are mostly services rather than the farmer’s expectation of direct economic benefits [25]. Thus, it is found that the planning process of extension programs is not fully participatory in nature.

3.2.2 Implementation of extension services

The implementation process is critical to expecting the desired results of the extension services. Therefore, equal participation of extension workers, farmers, and researchers is anticipated [26]. The implementation approach of extension services was dominated by the farmers and extension agents together, followed by the farmers, extension, and research rather than programs being implemented solely by farmers. This indicates a collaborative approach toward implementing the extension plans and programs. The implementation process is essential to meet the farmer’s needs and participation in the development and adoption of new agricultural extension techniques, including technologies and methods that address their current extension challenges [27]. The involvement of research, extension, and farmers together realizes the effective implementation of the projects intended to make a substantial difference in

the productivity and income of the farmers. Moreover, the participatory implementation approach ensures equal distribution of resources, thereby achieving social equity among small shareholder farmers. In this way, farmers have equal access to the programs and resources implemented by the extension agents.

3.2.3 Evaluation of extension services

The evaluation approach to the provision of extension services is not fully decentralized as respondents share practices of both the bottom-up and top-down approaches. Thus, the participatory approach in the evaluation of programs is poorly executed. The evaluation is essential to assess the outcome of the agricultural programs and extension services that meet the expected benefits or results [26]. The participatory approach is essential to evaluate the impact and success of the extension services that have brought them to farmers. The bottom-up approach allows equal participation of extension and farmers to determine the project's success and failure and helps evaluate future needs. Such process informs extensions to improve on training programs, assess needs and appropriateness according to the findings of the implemented projects, and create a database for future decision-making [27]. The result is in accordance with the finding of [28], who found that training evaluation and training needs evaluation significantly influence the employee's work commitment, job satisfaction, and job performance. The evaluation process is critical to assessing the relevance and performance of the implemented project so that it remains aligned with its objectives. Moreover, it involves gathering data and analyzing it to evaluate the influence of projects on farmers' situations as anticipated. The joint evaluation of extension programs intends to guide projects to completion on time so that desired results are obtained. Overall, the participatory approach is critical to assessing the effectiveness and impact evaluations of the extension services.

3.2.4 Reporting of extension services

The final outputs of the extension programs are reported jointly to increase the accountability and transparency of the projects. The reporting approach of extension services mostly involved farmers and extension, followed by participating farmers, extension, and research, and the farmers only. The finding indicates the existence of a participatory approach in terms of reporting the extension services. The performance outcomes of the project are reported to assess its achievement as per the plans and objectives. The reports are essential to indicate the project's completion at the stipulated time and to provide reasons why it has not been completed. The participatory approach determines the correct sharing of information and data to further mobilize the funding opportunities. The right reporting ensures the development and productivity of the programs implemented. The availability of a dataset on implementation and farmers' perceptions and experiences with extension services provide a unique opportunity to investigate the concerns they face. The data and information are essential in evaluating the developmental paradigm, thus providing recommendations and suggestions for future programs.

3.3 Agricultural extension training

As shown in table 3, among various training attended by the extension officials, majority (60%) of them mentioned that cereal production was the main training attended. Pest and disease management and weed management accounted for about 31% and 20% of training, respectively. While post-harvest management contributed 14%, product development and water management accounted for about 14% each in overall training. The rest of the training is less than 10%.

In general, the most common training attended by extension workers is on production, followed by post-harvest and marketing. Training regarding marketing lacks diversity, unlike production and post-harvest. This indicates a large gap in the acquisition of knowledge and skills that extension officials are intended to acquire in all dimensions of agricultural development.

The respondent shares that both extension officials and farmers are deprived of extension training opportunities in the remote areas of the country;

Bhutan has limited agricultural land with the least access to irrigation facilities for cereal crop production and other marketing aspects of cereal products. Moreover, in remote gewogs, both farmers and extension officers have less access to technical training opportunities on cereal crop production. (Respondent 49).

