THE BENEFITS OF CATTLE IN MIXED FARM SYSTEMS IN PABNA, BANGLADESH

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Summary

The internal and external outputs of the agricultural sub-systems of mixed livestock-crop farms in Pabna Bangladesh were analysed, to clarify the multiple functions of cattle in farm systems. Production systems with grazing areas were relatively more productive than those with no grazing. There was a tremendous variation in farm income, largely because of land area. An increase of one ha in land area was estimated to boost farm income by about 50%. Number of cattle, cattle off-take percentage and milk off-take per average cow related positively to farm income. As land area decreased the relative importance of cattle production increased. Crops were dominant in producing food for home consumption. Cattle contributed only 5-6 per cent to home consumption. Cattle supplied a significant cash income: 45 per cent in the villages with grazing areas and 57 per cent in the other villages. In future, the cash output from cattle will decline and emphasis will shift to the role of cattle in supporting crop production. Any research or development strategy for livestock needs to focus first on the importance of the complex relation between livestock and crops.

(**Key Words**: Cattle, Conceptual Model, Mixed Farm Systems, Bangladesh)

Introduction

The prospects for livestock production in Bangladesh are rather disturbing and uncertain (De Lasson, 1981; Shahjahan, 1983). Animals are performing poorly and the country is faced with shortages of all kinds of livestock products. At macro-economic level livestock contributes only about 13% to the agricultural Gross Domestic Product. At farm level, however, livestock will have more impact because intermediate products, such as manure and draught power, are considered to be important benefits (Dolberg, 1981; Jackson, 1982).

Cattle are by far the most important livestock in Bangladesh. When cattle performance was monitored in Pabna district, the traditional "milkshed" area in Bangladesh (Hermans et al., 1989; Udo et al., 1990) two cattle production systems were found: a draught-oriented system with local Deshi cattle, and more milk-oriented production with Pabna Milking Cow (PMC originating from crossing Deshi cattle with Sahiwal, Haryana and Red Sindhi bulls) stock. One of the major differences between the two production systems is that PMC stock has access to grazing lands along the rivers. Farm systems are not static. In Pabna, the grazing areas are now being used for cropping and the traditional milk production farm system is gradually disappearing.

To understand the prospects for cattle in Pabna their role in the farm system must be known. Analyses of this role are largely qualitative because of the general complexity of farm systems. Our study aimed to quantify some of the major components in livestock-crop farm systems in economic terms.

Materials and Methods

Pabna district straddles the confluence of the Brahmaputra and Ganges. Grazing land (bathan) is located next to the rivers. The bathan is flooded during the monsoon (June to October). In winter

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(November to February) the climate is relatively cool and dry. Summer (hot and some rain) is from March to the beginning of June. In winter and summer bathan lands are grazed.

Throughout 1982 the Bangladesh Cattle Development project at Baghabarighat in Pabna district monitored agricultural activities and off-farm activities in six villages: Fenchuan, Purandar Pur and Porjona (with PMC cattle and grazing areas), and Boromonohara, Ruppur and Samasnari (with Deshi cattle). For ease of presentation the first three villages will be described as PMC villages and the latter three as Deshi villages. At the time of the survey there were 794 households in all six villages in total. The survey covered 241 households. These households could be stratified into:

1. mixed farm households PMC villages, n = 41; households headed by farmers engaged in both livestock and crop production
2. mixed farm households Deshi villages, n = 70; households headed by farmers engaged in both livestock and crop production
3. labourer households, n = 49; households headed by labourers
4. business households, n = 66; households headed by businessmen
5. fishing households, n = 15; households in Purandar Pur that relied almost exclusively on fishing as a source of income.

Data were collected on the family background, the land use, sources of family income and expenditure. The main aim was to quantify the internal and external inputs and outputs of the different agricultural sub-systems of the farm systems. The analysis focused on the cattle sub-sector.

Procedures and assumptions in the economic evaluations:

– inputs to the livestock sub-systems were straw, weeds, leaves, brans, grazing, concentrates, animal treatments, and stock purchases

– opportunity costs for livestock feeds were based on Helmrich (1983)

– outputs from the livestock sub-systems were milk, sale of animals, beef, draught power for own farm and other farms, manure, fuel, meat (sheep, goats, poultry), and eggs

– inputs for the crop sub-system were agricultural expenditure (fertilizers, seeds, insecticides), draught, and manure

– draught opportunity costs were based on the hiring rates of draught cattle

– opportunity costs of manure were calculated in nitrogen equivalents (urea market price 4 taka per kg, 0.46% N), calculations of N-output per animal were based on N-intake, N-losses in animal products, collection and storage losses and N-activity coefficient (a measure of the side-effects of the manure by comparison with fertilizer, in paddy fields this coefficient is usually taken as 0.5)

– outputs from the crop sub-system were food crops (paddy, other grains, oilseeds, pulses, vegetables), other cash crops (jute, sugar cane), straw, weeds, leaves, brans, trees and bamboo

– it is estimated that 75% of the total straw production was used as feed for cattle and small livestock; the other 25% cannot be used because it is lost by being inundated

– average farm gate prices were used, irrespective of the season of cropping

– household consumption was expressed in farm gate prices

– gross margins of the different sub-systems were calculated as outputs minus inputs

– fixed costs were buildings, equipment, loans, land leased in and out, also maintenance and depreciation of cow sheds, nets and boats

– farm income was calculated as the gross margins minus the fixed costs and the paid interest

– total household income is farm income plus off-farm income

– family expenditure comprised school fees, social and religious expenses, and building costs.

