Agricultural Economics Research Review
Vol. 26 (No.2) July-December 2013 pp 221-228

Investment in Wheat Research in Nepal – An Empirical Analysis[§]

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Abstract

Investment in wheat research in Nepal has been examined through estimation of full time equivalent of researchers on the basis of their time spent on wheat crop research. The information about full time equivalent was collected through questionnaire survey of the researchers involved in various disciplines of wheat research. The research investment has been compared with production share in value-terms using congruency model in the major production domains, such as development regions, eco-zones and environments. The model comparing actual production share with full time equivalent of researchers has revealed a moderately low congruency percentage indicating discrepancies in research investment across production domains. On adjusting the production share with both research progress and equity factors at the same time, the congruency percentage increased in production environments and decreased in eco-zones and geographic regions, highlighting the mismatch in research investments. Some policy measures have been suggested to mitigate the mismatch in resource allocations to wheat research in Nepal.

Key words: Congruency, equity, full time equivalent, production environment, research investment, wheat research, Nepal

JEL Classification: Q16, Q18

Introduction

Wheat is Nepal's one of the major crops grown in different agro-ecological zones and environments endowed with varied production potentials. It is cultivated on 730 thousand hectares of land and has the production of 1.61 million tonnes with productivity of 2229 kg/ha in Nepal (MoAC, 2010). Investment on the crop research has been a driving force behind increasing its productivity through varietal development and improved management practices. Studies in different countries have revealed that investments in agricultural research and development (R&D) have yielded handsome dividends for society, more than enough to justify past investments and to support increased funding in the future. The past studies on returns to investment in agriculture have revealed that the average rate of return per year to be 100 per cent for research, 85 per cent for extension, and 48 per cent for research and extension taken together (Alston *et al.,* 2000). The rate of return for investments in varietal development of wheat ranged between 75 per cent and 84 per cent during 1960 to 1990 in Nepal (Morris *et al.,* 1994).

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§ The paper has been drawn from PhD thesis entitled, "Resource Allocation in Agricultural Research and Development in Nepal" submitted by the first author to Institute of Agriculture and Animal Science, Tribhuvan University

In order to allocate research resources efficiently, possibilities of advancing knowledge or technology need to be explored in a particular commodity, problem or discipline and while the research effort is successful, the likely level of adoption that would occur over a given time need to be studied (Fuglie, 2007). Type of resources, partnerships and extension strategies need to be formulated to increase the adoption. In Nepal, research on wheat is mainly carried out by the Nepal Agricultural Research Council (NARC), but the R&D activities on this crop are also carried out by some non-governmental organizations (NGOs), including the Local Initiative for Biodiversity, Research and Development (LIBIRD) and Forum for Rural Welfare and Agricultural Reform for Development (FORWARD). Other public organizations such as Nepal Academy of Science and Technology (NAST) and Institute of Agriculture and Animal Science (IAAS) of Tribhuvan University also carry out R&D activities in addition to their core programs. This study has analyzed the investment in wheat research across geographic regions, major agro-ecozones and production environments of Nepal. For the study, we considered three geographic regions, viz. eastern, central and western and each geographic region constituted three major agro-ecozones, viz. terai plains (sub-tropical), hills (warm temperate and sub-tropical), and mountains (temperate), and three major production environments, viz. irrigated, rainfed lowland and rainfed upland.

The public investment in agricultural sector has been about three per cent of the national budget during the past three years (2009-2011), although agriculture has contributed about 32 per cent to the country's gross domestic production (GDP). The investment in Nepal's agricultural research was about 0.26 per cent of agricultural GDP during the period. This was much lower than the average expenditure in the developing countries which was 0.60 per cent of their agricultural GDP (Pardey and Beintema, 2001). A significant increase in investment in agricultural research is needed to generate new technologies for future growth in productivity.

The country employed 33 full time equivalent (FTE) agricultural researchers for every one million farmers and invested 520 million Nepalese Rupees or 23 million purchasing power parity (ppp) US dollars in agricultural research at 2005 prices in 2009 (Rahija *et al*., 2011). Of the total human resources, 44 per cent of the agricultural researchers were focused on crops, 22 per cent on livestock, 16 per cent on fisheries and 5 per cent on forestry (Rahija *et al.*, 2011).

