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Dynamics of rice sub-sector in Nepal: Research investment, production, and supply chain

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Abstract. *Rice is a major cereal crop that ensures food security and rural income generation in Nepal. The objectives of this study were to analyse the dynamics of the rice sub-sector from the perspective of production, research investment, and supply chain as expected outcomes are not yet achieved in spite of continuity in priority for research and production investment. Accordingly, this study was done by using secondary data covering 2000 to 2018 combined with a case study. For the case study, Morang, the district with the highest rice production was chosen. A random sample of 144 supply chain actors in which 100 rice producers, 10 collectors, 10 wholesalers, 7 millers, and 17 retailers were chosen from the list of the targeted population in each category. Findings revealed that rice production, productivity, and research investment were increasing at the rate of 1.25, 1.65, and 10.57 percent per annum, respectively. There was a strong positive link between research investment and production. Millers were the main value-adding actor. They have been getting the highest profit margin (31.5%) based on investing more (46.51%) in value-added activities. In contrast, farmers received a relatively low-profit margin (13.9%) with a 1.26 benefit-cost ratio. This was mainly due to the low adoption of improved production technology and weak horizontal coordination of rice producers. The percentage of food surplus households has increased, mainly due to the adoption of rice technologies generated by rice research programs, but this has not well reflected in terms of getting more profit margin by the rice-producing farmers. On the other hand, the research investment in rice was not consistent, and even not adequate for the required technology generation. Therefore, an increased investment could enhance the efficiency of generating technology packages, and implementation of effective extension services targeting the rice-growing farmers through increasing total factor productivity is crucial to increase the profit margin of rice producers. Moreover, with strengthened horizontal coordination among the major actors and with the increased investment in value-added activities in each stage of the supply chain based on consumer demand, increased profit margin for making the rice supply chain sustainable*.

Keywords: food availability, profit margin, public investment, rice supply chain

Introduction

Cereal crops - rice, maize, and wheat cover more than 75% of the total cultivated area in Nepal. Despite the preference for these crops, Nepal imported cereal crops more than forty billion rupees with the export of only thirty million rupees in 2016/17 (MoALC, 2018). Among them, rice is the most important agricultural commodity, and there exists a greater degree of correlation between the growth of the national economy, and rice production (Joshi et al., 2011). Rice not only contributes to national food security largely, but also to the rural income generation, and accounts for more than 50% of the total agricultural area and production. Rice cultivation covered 1.47 million ha during 2017/18 with the production of about 5.15 million tons, and an average yield of 3.5 t/ha (MoALC, 2018). If self-sufficiency is achieved in rice production, it can ensure the sustainable availability of food for the food insecure population. With these potentials, however, smallholding farmers are facing several constraints that limit their farm production and income. There is a large yield gap between farmers' rice-field, and the research demonstration field, which indicates a great potential for increasing rice production in the country (Tripathi et al., 2019). The use of improved seed varieties is important to increase rice production and productivity, but the formal seed production, and supply chain system is still very poor whereas there is a lack of technical information about production methods and practices and market opportunities (Upadhyaya, 1996; Dhungana et al., 2004; Joshi et al., 2011). Public investment in agriculture is essential to generate productivity growth and reduce poverty. Timsina et al. (2019a, 2019b) reported that investment in wheat and potato research in Nepal has generated different proven potential technologies but still needs to invest more in research to meet the technology demand. Low investment in research has negatively impacted the technologies generation and out-scaling to farmers (Gairhe and Acharya, 2017). To introduce new technology, public investment in agricultural research is

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essential, but it is still inadequate in Nepal (Gauchan, 2008). Shrestha (2014) reported that the human resource involved in rice research in Nepal is limited. As a staple food crop, Nepal has the potential to promote rice production for food security and also to substitute annual import by increasing investment in research and innovation (Ghale, 2017). But the present situation is such that Nepal has been a net importer of agricultural products including rice (Table 1). Although there are several factors to increase rice imports in Nepal, Gaihre et al. (2020) reported that rice import is galloping in Nepal because of deficit production, increased rice-eating population, and increased fine and aromatic rice consumption.

