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Dairying and Whole-farm Economics of Crop-livestock Farming Systems - Comparing Arid and Irrigated Districts of Punjab, Pakistan

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Abstract

Dairying is an important component of Pakistan's mixed crop-livestock farming systems. The national economy engages some 8.8 million small-scale producer households. The country produces more milk than any other except for the United States and India. Yet little is known about small-scale producer microeconomics to inform policy development for improving their welfare. In this paper we aim to identify the whole farm profitability of small agricultural households, with a specific focus on milk production. We compare two contrasting agro-ecological regions within Pakistan's Punjab (irrigated Okara and rain-fed Bhakkar) using results for a single 2008-09 fiscal year of production for 212 farms.

Net farm profits, taking long-run opportunity costs of labour and capital into account, showed only 10 percent of these farms to be profitable in either district, though short-run profits, accounting for cash costs only, showed positive whole farm gross margins for 90 percent and 80 percent of farms in Okara and Bhakkar, respectively. The returns on assets (at 2.78 percent and 0.53 percent for the two districts) was lower than the national average return on savings (9 percent). For dairy enterprises, total costs were higher than incomes; so many farms (70 percent and 60 percent, respectively) were assessed as making losses. Given the low opportunity costs of feeds (often crop residues) and of labour (6.2 percent unemployment) and the high rate of inflation (11.8 percent), returns on factors of production including labour and capital, may not be lower than international standards. There is a need, however, to raise the dairy industry's overall productivity to make dairying viable; and to identify an optimal land and livestock combination that is profitable and commercially viable.

Key words: Gross margins, whole farm profitability, smallholder, agriculture, crop-livestock, farming system

Introduction

Despite the immense importance of milk to Pakistan's economy and smallholder producer welfare, little is known about its microeconomics. This research aims to fill this gap by using data (Wynn, Unpublished) collected for two years to understand the production of milk by smallholder farms in a mixed crop-livestock farming systems in two varied agro-ecological zones of Punjab, and to support pro-poor policy development processes in the country, with a special focus on the dairy industry. This study identifies some highly prospective drivers of milk productivity growth from a whole farm perspective using an Australian Center of International Agricultural Research (ACIAR) funded farm survey in two districts of Pakistani Punjab. The focus of the survey from the outset was to ascertain dairy diets; in particular the use of green fodders, crop residues and concentrate and their impact on milk production. The present study estimates economic impact of feed on increasing milk production and the whole farm profitability of the farms surveyed.

A few past studies, albeit with limited sample size, have indicated many smallholder producers are unprofitable. In a small sample study of four farms, Garcia et al. (2003) concluded that two of the four farms examined, with 7.5 and 15 acres of land and 3 and 10 buffaloes respectively, were profitable. Another study with no specified sample size by Staal et al. (2008) found that dairy enterprises with less than two milking animals were unprofitable. Another study (Ahmad & Pasha, 2009) that used cross-sectional data for six districts of Punjab, concluded that in Bhakkar and Pakpattan districts, farms with less than six animals, and in Faisalabad district farms with six to ten animals, were unprofitable.

Pakistan's economy is heavily reliant upon agricultural production which accounts for 19.5 percent of the country's GDP with livestock production maintaining a 58 percent share of agriculture's contribution to GDP. Milk is the primary product and meat the secondary product of 82 million buffaloes and cattle from which 61 percent and 36 percent of the total milk production is obtained, respectively (Government of Pakistan, 2017). The combined value of milk and meat of US$ 17.2 billion exceeds the economic value of all cash crops (Food and Agriculture Organization, 2013b).

South Asia's share in global milk production, mainly from Pakistan and India, is 23 percent (Hemme & Otte, 2010). Pakistan ranks as the 2nd and 11th largest country for whole fresh buffalo and cow milk production, and third largest overall producer globally (Food and Agriculture Organization, 2013b; Hemme, 2010). Pakistan's milk production grew at an average rate of 3.3 percent per annum from 2000 to 2010, and in the 2016-17 fiscal year, the country produced 56.1 million metric tonnes. This growth, however, is not based on gains in productivity per animal, but rather growth in numbers of livestock (Food and Agriculture Organization, 2013a; Government of Pakistan, 2017; Zia, Mahmood, & Ali, 2011).

Together, agriculture and livestock absorb 42 percent of Pakistan's total labour force (Government of Pakistan, 2017) but is categorized as non-wage employment with a very low added value per worker (US$ 1,187/worker) compared to Australia (US$ 70,416/worker) and the United States (US$ 59,247/worker) (World Bank, 2012). This is an important consideration when linking a nation's prosperity to its long-term productivity, that is, the value of output produced by a unit of labour and capital employed (Porter, 1998). In practice, farmers balance three classical factors of production, being an investment in capital (including livestock), labour and land, with the first two affecting what can be done with the third. They make decisions on what to produce and primarily grow commodities with no differentiation in quality grades and are therefore price takers facing a continuous cost-price squeeze and pressure to enhance efficiency (Tansey & Worsley, 1995).

Industry Structure (Dairying and Agriculture)

The structure of the dairy industry is such that 8.8 million or 37 percent of Pakistan's households raise livestock (buffalo and cattle), and 63 percent of these households are in Punjab. Thirty-eight percent of the dairy holders are landless, and the land ownership also has a strongly skewed distribution, with 89 percent of the households having less than 12.5 acres (or 5 hectares) of land and owning only 48 percent of the country's arable land. Approximately 80 percent of milk is produced in rural areas, and 91 percent of households have less than 10 animals. Punjab province has the largest dairy holdings (68 percent of Pakistan's buffalo population and 55 percent of the cattle). Half of the country's households (51 percent) are associated with land and/or livestock (Amjad, 2010; Government of Pakistan, 2010; Government of the Punjab, 2012; Zia et al., 2011).