In order to provide extension services, the extension workers must receive adequate knowledge and skills from education, training, seminars, refresher courses, and available information sources. Accordingly, extensive in-service agricultural training is needed to prepare extension employees to deal with farmers' expanding needs [1].According to [24] noted that insufficient skills of extension agents hamper planning and implementation of participatory extension approaches with farmers. Similarly, a majority of the respondents had a low to medium level of knowledge and skills in overall cereal production exacerbated by a low capacity building in their entire extension profession period (table 2). This implies that extension knowledge dissemination is weak. It is evident from astudy [30]that extension training is crucial and has found that hands-on training has bolstered adoption rates of orchard management practices of farmers, resulting in higher yields and productivity. Thus, it is suggested that capacity building of the extension personnel must consider all aspects of cereal production- production, post-harvest, and marketing.

Table 5. Training attended by the extension officials (frequency and percentage are based on the document coded, n = 40).

Training	Frequency	Percentage	Types
Cereal production	24	60	+
Pest and diseases management	11	27.5	+ ,++
Weed management	7	17.5	+
Post-harvest management	5	12.5	++

Product development	4	10	++
Water management	4	10	+
Cultivation methods	3	7.5	+
Seed selection	3	7.5	+
Plant protection	3	7.5	+
Soil nutrient management	2	5	+
Value addition	2	5	++,+++
Nursery management	2	5	+
Application of fertilizer	2	5	+
Threshing practices	1	2.5	++
Pollination management	1	2.5	+
Harvesting practices	1	2.5	++

+Production; ++ post-harvest; +++Marketing

3.4 Challenges in cereal production

3.4.1Production challenges

There are a plethora of challenges in the production of cereals that could be addressed by the extension services (Figure. 3). The labor shortage was the major production challenge accounting for 54% followed by the crop damages by the wildlife and pest and disease infestation each attributing to 49% and 36%, respectively. Rural-urban migration produces a slew of socioeconomic issues in rural areas, notably in agricultural development, increasing the elderly workforce, labor shortages resulting in fallow lands, and human-wildlife conflicts [31, 32]. Although it is implausible for the extension to provide a direct human workforce, the provision of technical facilities, including farm machinery, will greatly reduce the labor shortage. Moreover, labor shortage has a complex web of issues as it has provoked the use of herbicide, due to insufficient human workforce for weeding replacing an organic practice of the 'hand-weeding' method of weed management [33]. In this regard, extension agents must provide a required number of resources as a study [34] has shown that crop loss, inadequate resources, and a paucity of financial and technical assistance are all issues that discourage young people from working in agriculture in Bhutan.

One of the reasons for labor shortages as pronounced by the respondent is the rural-urban migration;
Rural-urban migration is the biggest issue in the village where most of the cultivated lands are left fallow due to labor shortages and those cultivated fields are destroyed by wildlife due to insufficient attendance by the elderly (Respondent 56).

Wildlife conflict is rampant in rural areas, plummeting agricultural productivity in all phases of crop production, including cultivation, harvest, and post-harvest, as well as depredating domestic animals and harming livestock production. A score of studies [31, 35, 36] have noted that crop depredation and livestock predation in Bhutan are common during cropping seasons, affecting livelihoods, causing economic losses, and threatening food security. Although electric fencing provided by extensions [37], and self-initiated methods such as wooden fencing, scarecrows, and self-guarding of crops [38] are practiced as mitigating measures, human-wildlife conflict continues to be a serious challenge to agriculture farming. Extension must consider diverse methods in curbing human-wildlife conflicts, according to the agricultural systems and the place and the diversity of the extension services is required to reach out to different stakeholders and meet farmers' needs [39].

The other pronounced challenge is the pest and disease infestation. Studiesmention that pests and diseases are prevalent in fruits, vegetables, and most serious threats to citrus orchards in Bhutan [40, 41,42]. Irrigation issues, which occur due to water scarcity, contributed to 37% of the production challenges. Extension agents play a critical role in providing irrigation facilities that ensure efficient use of water, improve the use of scarce resources, and promote farm production [43, 44]. Similarly, stakeholder collaboration, including extension agents and farmers, is important for irrigation management and enhances farmers' resilience to climate change [45]. In Bhutan, extension agents have been instrumental in providing irrigation technology to meet the farmer's demand for water for crop production. However, it has been much more difficult to conduct water in areas where it is too scarce, leading to a dependence on rainwater to recharge the sources or streams. The rain, on the other hand, due to its high intensity and frequency in a short period of time, is disastrous. Accordingly, a combined effect of rainfall, windstorm, and hailstones have 17% of challenges to crop production. In this regard, an extension agent is crucial to address the climate-resilient crops as well as disseminating timely weather information to the farmers. In Bhutan, although weather forecasts and information are provided early on television or in newspapers, it is difficult for illiterate farmers to avail themselves of these services. Therefore, extension agents must be trained in the use of information and communication technology related to agriculture to deliver weather and climate change information and improve advisory services to farmers [46].