Table 1. Rice import and export situation in Nepal, 2018

Commodity	Import NRs. (million)	Export NRs. (million)	Balance NRs. (million)
Cereal crops	40148.372	30.072	-40118.300
Rice	29393.661	0.309	-29393.352

Source: MoALC, 2018; DoC, 2018; Nepalese Rupees (NRs.) 1= USD ($) 0.0082

Indeed, the Government of Nepal has to focus on rice policy issues, research investment, capacity building, technology generation, and other promotional activities to mitigate food and nutritional security (Gauchan, 2017). In supply chain management some actors are linked with each other from producer to ultimate consumer through a distribution system (Shukla et al., 2011). Several supply chain studies in Nepal reported weak coordination and linkage among the supply chain actors and less investment in value-added activities reduce their profit margin (Chapagain et al., 2011; Timsina et al., 2012a, 2012b; Shrestha et al., 2012). The objectives of this study were thus to analyse the dynamics of the rice sub-sector from the perspective of production, research investment, and supply chain as expected outcomes are not yet achieved in spite of continuity in priority for research and production investment. Based on the review and objectives of the study the following research questions were designed to answer.

(i) Whether the investment in rice research to generate rice technologies is sufficient?

(ii) Are agricultural policies favoured to increase rice production to meet national demand?

(iii) Is horizontal coordination among the major actors effective to deliver extension services as well?

(iv) Are supply chain actors coordinated and invested in value-chain activities to generate profit?

Material and methods

Study site

The Morang district was selected as a study district as this district stands for the highest area of rice production (88000 ha) in Nepal (MoALC, 2018). The district was chosen for the study purpose also in consultation with rice stakeholders, agricultural scientists, and local authorities involved in agricultural activities on a national, provincial as well as local level to know how rural farmers have benefited from the public investment which is also necessary for future policy and program formulation for rice research. Accordingly, the study was carried out in Budiganga Rural Municipality (BRM) in Morang by ensuring that this area well represents the rice-growing area, status, and condition of Nepal. The rice cultivated area of BRM was 4315 ha with the engagement of 60% of people in rice farming together with 65% of rice production of total agricultural production (RP, 2018).

Identification of supply chain actors and information collection

Both qualitative and quantitative data were collected by reviewing the available literature and with the use of a questionnaire survey to meet the objectives. To determine the effectiveness, validity, and reliability of questionnaires, a pre-test was done considering question format, wording, contents, and order. The pre-tested questionnaire was modified and standardized based on information obtained while pre-testing the questionnaire. According to the category of respondents, different sets of questionnaires were designed to know the food availability situation, the role of extension agents in rice technology expansion, the role of supply chain actors, and their investment in value addition, cost of production, and profit margin in the rice supply chain system. The research was limited to the rice farmers and the rice supply chain actors only. A random sample of 144 individuals in which 100 rice producers, 10 collectors, 10 wholesalers, 7 millers, and 17 retailers were chosen as part of the survey. During the data collection process, the researcher first explained the study purpose systematically and asked the questions to the respondents. Likewise, secondary sources of time series data on rice production, productivity, area, and research investment to generate rice technologies were collected. Moreover, different agricultural policy documents combined with other related materials from government publications, books, online journals, and reports were reviewed, analyzed, and transcribed.

Data analysis

All the data collected from the questionnaire survey were compiled and analyzed by using Statistical Package for Social Science (SPSS) version 25.00 for windows. The descriptive statistics such as mean, percentage, trend analysis were used to analyze the major attributes such as involvements in agriculture cooperatives and farming training, the status of subsidies and grants, and degree of rice production and supply whereas the unitary method for analysis was applied to the variables total cost of production, investment, gross return, and net income of supply chain actors in the rice trading business. The net income was calculated by subtracting the total cost of production from the gross return. Gross return was calculated by adding the total production of rice, rice straw, and rice husk by multiplying with the average selling price per ton of rice. To

know the profitability index between cost and benefit, budgeting techniques, and cost concepts such as fixed cost, variable cost, and total cost, and economic efficiency measures such as Benefit Cost (B:C) ratio were considered. The data were distinguished into different categories, grouped, rearranged, and transcribed, and presented in graphical as well as textual format.

Simultaneously, the policy analysis was also made for the data related to the rice research investment, area, production, and productivity for the period of 2000/01 to 2017/18. Compound Annual Growth Rate (CAGR) was also calculated to know the growth rate of those variables. To assess the relationship between public investment in rice research and rice production and also to learn the degree of association among these variables, correlation analysis was applied. To quantify the strength of the relationship between two variables, the correlation coefficient (r) was calculated. The coefficient correlation lies between -1.0 to +1.0. When, r> 0 there is a positive linear relationship, when r< 0 there is a negative linear relationship, while when r= 0 there is no linear relationship (Schober et al., 2018).