Typical Crop-Livestock Production Systems and Issues

To investigate Pakistan's milk production requires a farming systems approach because crop-livestock interactions occur widely throughout these agricultural households (Byerlee & Hussain, 1992; Devendra & Thomas, 2002). These small-scale producers own land and livestock as major capital assets but have little commercial orientation and variable management capabilities (Erenstein, Thorpe, Singh, & Varma, 2007). The dairy animals are characterised by low milk yield, short lactation periods, long calving intervals, protracted age at first calving, and high mortality rates (Wynn et al., 2006). Milk from these animals, however, is an important source of nutrition for resource-poor households and its sale, after household needs are met, contributes to cash flows (Afzal, 2010; Government of Pakistan, 2017). The dairy enterprise also supplies marketable meat in the form of male calves and cull buffaloes and cows (Wynn et al., 2006). Livestock provides farmyard manure used as organic matter for soils and as fuel for cooking. It provides insurance against crop failure (Afzal, 2010) and is an asset that can be liquidated quickly in case of need but disease, death, or theft are some of the risks implied while keeping livestock (Kurosaki, 1995). With little to no mechanisation, livestock rearing is labour intensive (Jalil , Rehman, Sial, & Hussain, 2009). Livestock and land initially complement each other but then compete for labour though it is argued that livestock provides work opportunities for family labour with low opportunity costs (Otte et al., 2012; Staal et al., 2008). Limited land also leads to competition and compromise between animal and human dietary needs. Crops take precedence over livestock as the farmers' first aim is to ensure food security for their families and thus a limited amount of land is allocated to green fodder production (Afzal, 2010; Dost, 2003; Staal et al., 2008). Crop residues, straws, stover, and weeds, which otherwise have little use, provide an important share of livestock diets in cultivated areas (Nordblom & Shomo, 1995).

Pakistan has two cropping seasons, commonly known as *Kharif* for summer and *Rabi* for winter (Government of Pakistan, 2017). Wheat is the major winter crop across most of Pakistan, whereas the summer crop, usually the main cash crop, depends on local climate, soils, and access to markets. Common summer green fodders include maize, sorghum, sorghum hybrid, pearl millet; while berseem, lucerne and oats are common winter green fodders (Table 1) (Byerlee & Hussain, 1992; Dost, 2002, 2003). The dairy animals are mainly stall-fed with green fodders grown on the farm, which are supplemented with roughages such as wheat or rice straw (crop residues), while concentrates such as cotton seed cake, wheat bran or bread wastes are bought in as dietary supplements (Afzal, 2010).

Table 1. Cropping, seasons and cash crops and fodders of Pakistan

Cropping seasons	Sowing and harvest months	Major cash crops	Green fodders
Kharif or summer	Sowing: April-June Harvest: October-December	Maize, rice, sugarcane, cotton, lentils (depending on region)	Maize, sorghum and pearl millet
Rabi or winter	Sowing: October-December Harvest: April-May	Maize, wheat, gram, lentil, tobacco, rapeseed, barley and mustard (depending on region)	Berseem,lucerne and oat

*Source***:** Authors tabulation based on Byerlee and Hussain (1992), Dost (2002), Dost (2003), Pakistan Dairy Development Company (2006) and Farooq (2013)

Dairy production systems are classified based on the number of animals kept and the agro-ecological zone (Table 2) (Raja, 2001a, 2001b; Wynn et al., 2006; Zia et al., 2011). Average milk yield across the industry for both cow and buffalo remains low at 1,452 kg/year compared to 6,122 kg/cow/year in Australia (Dairy Australia, 2012; Fakhar & Walker, 2006; Wynn et al., 2006).

**Table 2. The dairy production system of Pakistan/Punjab and indicative milk production (kg/lactation)**

Production system	Farmer description	Production system	Buffalo	Cow	Average of buffalo and cow
Smallholder subsistence	Up to 3 animals with one or two milking; most milk kept for household use but some surplus sold	Irrigated	2000	900	1450
Rural market-oriented	More than six animals with two to three milking; regular sale of surplus	Arid (*barani* or rain fed)	1200	450	825

*Source***:** Authors tabulation based on Raja (2001a), Wynn et al. (2006) and Zia et al. (2011)

Materials and Methods

Data source and survey area

The data from a two-year longitudinal survey planned by an Australian Centre for International Agricultural Research (ACIAR) funded project entitled *"Improving dairy production in Pakistan through improved extension services"* (Wynn, Unpublished), was used. The survey was conducted from January 2008 to December 2009 and included 230 farms from 17 and 14 villages in Okara and Bhakkar districts (Figure 1a and 1b) of Punjab respectively.

Figure 1.a Maps of Pakistan and Punjab; b. Map of Punjab showing Okara and Bhakkar districts
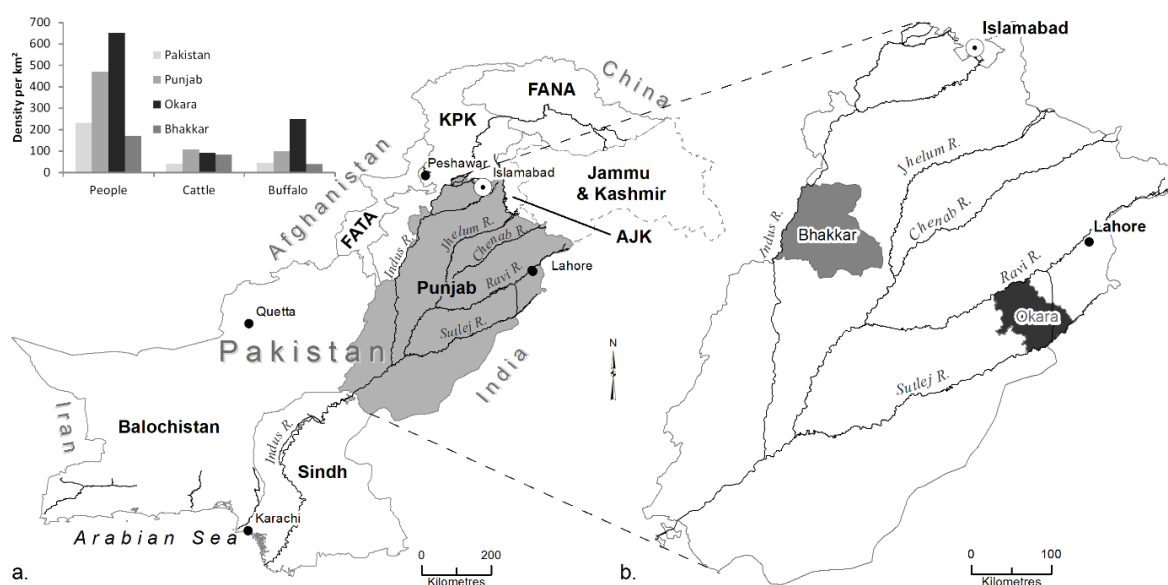
Source: City and border data spatial from 2012 ESRI data and maps