Low seed quality accounted for 17% of cereal production challenges. A quality seed determines a larger cereal production. The extension must provide farmers with quality seeds that are high yielding, pest, disease-resistant, and climate-resilient which are economically viable to promote food security and alleviate poverty [47,48].

Farm mechanization is an important driver of the transition to commercial farming from subsistence farming [49]. However, it still remains an issue in Bhutanese agriculture. One of the respondents' concerns regarding cereal production was as;

To combat the decreasing cereal crop cultivation, the ministry [Ministry of Agriculture and Forest] needs to adopt new cultivation methods using new technologies for increasing the yield, soil fertility, and pest and disease management. (Respondent 58).

A lack of farm mechanization,farmers' resistance to the adoption of modern technology and relying on conventional farming, land fragmentation and low soil fertility are also challenges to cereal production. The finding is congruent with the results of a previous study[50] who found that land fragmentation, low soil fertility, a dearth of farm techniques and knowledge, poor management and infrastructure, have resulted in low agricultural production. Land fragmentation due to land tenure systems has divided the land into uneconomic-sizedtracts, alienating a part of the financial capital and increasing the production costs [51]. The extension is instrumental in helping farmers adopt the technology by providing information on potential benefits, the utility of farm equipment, and alternative practices [52, 53] and understanding that technology transfer is influenced by socioeconomic status, the needs of farmers, and institutional and policy barriers [54, 55]. Extension programs, therefore, need to direct soil nutrient management for both small plots and plots ona commercial scale, and utility of farm machinery that is suitable for the sizable land [56]. Farm inputs are essentially crucial to reduce the production cost, which a lack of it affects the production;

Farmers give more importance to vegetables in my gewog as they fetch a better income than cereals. It is cheaper to import cereals when the production cost is compared to vegetables. For instance, one farmer cultivated vegetables on 30 decimals of land instead of paddy. He produced 85 kg of chili and earned twice the amount as compared to paddy. (Participation 21).

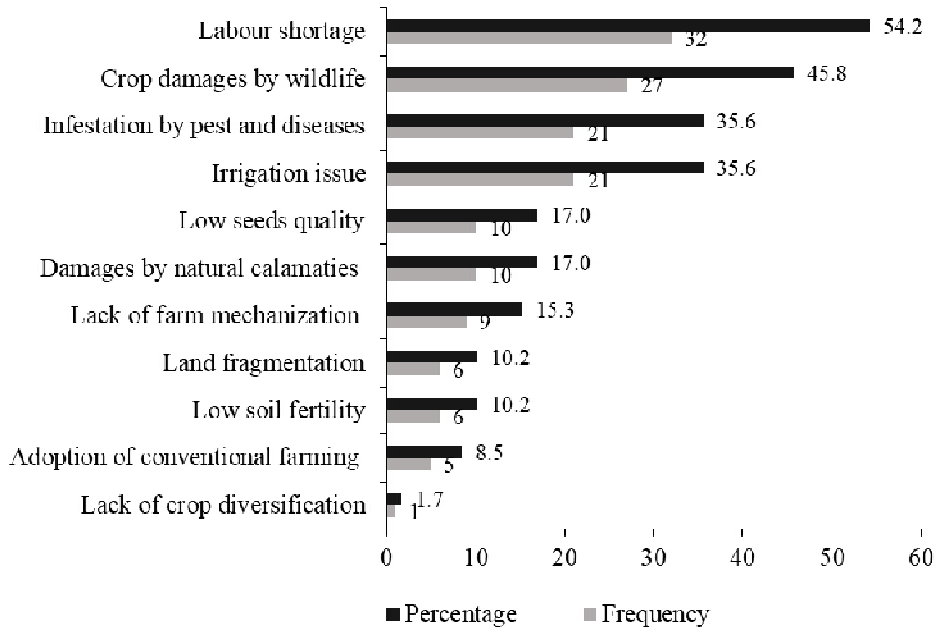

Figure 3.Production challenges (Frequency and percentage are based on the documents coded)(n =59).