There is a complex relationship across investment in agriculture, increase in production and productivity, and levels of rural poverty. Thirtle *et al.* (2001) have observed that an increase in agricultural output could lead to a reduction in poverty by evidencing 1 per cent increase in total factor productivity (TFP) and lowering the poverty ratio by 1.3 per cent in Asia. Fan *et al.* (1999) have found that improvement in TFP and reduction in poverty in India were driven by investments in agricultural R&D and infrastructural development, particularly roads.

During the past ten years, resource allocation to wheat research has shown an erratic pattern of growth in Nepal, although there has been a substantial increase from 2010 onwards (Figure 1). The resource allocation

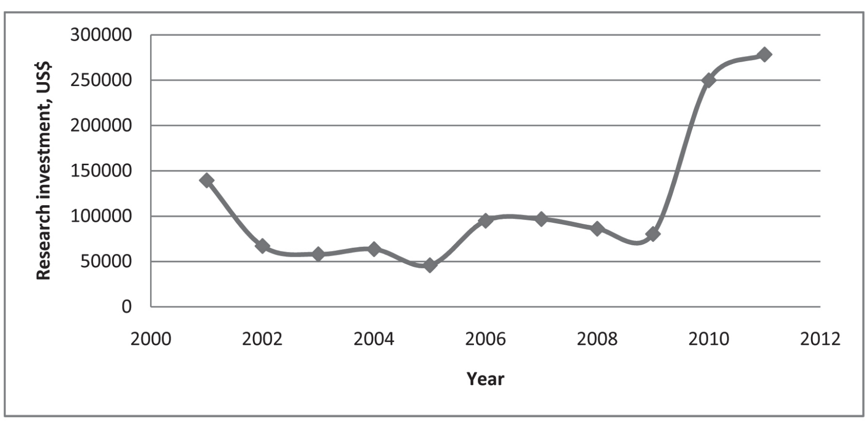

Figure 1. Investment in wheat research: 2000-2012

to wheat research has depicted a trend more or less similar to the overall agricultural research.

This study has investigated whether the research resources allocated to wheat research matched with the economic contribution of this crop in each of the geographical regions, agro-ecozones and production environments of Nepal.

Data and Methodology

A questionnaire survey was carried out among wheat researchers associated with different governmental and non-governmental organizations to identify the full time equivalent (FTE) for their time spent on crop research. The information was collected from 120 researchers of various disciplines who were spending their part or full time on wheat research. A measure of FTE in wheat research was used as a proxy for measurement of investment since the required information according to production domains such as geographical regions, ecological zones and environments was not available. The FTE is used as a common measure of research investment based on the time spent by a researcher on a commodity or discipline (Gauchan and Pandey, 2011; Pandey and Pal, 2007; Stads and Shrestha, 2006).

The various methods used for estimating the allocation of research resources are mostly based on economic surplus approach but vary in complexities and data requirements. A simple and commonly used procedure is based on the congruency approach which rules that resources should be allocated in proportion to the economic significance that is mostly measured by the value of production. This rule specifies that the share of a specific region or environment or commodity in the total research budget should be equal to its share in the total value of production (Anderson and Parton, 1983; Byerlee, 2000). Following Byerlee and Morris (1993) and Pandey and Pal (2007), the congruency was measured as per Equation (1):

$$C = 1 - \Sigma (R_i - V_i)^2 \qquad ...(1)$$

where, $0 \leq C \leq 1$, with $C = 0$ indicating no congruency between the allocation of research resources and value of output of a particular commodity. Congruency increases as the value of C approaches unity. R_i is the share of research resources allocated to the commodity *i,* and V_i is the share of the output value of the same commodity.

The above congruency approach can be modified to incorporate the elements of scoring approach (Alston *et al*., 1995; Gyrseels *et al*., 1992; Barker, 1988). In the present study, the index of output value in each domain was adjusted by weighting the value of production based on two factors, viz. research progress and poverty ratio. The first factor consisted of efficiency criterion relating the expected returns from commodity research expenditures which was termed as ‘expected research progress’. The second factor consisted of an equity criterion relating to the expected distributional effects of technical change which was termed as ‘poverty incidence’. Some more explanation on these factors is given below.