Results and discussion

Public investment in rice research in Nepal

It was learned that out of the country's total budget for agriculture, only 8.18% was invested in agriculture research during FY 2013/14 in Nepal, the trend was worsened (7.45%) in the FY 2014/2015, but increased a bit, and reached to about 10% (9.97%) in FY 2019/2020 (MoF, 2000-2019; NARC 2000-2019). These statistics fairly shows that public investment in agricultural research in Nepal is not adequate to increase the yield and develop appropriate technologies. Despite this low level of investment, the rice research wing of Nepal Agricultural Research Council (NARC) has developed and released 57 improved, and 17 registered rice varieties until last few years (CPDD, 2014), but expected benefits are not yet achieved perhaps due to several other institutional and technical factors related to the technology generation, lack of effective extension, adoption, and production of rice. Figure 1 depicts the status of public investment in rice, wheat, and maize research for the last 18 years in Nepal. Among all crops, rice research investment from FY 2000/01 to 2002/03 was higher. From FY 2003/04 to 2009/10, rice research investment was, however, cut-down, and in FY 2009/10 it was decreased by NRs. 0.943 million than FY 2008/09. In the FY 2010/11 it was picked up and again fell in FY 2012/13. In FY 2017/18, it was increased and reached to the top position during the 18 years, and again decreased in FY 2018/19 by NRs. 7.78 million. The lowest investment in rice research during the study period was for FY 2003/04. These findings clearly showed that public investment in rice has remained unpredictable - without a definite trend of increased investment. Similar findings were also reported by Joshi (2017) while examining and analyzing challenges and opportunities for enhancing rice production in Nepal. Similarly, Gauchan and Pandey (2011) and Gauchan (2017) also stated that there was underinvestment in rice research in Nepal.

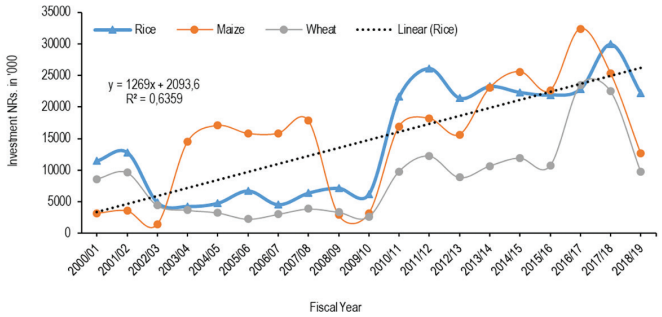

Figure1. Public investment in rice, wheat, and maize research in Nepal
(Source: NARC 2000-2019)

CAGR of public investment in rice research in Nepal from 2001 to 2019

The status of the CAGR of rice research investment from FY 2001 to 2019 has been presented in Table 2. Findings revealed that the CAGR of rice investment was increased at a rate of 10.05% per annum ($p<0.001$). In spite of the significant role, and the high importance of rice farming for food security, the growth of investment in rice research could be considered low, perhaps due to this reason, the development of rice technologies was affected. This could be considered as a serious challenge to the theme for rural poverty reduction, and food security.

Table 2. CAGR of rice research investment of FY 2001 to 2019

Parameter	Intercept	CAGR	R^2	P-value
Commodity rice	8.43	10.05***	0.57	0.000

***Significance at p<0.001

Trend of area, production, and productivity of rice in Nepal

Rice is the most important food crop and occupies a prominent place in Nepalese agriculture in terms of area covered production, and consumer preferences. Rice is cultivated in all the provinces in Nepal. The major rice-producing provinces are provinces 2, 1, and 5, respectively, as they jointly occupy 70% of the area and 70% of the production of rice. Karnali province comes as the lowest contributor in terms of area covered and the production of rice (MoALD, 2020). The area under rice cultivation ranged from 1.36 million/ha during 2015/16 to 1.56 million/ha during 2003/04 (Table 3). The area under rice cultivation seems a bit in decreasing trend, especially since 2012/13, except during 2016/17, indicating an inconsistency in the area under rice cultivation in Nepal (Table 3). A further prediction of decreasing areas for rice cultivation in the days to come indicates some other factors working that are related to rice production. Higher production costs and inputs, low productivity, and low-profit margin and unorganized marketing system could have triggered in developing this kind of scenario (Joshi, 2018).