In addition to support from Government of Punjab livestock department's district extension staff in both the districts, the farmers in Okara were selected from those recommended by Idara-e-Kissan, the only dairy farmer's cooperative in the country (which no longer exists), while in Bhakkar, the collaboration of National Rural Support Program (NRSP), a nationwide non-governmental organization (NGO) providing micro credit to farmers, was sought.

The irrigated *Okara* district lies between the rivers Ravi and Sutlej and is part of the Southern Irrigated Plains with calcareous clayey soils. The climate is arid subtropical and continental with hot summers and mild winters. In the hottest summer months, maximum temperatures reach 44°C, and minimums of 2°C occur during winter. Average annual rainfall is 500 mm and the majority of farmers use tube wells for irrigation to supplement canal-sourced water. The main crops grown are wheat, rice, maize, sugarcane, and cotton, with potato being a popular vegetable crop. The district is famous for rearing local Sahiwal cattle and Nili-Ravi water buffalo breeds (Dost, 2002, 2003; Government of the Punjab, 2011b, 2012; Pakistan Meteorological Department, 2013; Small and Medium Enterprises Development Authority).

The rain-fed *Bhakkar* district on the western bank of the river Indus has two zones within it, with well-cultivated lands in the west and dry and sandy lands in the east. The district has calcareous sandy soils and dunes. The climate is semi-arid with hot summers and cold winters and with a short dry season in early summer. The maximum temperature in summer reaches 47°C with winter minimums of 3°C. Mean annual rainfall is 400 mm. Sugarcane, gram, wheat, guar seed and cotton are the main crops, with cattle and buffalo also reared by farmers (Dost, 2002, 2003; Government of the Punjab, 2011b, 2012; Pakistan Meteorological Department, 2013).

Survey target and method

The longitudinal survey data aimed to establish a comprehensive picture of the operations of smallholder crop-livestock producers by recording the production, sale and home consumption of milk

as well as the staple and fodder crops grown. A key farmer selection criterion was to include farmers with at least one or two milk animals, some surplus milk production to be marketed, and some cultivable land. The aim was to understand the dimensions of the farming systems before the start of an extension project. There was no limit on the maximum number of milk livestock held, or the size of the land holding, although small dairy holders remained the main focus. An easy to understand herd book was used to gather data. The data recorded land value and prices. It also recorded buffalo and cattle classes by sex and age which were assigned market values.

The data collection frequency varied for different output and cost variables. Weekly data was recorded on milk volume per buffalo and/or cow, type and quantity of feed (green feed, concentrates and roughages) for the whole herd at each farm, expenditures on animal health and revenue from sale or cost of livestock purchase. Monthly data recorded land allocation for different crops grown as well as the number and composition of livestock kept, including milking animals.

From this survey, data for one cropping year from June 2008 through May 2009 was extracted for 115 and 97 farms in Okara and Bhakkar districts respectively. Farms with incomplete data and very large farm units, in terms of land area, which were outliers skewing the normal distribution, were excluded as they represented a very small percentage of the group's total production.

Although the key focus was the dairy enterprise and profitability from milk, livestock (milk and meat), all other major farm enterprises were also examined within a whole farm analysis framework (Kay, Edwards, & Duffy, 2008; Malcolm, Makeham, & Wright, 2005; Wilson, Charry, & Kemp, 2005).
The following are the terms used to define elements of our whole farm economic analysis:[1]

- **Gross margins** (*GM*), defined as the gross income from an enterprise minus the variable costs, were estimated for *crops, green fodders, milk, and meat,* for each farm. The cost of manual labour was excluded for all enterprises and was counted as a fixed cost.
- **Crop gross margin** (*GM_C*) was gross income (*GI_C*) from a crop enterprise based on market value less its variable costs (*VC_C*).
- **Green fodder gross margin** (*GM_F*) was taken as zero that is gross income (*GI_F*) from each fodder crop was equated to its variable cost of production (*VC_F*) as this cost was charged to livestock enterprise feeding green fodders grown at the farm.
- **Whole livestock activity (milk and meat) gross margin** (*GM_{WLA}*) was gross income (*GI_{WLA}*) from the livestock activity and included the value of total milk produced, plus livestock trading income (*TI_L*), less total variable costs (*TVC_{WLA}*) of rearing livestock that included feed, health and breeding costs. These costs were divided between *milk* and *meat* enterprise by allocating all *female* buffalo and cattle costs to milk enterprise and *males* to meat enterprise, while one fourth of milking buffaloes and cows that are culled for meat were allocated to meat enterprise (Wynn et al., 2006).
- **Milk gross margin** (*GM_{Mk}*) was gross income (*GI_{Mk}*) from milk production that included sales, home consumption and 5 percent to suckling calves, less variable cost (*VC_C*) allocated to milk enterprise.
- **Meat gross margin** (*GM_{Mt}*) was gross income (*GI_{Mt}*) from livestock trading (*TI_L*), less variable costs (*VC_C*) allocated to meat enterprise. Meat was only a very small proportion of home consumption. These animals are generally sold in the market.
- **Total fixed cost** (*TFC*) was taken as the labour (*L*) assumed to be provided by the farmer owner and / or his household. These labour costs had been excluded from all enterprise GM estimates. There were no other fixed costs.
- **Operating profits** (*OP_{WF}*) for the whole farm was calculated by subtracting total labour costs taken as the only fixed cost (*TFC_{WF}*), from whole farm gross margins (*GM_{WF}*).