Rate of Expected Research Progress

The progress in wheat research in favourable environment differs from that in unfavourable environment. The expected rate of research progress needs to be adjusted in actual production share in order to modify the future research allocation. The past researches have been successful in increasing productivity in the irrigated areas, but the success was less in the rainfed areas, as witnessed in the impact of green revolution. A modest productivity growth in the past reflected a low level of resource allocation in agriculture. The likelihood of future progress is significant in guiding the *ex-ante* allocation of resources.

To estimate productivity growth and future research progress, experienced agronomists and breeders of Nepal were consulted. Their estimation was based on high-yielding pipeline technologies in wheat for different environments or eco-zones.

Incidence of Poverty

To compare resource allocation to wheat research across different environments, poverty ratio was used. One of the major justifications for investing in research targeted at crops in marginal environments is the higher incidence of poverty in these environments.

Data on poverty ratio were available only for politically-defined areas such as districts and development regions. Mountainous districts comprise mostly marginal land with low productivity resulting in high poverty ratio and high vulnerability to food security. Hilly districts have relatively more productive

Table 1. Full time equivalent (FTE) in wheat research across different eco-zones and environments in Nepal

Environment	Eco-zones					
	Full time equivalent (FTE)			Area (% share)		
	Terai	Hills	Mountains	Terai	Hills	Mountains
Irrigated	8.00	7.00	0.50	46.15	14.74	2.50
Rainfed lowland	4.24	5.00	0.50	12.01	18.58	3.85
Rainfed upland	1.50	1.15	0.15	0.09	1.66	0.42
Total	13.74(49%)	13.15(47%)	1.15(4%)	58.25	34.98	6.77

land and show less vulnerability to food security. The terai districts have most favourable and productive land and depict low poverty ratio. Since the data on poverty ratio were not available according to environments, these were estimated based on their agricultural productivity.

Results and Discussion

Resource Allocation to Wheat Research

The total number of researchers involved in wheat was 28 full time equivalents (FTE) in 2011 (Table 1). The operational cost in wheat research was US$ 278 thousand at current price which is equivalent to US$ 9942 per FTE researcher. In the case of rice, Gauchan and Pandey (2011) have found US$ 5,930 per FTE of rice researcher in 2009 in Nepal. The investment per FTE researcher in rice in India was estimated to be US$ 15780 for eastern India and US$ 21,110 for the rest of India in 2000 (Pandey and Pal, 2007).

Of the total wheat area (730 thousand ha), 63 per cent was irrigated with average yield of 2471 kg/ha, and the remaining area was rainfed with average yield of 1074 kg/ha (MoAC, 2010). Across the eco-zones, terai plains comprised 58 per cent of the total wheat area with 49 per cent of FTE share, indicating a substantial proportion of underinvestment. Hill eco-zone comprised 35 per cent of the total wheat area with 47 per cent of FTE share that indicated a substantial level of overinvestment. Mountain eco-zone comprised about 7 per cent of the total wheat area with a share of 4 per cent in FTE, indicating underinvestment (Table 1). The mismatch of investment in wheat research might have resulted from the irrational resource allocation and inefficiency of research management.

Congruency Analysis across Eco-zones

The congruency between actual production share and FTE share was 92 per cent indicating a moderate level of under-investment in wheat research across different ecological zones (Table 2). The actual production share was 20 points higher than the FTE share in the terai plains, whereas it was lower than the FTE share by a similar magnitude in the hills. In the mountains, the actual production share was least but exactly equalled to FTE share, indicating a perfect balanced investment. The results revealed that wheat research in the hills was over-invested on the basis of contribution of hill eco-zone to the total production value. The terai plains had a relatively larger share in total production but this eco-zone had been underinvested for wheat research.

One of the important reasons behind the overinvestment in the hills is that the divisions of these disciplines are located in the Kathmandu valley, which is in the hill eco-zone. However, the issue of over-investment could be overlooked because these divisions carry out research work not only for hills but for mountains and terai plains also.