Table 3. Year-wise area, production, and productivity of rice in Nepal during FY 2000/01 to 2019/20

FY	Area of production million (ha)	Production million (t)	Productivity (t/ha)
2000/01	1.52	4.16	2.75
2001/02	1.54	4.13	2.67
2002/03	1.54	4.13	2.68
2003/04	1.56	4.46	2.86
2004/05	1.54	4.29	2.78
2005/06	1.55	4.21	2.77
2006/07	1.44	3.68	2.56
2007/08	1.55	4.30	2.78
2008/09	1.55	4.52	2.90
2009/10	1.48	4.02	2.72
2010/11	1.50	4.46	2.98
2011/12	1.53	5.0	3.31
2012/13	1.42	4.50	3.17
2013/14	1.49	5.04	3.39
2014/15	1.43	4.79	3.36
2015/16	1.36	4.30	3.15
2016/17	1.55	5.23	3.37
2017/18	1.47	5.15	3.50
2018/19*	1491744/ha	5610011/ha	3.76
2019/20*	1458915/ha	5550878/ha	3.80

*Estimated; Source: FAOSTAT, 2020; MoALD, 2020

Table 3 also presents the status of rice production to the corresponding areas under cultivation from 2000/01 to 2017/18. As in the case of the area under cultivation, the total volume production of rice corroborates well in line with the area devoted (Table 3). The scenario of the productivity of rice (t/ha) looks a bit different. Comparatively lower mean yield (t/ha) of rice was recorded until 2010/11 whereas notable improvement in rice yield has been reported since then. These improvements in yield could have been attributed to several factors such as the development of new and improved varieties, production techniques, and so on. However, these changes are not much significant in terms of overall productivity and production increment. Indeed, these improvements in yield and productivity are far away to compare with respect to the yield in the research station and potential yield (Table 3).

Rice policy issues in Nepal

A wide range of policies, programs, Acts, Rules, and projects have been implemented by the Government of Nepal since 1962 for increasing rice production and productivity. The government had prioritized in its every five-year plan to increase rice production and productivity through high yielding varieties, input supplies, and subsidies as needed to generate employment opportunities, to address food insecurity situations, and overall economic development of the country. But the results were in a mixed form. For example, until 1987, Nepal usually was a net exporter of rice. In FY 1975/76 the country exported NRs. 495.4 million worth of rice (Pokhrel, 1997). However, the country started to import rice then after. The import of rice in Nepal was believed to have started from FY 1982/83 with 34147 t while the domestic production was 1.83 million/t (Pokhrel, 1997). In the early years, the imports were found on a smaller scale, but in recent years the import volume of rice has seen in some large quantities.

In view of the increasing trend of imports of rice and other agricultural commodities, the government had implemented 20 years Agricultural Perspective Plan (APP) (MoAD, 1995). But the scheme did not achieve success as it had planned. The National Agricultural Policy (NAP) was implemented in the year 2004 by proclaiming the special agricultural production pocket area, providing technical, financial as well as other input supplies assistance to the small farmers (MoAD, 2004). But this policy did not implement specific programs for rice production. National Seed Vision (NSV), 2013 was then implemented to increase crop productivity, and production, ensuring food security, reducing poverty, and raising household income (MoAD, 2013). NSV had targeted to release 100 rice varieties, with its Seed Replacement Rate (SRR) of 25% by 2025. In a similar timeline, in 2012, the government introduced a Special Agriculture Production Program (SAPP). Under this scheme, the government distributed subsidized improved seeds of rice, wheat, maize, chemicals, and organic

fertilizers to the farmers through Agriculture Inputs Company Limited (AICL) (MoAD, 2012). This program was regarded as very effective for private seed companies and seed traders (Bhandari et al., 2017). Agriculture Development Strategy (ADS) came in 2015 in addressing food insecurity problem, and commercialization of agricultural production (MoAD, 2015a). This strategy focuses on increasing the availability of food production faster than population growth. Although, this strategy is predicted to reduce the area of rice production by 0.1%, yet the total yield is expected to grow by about 1.7% annually. Likewise, Agricultural Mechanization Policy (AMP) 2014 aims to increase rice production, and productivity as one of the objectives, through the use of farm machinery in production, processing, and marketing (MoAD, 2014a). Mega Rice Production Program (MRPP) (MoAD, 2015b) and Fine and Aromatic Rice Production Program (FARPP) (MoAD, 2014b) were also launched to increase production, and productivity of local, and improved rice varieties by supporting the farmers' group, cooperatives, and seed companies for seed store, treatment, packaging, and marketing activities. With the vision of the commercialization of agriculture, Prime Minister Agriculture Modernization Project (PMAMP) (MoAD, 2016) was implemented by establishing a rice zone in the Jhapa district to increase rice production. To sum all these efforts, it is learned that from the 1960s to date, more than 50 different agricultural projects were implemented in Nepal (Bhandari et al., 2017). Most agricultural projects aimed to promote agricultural production, and productivity to addressing food security where rice is highly valued in fulfilling these goals. However, a significant increment in rice production through increased productivity has not been achieved so far. Lack of enough investment in generating rice technologies and the implementation of effective extension services to increase the adoption of generated technology could be the reasons to have this situation.