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[1] Detailed equations used are available from the authors.

- **Net Profit** (NP_{WF}) for the whole farm was OP_{WF} less opportunity cost of capital (OCC_{WF}) for the whole farm. FC_{WF} was calculated by applying an annual interest cost on the value of land and livestock utilised as key farm assets *(their opportunity cost)*. The opportunity cost of capital was based on the long-term average national savings rate of 9 percent and that used by the government of Punjab in its crop gross margin estimates for the fiscal year 2008-09 (Government of the Punjab, 2011a; National Savings Organization, 2000).

Statistical analysis was carried out using t-tests to compare means of physical and economic attributes for the two districts. A two-sample t-test with 95 percent confidence interval and the district as group factor was applied to compare sample farm variables in the irrigated Okara and arid Bhakkar districts of Punjab. Linear regression was used to explore associations between milk production and land allocated for fodders. Furthermore, multiple linear regression was used to explore associations between milk production and three key variables; green feed, concentrates, and roughages fed to the dairy herd.

Results

Taking long-run opportunity costs of labour and capital into account, the analysis showed that only 10 percent of these farms were profitable in either district. However, short-run profits, accounting for cash costs only, showed positive whole farm gross margins for 90 percent and 80 percent of farms in Okara and Bhakkar, respectively. The returns on assets (at 2.78 percent and 0.53 percent for the two districts) was lower than the national average return on savings (9 percent). For dairy enterprises, total costs were higher than incomes; so many farms (70 percent and 60 percent, respectively) were assessed as making losses.

Inter-regional farm characteristics

Although average land holding was the same in the two districts, more land was more intensively cultivated in rain-fed Bhakkar for different crops, during the two cropping seasons, compared to irrigated Okara (Table 3). There was a significant difference ($p < 0.001$) between the mean number of buffalo and cattle kept per farm in the two districts with more buffalo in Okara and more cattle in Bhakkar, which conforms to the national statistics (Government of the Punjab, 2012). There was a significant difference ($p < 0.001$) in green feed and roughages fed, with Okara higher on both.

Table 3. Mean physical and economic attributes of agricultural land and livestock for farm survey data. Standard error of mean (SE) indicated in parentheses. Results of t-tests comparing means

Measure	Okara	Bhakkar	t	df[2]	p
Total sample size (*n*)	115	97			
Land (Acres)					
Total land	9.04 (0.66)	9.47 (0.91)	-0.38	181	0.702
Total cultivated area (summer and winter crops)	16.15 (1.11)	21.77 (1.81)	-2.65	163	0.009
Land cultivated for fodder crops	5.44 (0.35)	5.18 (0.38)	0.51	210	0.612
Land cultivated for other crops	10.71 (0.85)	16.59 (1.51)	-3.40	154	< 0.001
Livestock (kept for milk and meat)					
Herd size (hd)	10.93 (0.48)	10.50 (0.57)	0.59	210	0.555
Buffalo (hd)	7.67 (0.34)	4.19 (0.35)	7.09	210	< 0.001
Cattle (hd)	3.27 (0.31)	6.30 (0.44)	-5.63	177	< 0.001
Milking cows and buffaloes (hd)	3.71 (0.18)	3.77 (0.27)	-0.20	210	0.840
Total milk production (kg/annum/farm)	3,400 (181)	3,453 (278)	-0.16	169	0.875
Average milk production (kg/annum/milking animal/farm)	999 (44)	916 (54)	1.19	210	0.234
Milk sold (kg/annum/farm)	658 (73) 29% of total	1558 (334) 37% of total	-2.63	50	0.011

Source: 2008-2009 Australian Centre for International Agricultural Research (ACIAR) farm survey data from Wynn (Unpublished) (1 acre = 0.4047 ha or 1 hectare = 2.471 acres)

Linear regression to investigate associations between total farm milk output and land allocated for growing different fodders showed an apparent increase in milk output with increase land allocated for forage production (Figure 2a). It also indicates that the Bhakkar district has the higher rate of increase in milk production with increased forage area. Further feed analysis using multiple linear regression showed no association between milk output per animal and green feed or roughages fed per head per annum (not shown here). The linear regression showing association between milk output per animal and concentrates (Figure 2b), however, was more significant. The linear equations indicated that with a one kilogram per annum increase in concentrates fed per milking animal, it would lead to a 1.9 kg and 1.4 kg increase in milk production per milking animal per annum for Bhakkar and Okara respectively.

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[2] When comparing average land held by the farmers in the two districts, the variances for Okara and Bhakkar were not equal. Okara $s_1^2 = 50$ and n_1=115 and Bhakkar $s_2^2 = 81$ and n_2=95. A two-sample t-test without assuming the equality of variances was used. To calculate the degrees of freedom (d.f.) the formula is as follows, which gave df=181:

$$df = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}{\frac{1}{n_1-1}\left(\frac{s_1^2}{n_1}\right)^2 + \frac{1}{n_2-1}\left(\frac{s_2^2}{n_2}\right)^2}$$

GenSTAT statistical software was used to carry out the statistical tests. The software estimated degrees of freedom (df) for total land, for example, to be 181. While performing the two-sample t-test, the option of automatic was used to the estimate of variance and degrees of freedom for three land and three livestock variables and hence the result provided in the table. Imposing equal variance in the t-test would have given 210 degrees of freedom for the total land variable.