Based on the experience and knowledge of wheat researchers, the expected increase in wheat productivity in the next ten years was estimated as 20 per cent in the terai and 10 per cent each in the hills and the mountains. The terai belt of Nepal has higher potential of productivity increase due to relatively good soil fertility and availability of abundant water for irrigation. In another study, the expected yield gains in rice relative to the current values were estimated as 30 per cent for the terai, 20 per cent for the hills, and 10 per cent for the mountains (Gauchan and Pandey, 2011). The poverty ratios for the mountains and the hills were estimated to be 10 per cent and 15 per cent

Table 2. Full time equivalent (FTE) of researchers and share of wheat production across eco-zones in Nepal

Parameters	Eco-zones				
	Terai	Hills	Mountains	All	Congruency
FTE	13.74	13.15	1.15	28.04	
FTE share	49.00	47.00	4.00	100.0	
Actual production share	69.37	26.63	4	100.0	0.92
Adjusted production share (research progress)	71.19	25.05	3.76	100	0.90
Adjusted production share (equity)	66.45	29.34	4.21	100.0	0.94
Fully adjusted production share (research progress and equity)	77.57	20.93	1.50	100.0	0.85

higher, respectively than for the terai plains. We used the poverty weight 1 for the terai, 1.15 for the hills and 1.10 for the mountains. The Nepal Living Standard Survey (NLSS) of 2003-04 has shown that the poverty rate is lowest in the terai region than in the mountains and the hills (CBS, 2005). While we have adjusted the actual production share with the rate of expected research progress alone, the congruency percentage declined by 2 points. In contrast, the congruency percentage increased by the same magnitude when the production share was adjusted with equity factor for poverty consideration. When the production share was fully adjusted with both the factors, the congruency had declined by 7 points, amplifying the mismatch of investment across different eco-zones.

Congruency Analysis across the Environments

When FTE share and actual production share were analyzed for three production environments, viz. irrigated, rainfed lowland and rainfed upland, the congruency was found to be 91 per cent (Table 3). This indicated a moderate level of underinvestment in wheat research across different environments in Nepal. The actual production share was 25 points higher than the FTE share of irrigated environments, whereas it was 12 points lower than the FTE share of rainfed lowland and 13 points lower than the FTE share of rainfed upland. It indicated a discrepancy in investment in these production environments with empirical evidence of underinvestment in the irrigated environment and overinvestment in the rainfed environment. The actual pattern of wheat research across the production environments has shown an overall congruency of 92 per cent in India and 96 per cent in CIMMYT member countries (Byerlee and Morris, 1993). The congruency in rice research in India was as high as 99 per cent across different environments of the country (Pandey and Pal, 2007).

The research emphasis on rainfed wheat might be due to the present scenario of climate change that compelled to invest in resource conservation technologies to cope-up with unfavourable environment. Although the production share of rainfed environment is low at present, push-up in investment is required for the long-run production growth and poverty reduction in such a marginal area. However, the importance of according highest weight to favoured environments is supported by the evidence that there are significant positive spillover effects from technological change in these environments which ultimately benefit the poor in marginal environments through lower food prices, increased employment and higher wages (David and Otsuka, 1992). These spillover effects may actually exceed the positive benefits generated through research targeted specifically at marginal environments (Renkow, 1991).

The future progress in wheat research has been estimated to be 15 per cent in the irrigated environment, 30 per cent in the rainfed lowland, and 20 per cent in the rainfed upland environments. The reason behind the modest future productivity growth in irrigated environment is the current higher yield due to relatively high use of inputs in these environments. The potential of yield increase in the rainfed lowland is more because of the upcoming water-saving technology which is highly suitable in this environment. The irrigated environment received high priority during the green revolution period primarily because of its high growth potential. This paid rich dividends in terms of quantum jump in crop yields, but in the process, rainfed and

Table 3. Full time equivalent (FTE) and share of wheat production across different production environments in Nepal