Rice research investment and production improvement

There are several reasons for increasing and decreasing agricultural production, and productivity that may be equally applicable in the case of rice production. If other things remain constant, agricultural production increases when the research investment generates high yielding varieties and effective management technologies.

In spite of the significant contribution of agricultural research in technology generation, the share of agricultural research in the national budget was only 0.18% in FY 2019/20, whereas the average investment during the period from FY 2000/01 to 2019/20 was hardly 0.27% (MoF 2000-2019; NARC 2000-2019). Considering the direct as well as the indirect role of investment in agriculture, the declining trend in public investment needs to be correctly addressed. Investment in agricultural technology development is a "win-win" strategy for reducing rural poverty by increasing agricultural production with higher wages (Baba et al., 2010). Classical economics theorists originated the fundamental principle of public investment. According to this theory, when the government decides to invest public funds in agriculture, the supply curve shift towards a higher position. Indeed, the overall impact of public investment is to reduce the price. Both the farmers and the other stakeholders can enjoy the benefit of the public investment (Dorward, 2009; Dwivedy, 2012; Chirwa and Dorward, 2013). Figure 2 shows the interrelationship between rice research investment and rice production during the last 18 years in Nepal. Accordingly, during FY 2006/07 rice research investment and total rice production was decreased. When rice research investment was increased in FY 2010/11 and 2011/12, the production of rice was also increased. It is further clear from the data that rice research investment and rice production trends are fluctuating, and moving in a nearly parallel way. It is also important to note that the investment in rice research in a particular year may not result in increased production in the same year, however, the effect could be more visible in the subsequent years. The calculated correlation (0.78) could be considered as a fair indication of a positive relationship between investment in rice research, and rice production in the country. The correlation coefficient describes the strength and direction of an association between variables (Schober et al., 2018) which are scaled within the range from -1 to +1, where 0 indicates that there is no linear relationship.

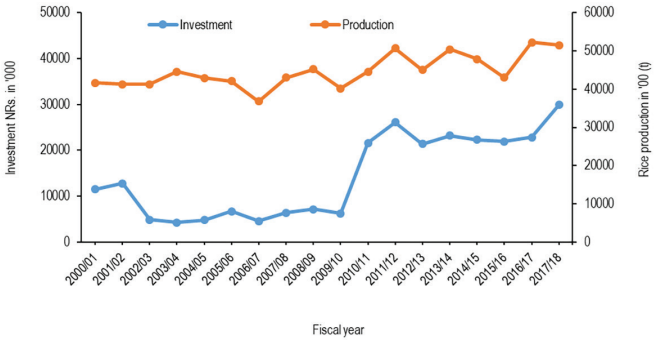

Figure 2. Rice research investment, and rice production in Nepal
(Source: FAOSTAT 2020; NARC 2000-2019)

CAGR of research investment, area, production and productivity of rice in Nepal

CAGR of rice research investment, area, production, and productivity in Nepal during 2001-2018 is presented in Table 4. The findings revealed that rice research investment, area, production, and productivity were not statistically significant in the first period (2001-2009). During the second period (2010-2018), investment in rice research increased so as the production and productivity (Table 4). In the overall period, rice research investment, production, and productivity were increased only at the rate of 10.57, 1.25, and 1.65 percent per annum, respectively. During the same period, the rice area showed negative growth. Gairhe et al. (2018) also reported similar results while analyzing the dynamics of major cereals productivity in Nepal.

Table 4. CAGR of research investment (NRs.), area (ha), production (t) and productivity (kg/ha) of rice in Nepal from 2001 to 2018

Year	Parameters	Intercept	CAGR	R^2	P-value
2001-2009	Investment	15.99	-5.91	0.17	0.264
	Area	14.25	-0.06	0.005	0.862
	Production	15.24	0.27	0.02	0.750
	Productivity	10.20	0.33	0.06	0.540
2010-2018	Investment	16.32	10.76*	0.38	0.079
	Area	14.21	-0.25	0.03	0.659
	Production	15.27	2.01*	0.35	0.092
	Productivity	10.26	2.27**	0.60	0.014
2001-2018	Investment	15.30	10.57***	0.56	0.000
	Area	14.26	-0.40**	0.29	0.021
	Production	15.19	1.25***	0.48	0.001
	Productivity	10.14	1.65***	0.75	0.000