Figure 2. Linear regressions for (a) total milk production per farm and land allocation for green fodders, and (b) average milk production per milking animal per farm for the concentrates fed in irrigated Okara and arid Bhakkar districts of Punjab
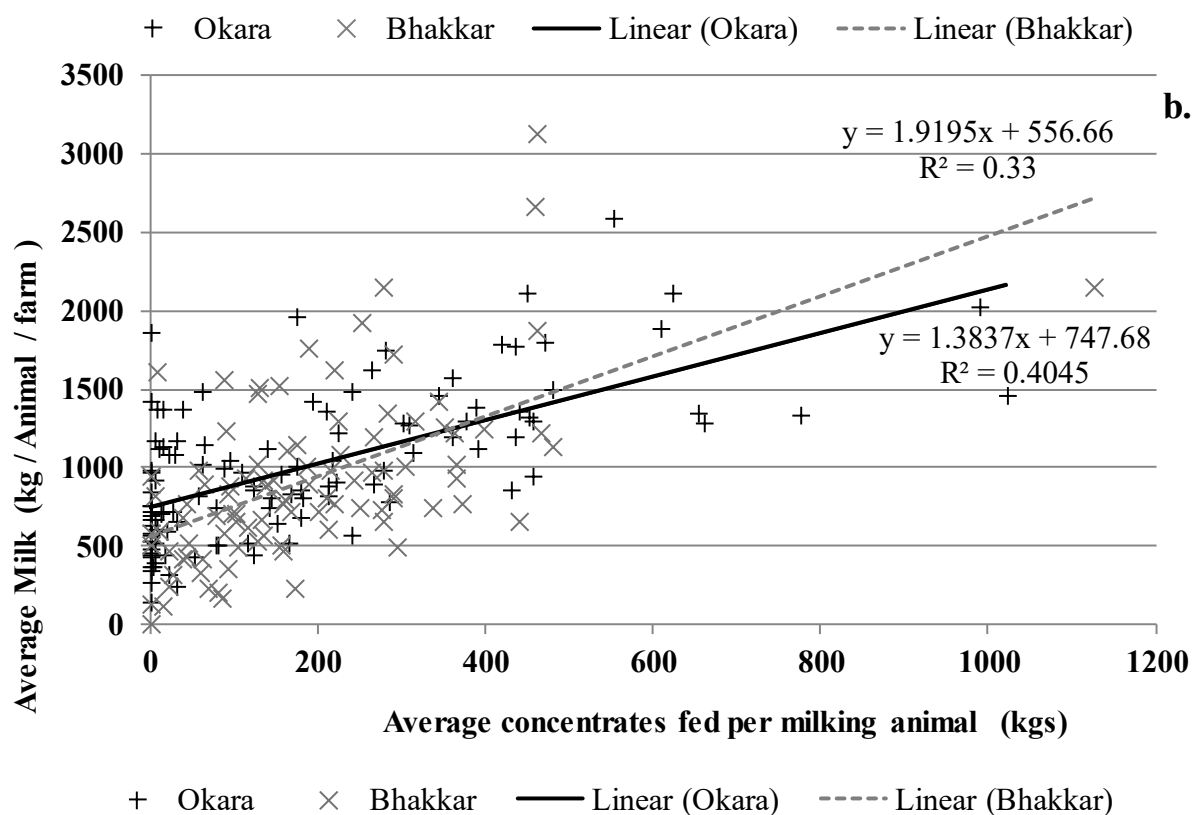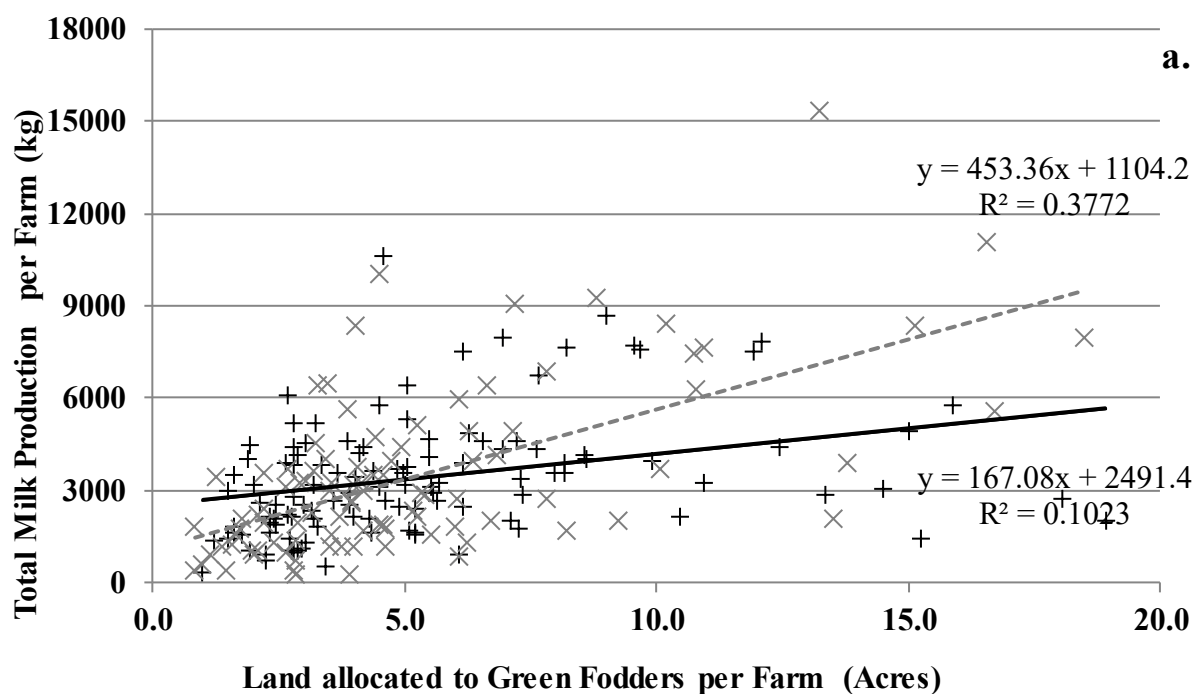
Source: 2008-2009 ACIAR farm survey data from Wynn (Unpublished)

Milk enterprise analysis and comparison for the two regions[3]

The average milk enterprise gross margin (GM) was positive in both the districts though Bhakkar showed better results (Table 4). A cumulative relative frequency distribution (CRFD), however, revealed that 30 percent and 20 percent of farms in Okara and Bhakkar respectively, were making losses and that these farms had average variable costs (Rs/kg) higher than farm gate milk prices (Table 4 and Figure 3).