3.4.2Post-harvest challenges

The post-harvest challenges that could be addressed by the extension services are presented in figure 4. The lack of storage facilities is the major challenge, accounting for 50% of post-harvest challenges. Pest infestation continues to be a challenge for the post-harvest as well, contributing to 24% of the challenges. The grain loses its quality and quantity when it is stored for either a short or long duration as immediate food consumption or preserved as seeds for the next season. During this storage period, many external factors affect the grains, including moisture, attack by pests, insects, and diseases. Previous study also found that grain loss during storage accounts for the highest percentage of loss [57]. Another study by [58] found that post-harvest loss in cereal was 24%, destroyed by rodents and other pests when products were stored inside the house in bags due to insufficient storage methods. The study also indicated that the post-harvest loss was attributed to a longer distance of households to the market and road, and average annual rainfall. The current study shows that cereals are damaged by natural calamities including heavy rainfall, windstorms, and hailstones. The farmers keep paddy in the open field for a few days to let it dry up after harvesting. During this time, the harvested grains are attacked by rodents and birds and befall the harsh realities of natural calamities. Similarly, a previous study [59] has found that

3.5% to 4.5% of maize grain is lost during the drying process on raised platforms. Extension must facilitate and educate farmers on the storage techniques including ways to drive the pest and diseases with the application of modern technologies, practices, and methods [60].

One of the respondents shared that about 30-40% of cereals are lost to pests every year;

Due to poor storage facilities, about 30-40 % of cereal grains are lost to pests every year. (Respondent 11).

Another extension official says,
There are no storage facilities to preserve their own seeds for the coming season. Many post-harvest losses during storage are due to infestations by pests and diseases. (Respondent 33).

Extension officials shared that 25% of post-harvest issues were due to a lack of the harvest facilities, which further exacerbated poor harvesting practices and post-harvest handling. A lack of threshing facilities and a lack of technical guidance accounted for 4% of the post-harvest challenges. This implies that technical guidance from the extension is imperative in informing farmers about the use of new technologies and the adoption of new methods related to harvesting and post-harvest. In developing countries, crop harvesting is primarily carried out by manual methods using hand tools such as sickles, knives, scythes, and cutters [61]. The ineffective harvesting practices including manual operations, significantly contribute to the cereal loss during harvesting time. A study done on post-harvest loss in paddy in India estimated an increase of 10.3% in harvest loss due to delayed harvesting aggravated by insufficient harvesting technology [62]. When a crop is delayed in harvesting, the products are mostly lost due to shattering, attacks by pests and birds, and natural calamities [63, 64]. Similarly, when harvested crops are kept unattended in the open field, the delay in threshing results in quality and quantity loss due to exposure to the atmosphere and pests [65]. Moreover, grains are lost during the threshing processing due to grain breakage, spillage, and incomplete separation from the chaff [66,67]. Integrating conventional practices and modern technologies could address harvest and post-harvest challenges as farmers still practice traditional techniques, contributing to 4% of the challenges. According to previous studies, storing grains in traditional structures shows less effective methods as they are mostly made from locally available materials and are underpinned by unscientific design, making it easier for the pests to attack the grains [64,68). Extension programs are essential to inform and change the attitudes of farmers to adopt more reliable and effective techniques to improve cereal production [69].

The extension official has experienced farmers' preference for traditional practices that have led to post-harvest loss;

Farmers still prefer the traditional techniques to preserve and store their cereals. They do not adopt the post-harvest technologies as they are costly, so they are lost to the pests (Respondent 59).

Lack of processing and packaging facilities, poor product development, and a lack of value addition contributed to 17%, 13%, and 8% of the post-harvest challenges, respectively. Food processing involves the transformation of agricultural products into other forms of food. A lack of processing technology limits agricultural produce's ability to be transformed into other by-products (product development), which will significantly reduce grain loss by reducing early attacks of pests and insects and the effects of environmental factors during storage. The transformation of grain into by-products increases the consumption forms of grain, minimizing the loss of grain production. Moreover, the value added to the product increases the nutritional content and increases the marketability, thus reducing the grain loss. Proper packaging is required in the fields or in the store for products kept as a food source or for marketing. Most grain or food loss occurs due to a lack of packaging facilities and poor packaging techniques, resulting in leakage. Grain loss due to poor packing takes place during storage in the field and transport to the store [70]. A lack of extension service has resulted in low crop production, further exacerbating the post-harvest issues [69], however, farmers have shown a positive attitude towards the needs and use of post-harvest technologies addressed by the extensions [71].