***Significance at 1% level, **Significance at 5% level and *Significance at 10% level

Rice supply chain function in Nepal

A supply chain is a sequence of flows, and movement of goods from the procedures to the final consumers. The supply chain not only includes the producer, but also its suppliers viz. rice distributors, wholesalers, and retailers (Van, 2004). Effective sourcing, handling, transportation, and retailing without facing the situation of loss of its value are considered important dimensions in supply chain management (Morash and Clinton, 1997). Various individuals and organizations involved in rice-producing and supplying network are called supply chain actors. Agriculture supply chains are economic systems that distribute benefits and apportion risks among participants (Patil, 2012). Different multi-stage actors are involved in rice supply chain networks including farmers as the fundamental provider of rice along with farmer's cooperatives, rice handling businesses, wholesalers, and retailers (FAO, 2008). During this long network process, numerous exercises happen at each stage, which influences the capacity of the next stage. There are some public as well as private responsibilities in the network (Figure 3). The public responsibilities include infrastructural development, the formation of rules, regulations, and policies, conducting research and development, and providing agricultural extension services. Private responsibilities are very important in strengthening the supply chain for the rice sector through business activities. Figure 3 depicts the multi-stage network flow of the rice supply chain model in Morang district, Nepal that broadly covers the scenario of producers to the consumers.

Figure 3 depicts the fact that the regulatory body stands on the top of the process that the major rules and regulations developed from this body directly link with government Research and Development (R&D) and with banking sectors. Input suppliers also have a strong linkage with them. Government bodies relate their activities directly to the producers and then to the different scales of collectors. These collectors and cooperatives are directly linked to the millers and other buyers that they will have a strong connection with the wholesalers, retailers, and consumers. In this way, consumers are the producers as well as sellers whereas farmers as producers have to be confined with the initial production price regardless of value chain opportunities to receive a higher price and profit margin.

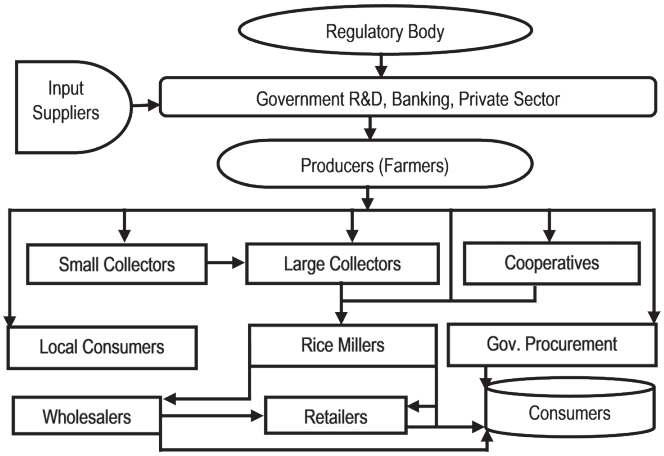

Figure 3. Rice supply chain map of Morang district of Nepal (Source: Field survey 2019)

Roles and responsibilities of rice supply chain actors

It was revealed from the study findings that actors along the rice supply chain have been playing different roles in input supply, production, collection, processing/milling, wholesaling, and retailing. Farmers are the producers. Farmers get inputs from the government agencies, research organizations, cooperatives, banking, and other related agencies under the umbrella rules and regulations for the country (Dania et al., 2016; Kumar and Iyengar, 2017). A total of 20 agriculture-based cooperatives are working in the study area, but they do have a weak linkage and coordination. Findings from this study revealed that 43% of respondents were involved in different

agriculture cooperatives. Only 23% of them had received credit facilities with a total amount of NRs. 1.596 million in which 50% of respondents received credit from cooperatives. Only 13.19% of respondents received subsidies from the government wherein 57.89% of the subsidies invested were related to the farm machinery and equipment. Likewise, 22.2% of respondents received rice production-related training in which 65% of such training was organized by the Department of Agriculture (DoA), while NARC organized only 6.25%. Meanwhile, some of the millers got the opportunity to train their technical staff covering machine operation and maintenance at their costs. The findings also showed that only 55% of respondents sold part of the produced rice after allocating the required rice for their household consumption. Since ancestral land is to be divided among the family members from one to next-generation resulting in small landholding size with a small scale of production.

The major actors in the supply chain were the collectors and the millers. It was well revealed that large collectors supply their 100% stock to the millers. Millers are the main value-adding actor in the overall rice supply chain dynamics. They are involved in de-husking, polishing, grading, packaging, and supply to the wholesalers, and sometimes to the retailers, and often directly to the consumers also. These facts and processes resemble largely the research findings of Gurung et al. (2010) as the authors also had reported that generally, large millers collect and store rice for about eight to nine months to fetch high prices during the scarce season. Normally, wholesalers supply the produced to the retailers, and in some cases directly to the consumers. Wholesalers' functions are associated with collecting, storing, and distributing the packaged rice. Retailers served as the last outlet of the supply chain dynamics with the function of making them available to the consumers as per the requirements with certain additional services. Reflecting on all these processes also in this study, it was revealed that the highest profit margin was achieved by the millers even though all actors had their responsibilities and investments in the entire supply chain dynamics.