The total cost of milk production, after taking labour costs[4] into account, was almost double the price of milk in both districts and made the milk enterprise (economic) loss bearing for 70 percent and 60 percent of the farmers in Okara and Bhakkar districts (Table 4 and Figure). A marginal cost analysis, assuming a hypothetical scenario of 50 percent increase in milk production with an associated 30 percent increase in total variable costs, relating to overall better animal husbandry practices (Burki, Khan, & Bari, 2004; Teufel, 2007), revealed a reduction in economic losses, but not to the point where milk production became profitable. Even with such improvement, milk enterprises remained unprofitable for 50 percent and 40 percent of the farms in the Okara and Bhakkar respectively (Table 4 and Figure).

Table 4. Mean production and economics of milk enterprise. Mean with Standard error of means (SE) indicated in parentheses. Results of t-tests comparing means

| Measure	Okara	Bhakkar	t	df	P
Total sample size (n)	115	97			
Milk economics					
Milk prices (Rs/kg)	22.99 (0.24)	21.14 (0.31)	4.81	210	<0.001
Milk GM (Rs from milk enterprise)	25,797 (3,734)	37,416 (4,691)	-1.96	210	0.051
Milk production profit (Rs from milk enterprise)	-25,427 (3,776)	-9,598 (3,947)	-2.89	210	0.004

Source: 2008-2009 ACIAR farm survey data from Wynn (Unpublished) and a range of secondary sources
Note: 1USD = 70.1 PKR, Official exchange rate from State Bank of Pakistan as an average of the fiscal year 2007-08 and 2008-09 (State Bank of Pakistan, 2013)

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[3] The analysis was performed to estimate economic and not accounting profits. The variable costs for crops and livestock, whole farm labour costs and the opportunity costs of capital to estimate net farm profits are treated as follows:
1. Variable costs (explicit or out of pocket costs such as purchase of fertilizer) for estimating gross margins for milk, meat, livestock and crop enterprise.
2. Labour costs have been used to estimate operating profits. These costs have been treated as fixed costs on actual basis assuming that the farmer and/or his household is providing all the labour and no contractual labour is hired. These cost are therefore explicit and not implicit as in accounting.
3. Implicit costs have only been used to estimate net farm profits. It has been assumed that farmer could have earned 9% interest on land and livestock assumed to be the only assets held.

[4] All the manual labour was taken as fixed cost for all the farm enterprises. Crop and fodder manual labour estimates were excluded from gross margin estimates and brought in later as fixed costs.

Figure 3. Milk gross margin comparison between irrigated Okara and arid Bhakkar districts of Punjab
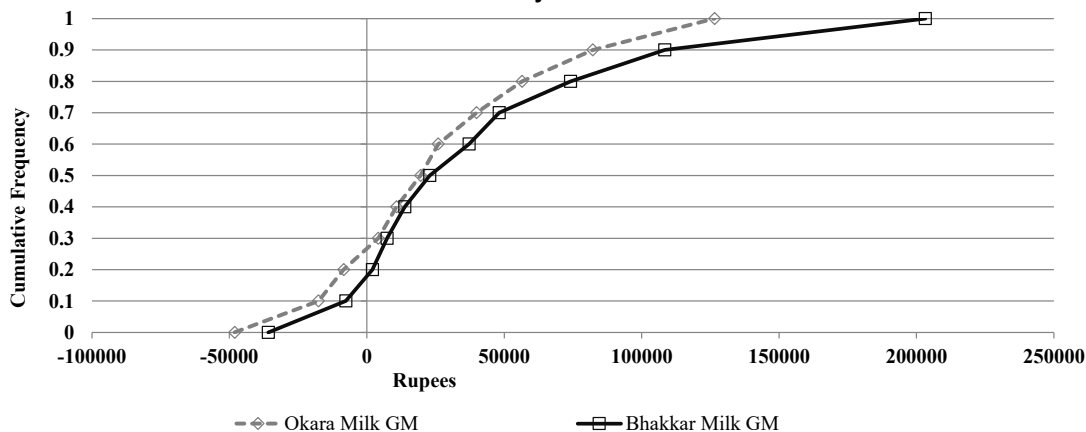
Source: 2008-2009 ACIAR farm survey data from Wynn (Unpublished)

Figure 4. Milk profit and new milk profit comparisons between irrigated Okara and arid Bhakkar districts of Punjab
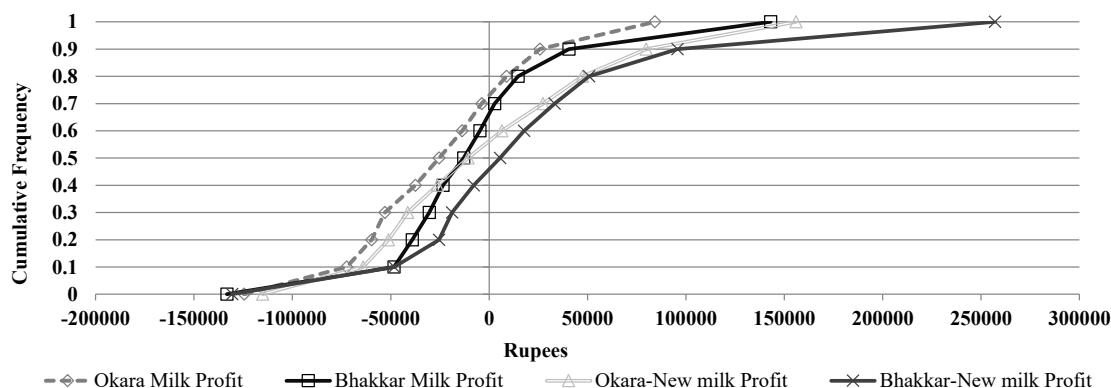
Source: 2008-2009 ACIAR farm survey data from Wynn (Unpublished)

Livestock enterprise and whole farm economic analysis

In all surveyed farms, livestock trading income was a loss. In addition, whole livestock activity GMs that included both milk and meat enterprises, were negative on average for both districts and cumulative relative frequency distribution indicate that 40 percent and 50 percent of the farmers in Okara and Bhakkar were making losses (Table 5 and Figure 5). Gross margin per Rupee invested in livestock activity showed negative returns on investment in livestock for both districts (Table 5).