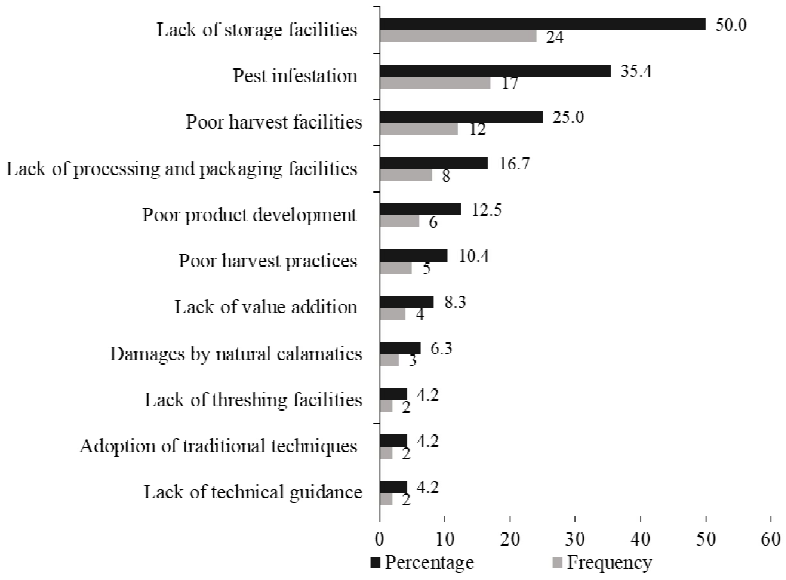

Figure 4.Post-harvest challenges (frequency and percentage are based on the documents coded) (n=56)

3.4.3Marketing challenges

Figure 5 shows marketing challenges for cereal production. Among eight marketing challenges, cereal products fetching a low price and mismatches between prices set by farmers and buyers are the most serious issues. According to the extension personnel cereals produced are not market-oriented accounting for 34% of the marketing challenges. The lack of a market and the inaccessibility of a market contributed to 20% and 26% of the marketing challenges, respectively. Poor road conditions and transportation difficulties also challenged 22% of cereal marketing. Poor linkages between sellers and buyers have 20% difficulties in selling farm products. A lack of value addition and a lack of promotion of products account for 8% and 6% of marketing challenges, respectively.

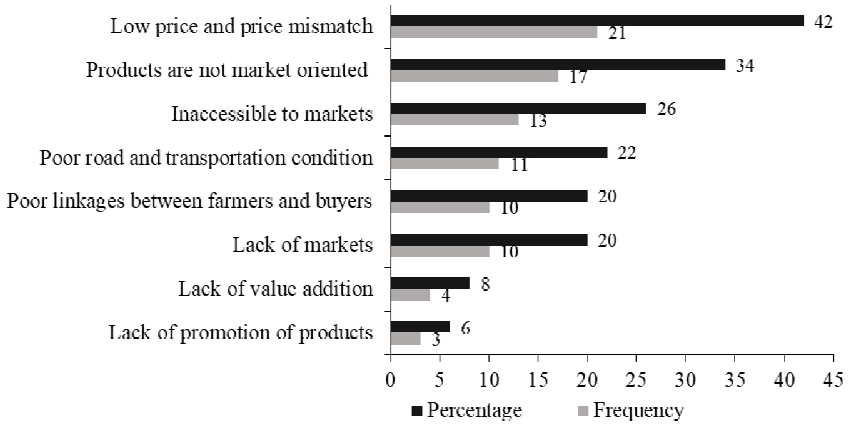

Figure 5.Marketing challenges (frequency and percentage are based on the documents coded) (n = 50)

Farmers' decision on marketing depends on the price they fetch for the farm produce [72,73]. The extension is essential in negotiating and setting up the price, enabling a favorable condition for farmers to sell their farm produce at a reasonable price. In most cases, the middle man leverages the profits when the product is purchased from the farmers and then sold to a third party. Creation of markets that are readily available creates opportunity to small farms to have direct contact with the buyers and maximize their profit [74]. The interest of the farmers in commercializing their produce largely depends on the profit margin, which is influenced by their participation in agricultural cooperatives [75]. Furthermore, good road and transportation conditions facilitate the marketing of the products, which determine farmers' access to target markets [76].