Cost and return from rice farming

Cost of production of rice in the study area with respect to the variable costs, fixed costs, income, and B:C ratio has been presented in Table 5. The costs and the income of all supply chain actors (in terms of one-hectare area cultivation) covered the average value of the 144 respondents who were involved in the survey. Accordingly, the result showed that the total variable cost and total fixed costs were NRs. 74765/ha and NRs. 440/ha, respectively. Likewise, the net income from one hectare of rice farming was NRs. 19245 with a benefit-cost ratio of 1.26. The benefit-cost ratio as revealed in this study was profitable while considering the investment, but this is not enough to retain a higher profit margin. Farmers are the originator and main actor of the overall rice supply chain dynamics, but they are getting relatively low-profit margin. About one-fourth of the respondents in this study reported that because of the high cost of production, income from the sales of straw remains only the source of profit to them. Farmers, who particularly reported this statement believed that if the government provided subsidies on farm machinery, and input supplies along with high yielding improved varieties and the package of technologies that could reduce the cost of production, that would increase the profitability of farmers.

Table 5. Cost of production of rice in Morang district, 2019

Particulars	Unit	No.	Rate	Cost (NRs.)
Variable costs				
Labor	ha			36200
Machinery	ha			17500
Inputs	ha			21065
Total variable cost	ha			74765
Total fixed cost	ha			440
Total costs (variable + fixed)	ha			75205
Gross income				
Rice	t	4.385	20000	87700
Straw	t	4.500	1500	6750
Rice husk				1500
Total income	ha			94450
Net income (total income – total cost)	ha			19245
Benefit-cost ratio (total income ÷ total cost)				1.26

Source: Field survey 2019; NRs.1= $0.0082

The increase in the profit margin and costs will realize a higher retail price, or lower farm gate price, or sometimes joint results of both (William, 2003). Findings also revealed the fact that farmers were not getting a satisfactory return. They thought that they only received the reward of their family labor. Furthermore, as Gurung et al. (2010) reported the productivity, and profitability of rice is low mainly due to the high cost involved in the production processes, and due to insufficient and perhaps untimely supply of inputs, including irrigation, and inadequate use of technologies. Generally, the price gets very low during the harvesting period, and it became too high before the planting period. Indeed, agricultural markets push costs and risks into weaker players in the supply chain framework. Farmers are not able to make storage for a long time because they are the

weaker players (Don Seville and Vorley, 2011). This condition further worsens if farmers are less-educated and they receive no or very little information related to supply chain management.

Marketing cost of small collectors and large collectors

Small collectors' activities are confined mostly to transportation, load-unload, and bags preparation. Their average profit per/t was found NRs. 2070 (Table 6). On the other hand, large collectors' volume and dimension increases as they involve in purchasing, transportation, storing, and load-unload processes. Their profit margin becomes slightly higher than that of small collectors.

Table 6. Marketing cost of small collectors and large collectors of rice in Morang district, 2019

Activities	Small collector price (NRs./t)	Large collector price (NRs./t)
Buying cost	20000	22770
Transportation	200	226
Load unload	100	114
Sack/packaging	200	228
Storage cost/rent	0	114
Interest of input money	200	228
Sub-Total	20700	23680
Sales price	22770	26050
Profit	2070	2370

Source: Field survey 2019; NRs.1= $0.0082

Marketing cost of millers

Table 7 presents the detail of purchasing and milling costs, sales price, and profit per unit of sale. Millers indeed fetch the highest profit margin. Rice millers also get money from husk, bran, and other rice bi-products sell. In contrast, rural farmers, as well as small-scale supply chain actors, received relatively low-profit margins because they do not have the financial as well as management capacity to store the rice for the time of scarce (Kisanga, 2015).