Whole farm GM, which included cropping, was 90 percent and 80 percent positive for farms in Okara and Bhakkar and mitigated the negative effects of livestock activity losses (Table 5 and Figure). Overall, Okara district farms performed better than Bhakkar due to the higher productivity of the irrigated district. Operating profits after accounting for labour costs showed 30 percent of farms in Okara and 40 percent in Bhakkar were bearing losses. After the deduction of opportunity costs[5],

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[5] which relates to the opportunity cost of capital invested in the farms

however, whole farm net profits were negative for 90 percent of the farms in both districts (Table 5 and Figure) at the net profit level. The return on assets (RoA) was higher for Okara than Bhakkar.

Table 5. Mean economic attributes for livestock and whole livestock activity. Mean with Standard error of means (SE) indicated in parentheses. Results of t-tests comparing means

Measure	Okara	Bhakkar	t	df	p
Total sample size (n)	115	97			
Livestock trading income (Rs)	-9,687 (20,311)	-16,057 (15,124)	0.25	202	0.802
Meat GM (Rs)	-51,369 (20,449)	-45,567 (14,885)	-0.23	200	0.819
Milk GM (Rs)	25,797 (3,734)	37,416 (4,691)	-1.96	210	0.051
Livestock activity GM (Rs)	-25,572 (20,549)	-8,151 (15,495)	-0.68	203	0.499
GM return per Rs invested in livestock activity	-0.015 (0.01)	-0.028 (0.01)	0.79	183	0.428
Crop GM (Rs)	355,164 (28,462)	231,545 (20,067)	3.55	198	<0.001
Whole farm GM (Rs)	329,593 (36,416)	223,394 (27,849)	2.32	204	0.022
Operating profit (Rs)	202,062 (32,548)	84,625 (21,901)	2.99	194	0.003
Net profit (Rs)	-294,271 (28,313)	-324,547 (29,568)	0.74	210	0.462
Return on assets (%age)	2.78 (0.708)	0.53 (0.704)	2.24	210	0.026

Source(s): ACIAR farm survey data from Wynn (Unpublished) and a range of secondary sources
Note: 1USD = 70.1 PKR, Official exchange rate from State Bank of Pakistan as an average of the fiscal year 2007-08 and 2008-09 (State Bank of Pakistan, 2013)

Figure 5. Livestock and whole farm gross margin comparison between irrigated Okara and arid Bhakkar districts of Punjab
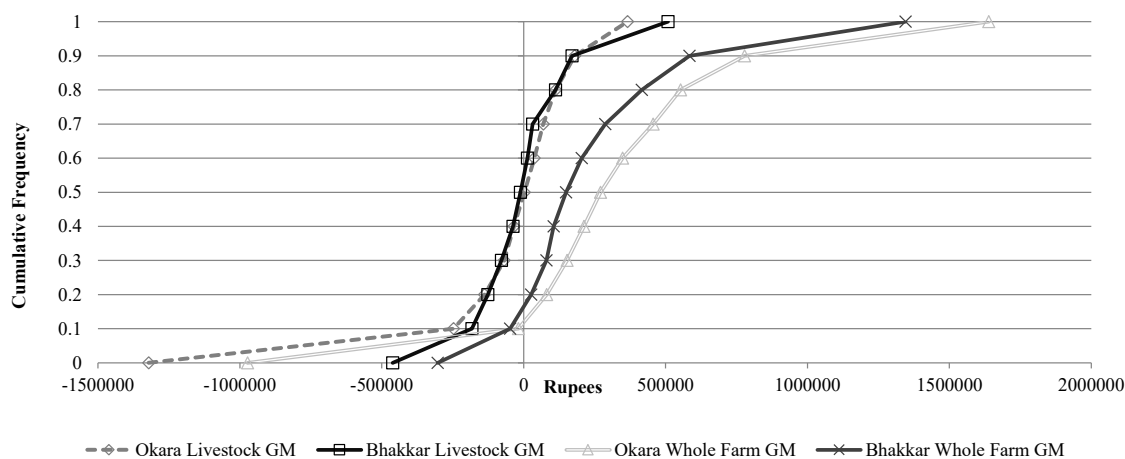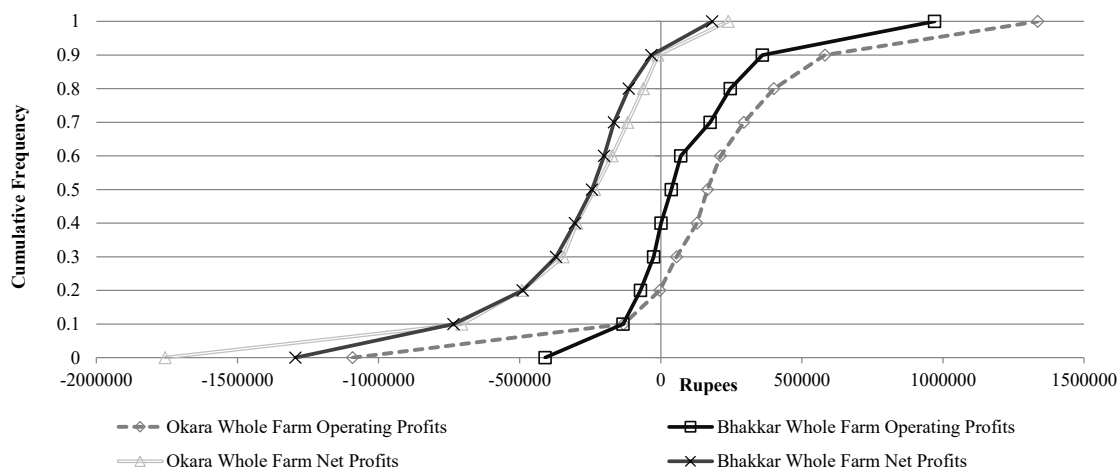

Source: 2008-2009 ACIAR farm survey data from Wynn (Unpublished)

Conclusions

Whole farm profitability is negative in net terms when accounting for farm households' labour and capital costs, which indicates that the factors of production, particularly labour and capital are not getting appropriate returns. The return on farm assets (Table 5) is lower than the interest rate on national savings (9 percent) (National Savings Organization, 2000). Gross margins are positive for both

milk and farm enterprise as a whole though meat is a loss-bearing enterprise and made the livestock *(milk and meat)* rearing unprofitable even in the short-run (Table 4 and Table 5).