Parameters	Environment				
	Irrigated	Rainfed lowland	Rainfed upland	All	Congruency
FTE	15.55	7.74	4.75	28.04	
FTE share	55.00	28.00	17.00	100.0	
Actual production share	80.00	16.00	4.00	100.0	0.91
Adjusted production share (research progress)	78.23	17.69	4.08	100.0	0.92
Adjusted production share (equity)	74.91	19.48	5.62	100.0	0.94
Fully adjusted production share (research progress and equity)	47.25	41.66	11.09	100.0	0.97

marginal regions were neglected (Pal and Singh, 1997). The poverty ratio was estimated to be 30 per cent higher in the rainfed lowland and 50 per cent higher in the rainfed upland as compared to in irrigated environment. The estimated poverty ratio was based on the wheat productivity which varied widely across different environments. The average wheat yield with improved variety was 2471 kg/ha in the irrigated condition, and 1074 kg/ha in the rainfed lowland. The average wheat yield of local variety in rainfed upland was 752 kg/ha (MoAC, 2010).

When the actual production share was adjusted with the expected research progress, the congruency index had increased by only one per cent. When the actual production share was adjusted with equity factor, the congruency index inclined to 94 per cent. The congruency index increased up to 97 per cent when the actual production share was adjusted with both the factors (Table 3).

Congruency Analysis across the Geographic Regions

The western region of Nepal had the highest production share (51%) in the total wheat production despite its lower FTE share of 36.5 per cent (Table 4). Since the western region comprised the largest wheat area and had potential of a significant increase in yield, the resource allocation to wheat research need to be increased substantially in this region. Also, an incentive mechanism should be developed for motivation of researchers to work consistently in the region.

The gap between potential yield and on-farm yield of wheat was higher in the western than in the eastern and central regions. Based on the potentiality of pipeline technologies, the wheat productivity was anticipated to increase by 10 per cent each in the eastern and central regions and by 20 per cent in the western region in the next ten years. It was because the soil of

Table 4. Full time equivalent (FTE) and share of wheat production across different geographical regions of Nepal

Parameters	Eastern region	Central region	Western region	All regions	Congruency
FTE	2.40	15.39	10.25	28.04	
FTE share	8.50	55.00	36.50	100.0	
Actual production share	16.00	33.00	51.00	100.0	0.92
Adjusted production share (research progress)	15.29	31.54	53.17	100.0	0.91
Adjusted production share (equity)	15.05	28.23	56.72	100.0	0.88
Fully adjusted production share (research progress and equity)	11.07	20.74	68.19	100.0	0.78

western region has not been exploited with higher inputs as compared to in the eastern and central regions. Poverty ratio was estimated to be higher in the eastern and western regions by 10 per cent and 30 per cent, respectively as compared to that in the central region. It was because the central region had a better access to inputs and market, thereby increasing income generation activities of the farmers. The average farm yield was 2122 kg/ha in the eastern region, 1608 kg/ha in the far western region and 2322 kg/ha in the central region (MoAC, 2010).

Conclusions

The congruency index with actual production share has indicated moderate discrepancies in research investment in wheat in all the production domains of Nepal. The wheat research has been found over-invested in the hills, and rainfed environments and under-invested in the terai plains and irrigated conditions. Across geographic regions, the central region has been observed to be over-invested whereas eastern and western regions are under-invested. When the production share was adjusted with research progress and equity factors, the congruency percentage increased in some cases and declined in other cases. A higher investment is required for wheat research in the irrigated environment as well as in terai plains. The western region also needs substantial increment in research investment since it has the largest contribution to the total value of wheat production. Although the issue of mismatch in the allocation of research resources across the production domains is important, it is even more important to raise the investment in the agricultural research system in Nepal.

Acknowledgements

The authors are grateful to International Rice Research Institute (IRRI), Manila, for providing financial support to conduct this study as a partial fulfillment of PhD thesis on 'Resource Allocation in Agriculture Research in Nepal'. They thank Dr Sushil Pandey of IRRI for his generous support and technical guidance. They are also thankful to Dr Devendra Gauchan, Nepal Agricultural Research Council and Dr Bhaba Tripathi, IRRI-Nepal office, for their support during the study. They thank the anonymous referee for the critical comments which helped on this paper.

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Received: January, 2013; Accepted June, 2013