Table 7. Milling and marketing cost of millers of rice in Morang district, 2019

Miller	Price (NRs./t)
Purchasing cost	26050
Grading, sacks, bagging, and tagging	530
Milling, electricity, labor and other	1300
Machinery maintenance	2600
Labor	260
Transportation	260
Load unload	130
Weight loss by de-husking	2600
Interest of input money	790
Sub-Total	34520
Sales price	41420
Other income	3000
Total income	44420
Profit	9900

Source: Field survey 2019; NRs.1= $0.0082

Marketing cost of wholesalers and retailers

Table 8 shows the activities of wholesalers and retailers in the supply chain management system. Their higher profit margin is mainly related to the better stocking capacity, and widely spread business (Gurung et al., 2010). Nevertheless, the lack of market facilities and difficulties in price regulation were the major problems faced by wholesalers. Likewise, retailers purchase rice from the wholesalers, and sometimes even from the millers. It was revealed that retailers get a comparatively higher profit margin than wholesalers due to several risk factors associated with the business.

Table 8. Marketing cost of wholesalers and retailers of rice in Morang district, 2019

Activities	Wholesaler price (NRs./t)	Retailer price (NRs./t)
Buying cost	41420	50340
Electricity, rent and other	2065	1010
Labor	414	503
Transportation	414	503
Load unload	207	254
Interest of input money	1240	1510
Sub-Total	45760	54120
Sales price	50340	62240
Profit	4580	8120

Source: Field survey 2019; NRs.1= $0.0082

From the evidence of supply chain studies, it can be said that among all supply chain actors, millers and retailers enjoyed a large amount of profit margin because of power imbalances within actors, and greater value exercising by millers and retailers relative to other actors (Table 9). They also had a dominating role in supplying and pricing of rice because of weak linkage and coordination among all actors. Lack of understanding of the benefits of supply chain implementation may also contribute to this situation (Aji, 2012). To combat this condition, the government can facilitate the sharing of the benefits with equitable methods among all actors by

formulating appropriate marketing guidelines and norms. On the other hand, weak marketing information to the farmers might have a negative effect to fetch a higher profit margin. When farmers have access to better marketing information, they could enhance marketing efficiency and possibly sell their product at a higher price. Thus, effective research and extensive services from the government sector are required to increase productivity through the adoption of a package of technologies. The government and the private sectors should coordinate, and collaborate to improve the performance of smallholder farmers by providing subsidies, grants, and soft loans on agricultural inputs. Coordination meetings, workshops, and interaction programs should be organized as an integration model among rice supply chain actors in a scheduled way. Establishment of a mechanism for input supply, irrigation system, modern land reform policy (Paudel and Saito, 2015), and increased public investment on rice technology generation with group farming system in cooperation among the rice supply chain actors are required for higher income generation, job creation, and to improve the food security situation in rural areas of Nepal.

Table 9. Profit margin of different supply chain actors of rice in Morang district, 2019 (NRs./t)

Actors	Buying cost	Operational cost	Total cost	Income	Profit	Margin (%)/t
Farmer			17150	21540	4390	13.97
Small collector	2,0000	700	20700	22770	2070	6.59
Large collector	22770	910	23680	26050	2370	7.54
Miller	26050	8470	34510	44420	9900	31.51
Wholesaler	41420	4340	45760	50340	4580	14.56
Retailer	50340	3780	54120	62240	8120	25.83
Total			195920	227360	31430	100

Source: Field survey 2019; NRs.1= $0.0082

Conclusion

Despite the significant role, and the high importance of rice farming for food security, the growth of investment in rice research could be considered low, perhaps due to this reason, the development of rice technologies was affected. Findings revealed that the CAGR of rice investment was increased at a rate of 10.05% per annum. However, it is noticed that public investment in rice has remained unpredictable - without a definite trend of increased investment. The positive relationship between investment in rice research and rice production in the country showed the importance of increment in the rice research program. Although the growth of rice production and productivity is significant during the study period, these improvements in productivity are far away to compare with respect to the yield in the research station and potential yield. Similarly, the current growth of production and productivity of rice is not sufficient to meet the national requirements. This showed there is a gap in policy design and implementation to achieve the goal. Whereas the findings of this study revealed that about four-fifths (78%) of rice was supplied by large collectors, one-tenth (13%) by the cooperatives, and less than that (7%) by small collectors. It showed that if farmers use improved technologies coupled with strengthened horizontal coordination among the actors for effective storing with a timely sell directly to millers during the scarce season, profit margins of the rice producers could be increased. The findings of this study also revealed that although the government has emphasized to increase rice production, and productivity through various rules, regulations, and programs, investment in rice research is not yet adequate as required to increase productivity and profitability of the rice production system. Increased investment also enhances the efficiency for generating package of improved technologies targeting to the rice-growing farmers that ultimately strengthen supply chain management. Besides, the implementation of effective extension services targeting the rice-growing farmers through increasing total factor productivity is crucial to increase the profit margin of rice producers.

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