Agro-ecologically, Bhutan is suitable for the commercial production of cereals. However, it is constrained by marketing issues,

Bhutan's agro-ecological condition favors cereal production to the economy's scale. Bhutan must venture into large commercial farming. However, a lack of marketing in any form has encouraged farmers to do subsistence farming instead of growing cereals for commercial purposes. (Participant 12)

Ensuring market stability for farmers is a crucial extension service. They must have access to market information, including prices, accessibility, and availability of the markets. The linking ability of extension to the diversity of market availability, such as formal and informal markets, domestic and regional markets, traditional cash crops and higher value markets, and public markets, is essential for farmers to find the appropriate markets as per business needs [77]. Marketing information provides farmers with information about what, how, and when to produce according to the needs and demands of the customers. The farm's products must be innovative in the supply chain, notably through value addition without losing their organic value. The customer attraction as well as adding value to produce largely increase the marketability. Therefore, creating efficient marketing services must exist to enable farmers to supply their larger farm produce. The report also indicates that extension must be provided with capacity building regarding commercialization and production, and specialization in crop husbandry in Bhutan [78]. The efficient services not only support farmers to produce in large quantities and increase income but also encourage farm enterprises, including the operation of agri-business to ensure food security and reduce poverty.

4. Nexus between extension approaches, training, and challenges

The interlinkages between extension training and the existence of challenges are crucial to understanding their combination in addressing agricultural production. Extension training for extension officials must relate to the challenges faced by farmers. Therefore, this must meet the demand and supply chain—demand for extension services from the farmers and supply of services from the extensions—in the pursuit of progressive crop production and food security. The training ensures extension workers' performance, skills, and efficiency [29]and is essential to disseminate this acquired knowledge and skills to farmers to increase agricultural productivity. Similarly, to understand the needs of the farmers, the extension approaches must take account of the farmers' perspectives in planning and decision making. The two-way traffic provision of extension services improves its quality and effectiveness. Therefore, agricultural production remains at the locus of how extension agents work closely with farmers to provide demand-driven services rather than merely focusing on push-technology (supply-driven) [79].

The current finding highlights a poor linkage between the training received by the extension personnel and the challenges they could address in cereal production. This discrepancy would greatly impact agricultural development, thereby not addressing rural poverty. The training is mostly singularity in nature in lieu of addressing multidimensional issues. To put this in context, training is mostly designed for production and post-harvest, and not addressing marketing challenges. Revisiting Figure 2 shows that

training attended by the extension officials on marketing is greatly lacking, and this must have affected areas where 36% of extension officials did not attend the training at all.

Regarding the extension approach, the participatory approach is not fully practiced by the extension agents. This also hinders the execution of the extension services as per the needs of the farmers, plummets technological transfer, obstructs the transition to commercialization of the farms, and ultimately impacts agricultural production and rural development.

5. Conclusion

This study examined the extension approaches adopted by the extension agents and explored the linkages between the extension training and the cereal production challenges. The extension approach in providing the extension services was assessed in planning, implementation, evaluation, and reporting. The study found that the planning and evaluation are not fully decentralized as these working conditions still undertake a top-down approach. The training of extension personnel is mostly dominated by production and post-harvest, where challenges are largely distributed among production, post-harvest, and marketing of the cereals. This clearly shows the discrepancy between the training given and the challenges faced in promoting extension services to promote cereal production. Therefore, it is recommended that the methods of the provision of extension services be improved to ensure the quality and effectiveness of the extension services. The capacity building of extension personnel must consider all aspects of cereal production— production, post-harvest, and marketing. Marketing is beyond the limits and highly volatile…. how it can be handled…plz brief the appropriate strategy The training must focus on the most prominent challenges, upgrading the knowledge and skills of the extension personnel so as to adequately disseminate it to the farmers.

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