Figure 6. Whole farm operating and net profit comparison between irrigated Okara and arid Bhakkar districts of Punjab

Source: 2008-2009 ACIAR farm survey data from Wynn (Unpublished)

Milk enterprise total costs, taking assumed labour costs into account, are almost double the price of milk. Milk production is not profitable, even with a production increase of 50 percent per farm (Table 4). This raises the specific question as to which producers are making profits from milk production. What should be the milk farm gate price and how is it fixed? How much would final consumers be paying if dairying were viable for the producers? This also relates to the question of margins along the milk value chains and farmers share of consumers' rupee spent on milk. These questions suggest the need for a study of milk markets and value chains to inform pro-poor policy development.

Significant losses from livestock enterprises, both as a whole and from livestock trading incomes, are suspected to be linked to low reproductive rates and high mortality rates (Table 4) (Teufel, 2007; Teufel & Gall, 1999; Wynn et al., 2006). These losses, in turn, are possibly linked to widely acknowledged, constrained nutrition of the herd and green fodder shortages, particularly during peak summer and winter (Raja, 2001a; Teufel, 2007; Wynn et al., 2006). Our hypothetical improved practices (Table 4) scenario though did not make all the farms profitable.

Livestock and crops compete for limited land, initially complementing each other but then become extremely competitive for limited land and labour, adversely affecting profitability and causing inefficiencies. As a limited resource, over-allocation of labour to livestock also adversely affects the farm productivity, livestock rearing being highly labour intensive must be considered in the trade-off for crops grown (Erenstein et al., 2007). In addition, the interactions between herd nutrition and land allocation to forage production, and its interaction with supplementary feeding policies adopted by these small holder farmers, need further consideration. The logical explanation for keeping livestock in these mixed farming systems includes the other tangible and intangible benefits not explored here in detail. These benefits include regular cash flows (very important when the cost of capital is so high and the consequence of debt so devastating) and milk for household consumption, manure as fertilizer and fuel, and livestock as a liquid asset for quick disposal (Kurosaki, 1995; Otte et al., 2012; Staal et al., 2008; Upton, 2004). Estimation of these benefits would be a useful further analysis, including work into system optimisation for improved household and economic benefits.

The structure of Pakistan's dairy industry at the level of farmer producers and the challenges they face are those identified by Bain (1968); excessive competition within a concentrated industry (8.8 million small household farmers and a comparatively small number of processors) that is economically inefficient. Furthermore, milk production is continuous and highly perishable implying considerable market power by purchasers' (Plunkett, 2002). A typical policy response in many countries to correct for low terms of trade as a result of market power has been to encourage the formation of dairy co-operatives. Terms of trade and total factor productivity are combined to measure profitability (O'Donnell, 2010). Total factor productivity could be improved by relocating resources to more efficient economic sectors. Bain (1968) suggested government intervention to move redundant resources from distressed industries to other occupations and to ensure optimal resource allocation and equity in income distribution.

However, in Pakistan's current situation, it is not a practical proposition, given that 42 percent of the country's labour force and 51 percent of it's households are associated with agriculture and livestock, with a low skill base. The official unemployment rate is 6.2 percent. Though lower than perceived, the official explanation is that the scarce public social safety nets mean people are obliged to engage in any sort of economic activity, irrespective of reward considerations, to make ends meet (Government of Pakistan, 2013, p. 31; 2017). As for low return on capital (Table 5), given a high double digit inflation averaging 11.8 percent for the last five years (Khan, 2012, 2013), it seems sensible to hold on to assets such as land and livestock whose value does not depreciate over time.

A fundamental need for Pakistan's dairy industry is to raise its productivity given that 8.8 million households (37 percent of total households) depend on it for some of their livelihoods, with 89 percent land and 91 percent livestock owner households falling into the analysed sample (Government of Pakistan, 2010). Their prosperity depends on the industry's long-term productivity; that is, efficient use of the local factors of production, linked to their microeconomic competitiveness (Porter, 1998, n.d.). Porter (1980) suggests that the benchmark for profitability is long-term government securities. Therefore, the farms earning lower returns will eventually have to go out of business. This implies that an appropriate goal of government development policies should be to lift long term total factor productivity in the country's agricultural industries, particularly if labour resources have no higher returning alternative.

This study established descriptive economic estimates of milk, meat, and whole farm as part of an integrated mixed farming system, based on the data available. Given the importance of the dairy industry and agriculture sector, there is a need however to benchmark costs, yields and prices to estimate farm profitability for various districts in the country on a regular basis. Understanding the economics of this complex integrated system in detail may lead to specialised crop, fodder, meat or milk producers having a comparative advantage in production or more productive integrated production systems, thus increasing the industry's overall efficiency.

Dairy enterprises turned out to be unprofitable for 50 percent and 40 percent, and whole farm enterprises unprofitable for 80 percent and 90 percent of the farms in Okara and Bhakkar respectively. Poor nutritional intake, was an important issue and prevalent in both districts, which is a major factor contributing to the existing low base of milk production in the country. This leads to the important question of what land and livestock combination is profitable and commercially viable for both districts? This question requires further breakdown and analysis of these farms to find the optimal land and livestock combination. Those that are inefficient will ultimately have to exit the industry but this also remains a social and policy challenge given limited off-farm work opportunities.

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