For detailed information on the methods of calculation, see Meijer (1988).

Farm income combines two main functions of agricultural activities: supplying food for home consumption and generating a cash income. We used least-squares methods to explain variations in farm income in terms of differences in farm resources. The analytical model for farm income included the effect of the cattle-keeping system and the covariables labour force, land area, cropping intensity, number of cattle, milk off-take for the average cow, bullock percentage, calf percentage, and cattle off-take percentage. Variation in cropping intensity was explained in terms of differences in cattle-keeping system, land area, cattle density, cash inputs per ha and labour employed in crop production. Variation in milk off-take per cow was analysed by a model that considered cattle-keeping system, land area, labour employed in livestock production, and cash inputs per animal.

The above-mentioned variables were calculated as follows:

– labour force; the number of household members involved in agricultural work, in full-time equivalents

– land area; the agricultural area per farm, in ha

– cropping intensity; average percentage cropped of the agricultural area

– number of cattle; the average number of bullocks, bulls, dry cows, lactating cows and heifers, per farm

– milk off-take for the average cow; average milk off-take per year for the average cow (calculated from dry plus lactating cows)

– bullock percentage; percentage of bullocks in the herd

– calf percentage; calves as a percentage of the number of cows (dry plus lactating)

– cattle off-take percentage; number of cattle sold annually as a percentage of the average number of animals kept

– cattle density; the average number of animals per farm per ha

– cash inputs per ha; the amount spent annually on seeds, fertilizers and insecticides per ha

– labour employed in crop production; number of household members employed in crop production in full-time equivalents

– labour employed in livestock production; number of household members employed in livestock activities in full-time equivalents

– cash inputs per animal; the amount spent annually on concentrates and treatments per animal.

Results

Table 1 gives means and coefficients of variation for family size, family labour, land area, number of animals, gross margins, farm and off-farm income for the different household systems. Average family size varied from 4.9 in labourer households to 8.5 in the mixed farms in the PMC villages. Even though the labourer and business households did depend primarily on off-farm income they nevertheless did engage in some crop and livestock production (farm income contributed 9% and 14% to the household income in the labourer and business households respectively). In the fishing households crop and livestock contributed 9% to the agricultural gross margins. The mixed farms had a considerable off-farm income: 27% of the household income in the PMC villages and 29% of the household income in the Deshi villages. On average, the mixed farming households had a higher household income than the households in the other three strata. However, the coefficients of variation were extremely large. Average size of mixed farms was 1.4 ha in the PMC villages and 1.1 ha in the Deshi villages. The average labour force in full-time equivalents for agricultural activities in the mixed farming households was 4.9 in the PMC villages and 3.2 in the Deshi villages. In both mixed farm systems, women accounted for about 30% of the labour force. In the PMC mixed farms 45% of the available household labour was used for livestock-related work, in the Deshi villages this figure was 38%. Yet, livestock only added 16% (PMC villages) and 27% (Deshi villages) to the agricultural gross margins.

Figure 1 shows a conceptual model of the internal flows and external cash flows of the cattle, small livestock and crop sub-systems for the PMC and Deshi mixed farms. All flows are expressed in taka per year. Magnitude rather than absolute size of results is important. Note the following trends:

– In the PMC villages the cash sales and home consumption flows for both the cattle and crop production are wider than in the Deshi villages.

– Cattle contribute only slightly to home consumption: 6% in the PMC villages and 5% in the Deshi villages.

– Cattle supply a significant part of the cash income from farm activities: 45% in the PMC villages and 57% in the Deshi villages.

– The grazing system with PMC cattle is more productive in terms of milk production and cattle sales.

– The support of cattle for crop production (mainly draught power) is, on average, more or less the same in both production systems.

TABLE 1. SELECTED VARIABLES, GROSS MARGINS, FARM AND OFF-FARM INCOME FOR HOUSEHOLDS HEADED BY FARMERS, LABOURERS, BUSINESSMEN AND FISHERMEN IN PMC AND DESHI VILLAGES IN PABNA DISTRICT

	Mixed Farms				Labourers		Businessmen		Fishermen	
	PMC		Deshi							
	$\bar{x}$	c.v.[1]	$\bar{x}$	c.v.	$\bar{x}$	c.v.	$\bar{x}$	c.v.	$\bar{x}$	c.v.
Number of households	41		70		49		66		15	
Number of household members	8.5	44	7.0	47	4.9	49	6.5	46	6.3	41
Number of household members employed in agric. (fte[2])	4.9	43	3.2	50	0.3	200	0.7	157	2.5	52
crops (%)	55		62							
livestock (%)	45		38							
Area cultivated (ha)	1.44	76	1.13	105	0.03	300	0.20	210	0.02	250
Number of cattle	5.7	89	3.5	66	0.2	300	0.4	400	0.5	280
Number of small ruminants	1.0	90	0.9	155	0.5	310	0.5	350	0.2	380
Number of poultry	8.0	94	6.3	111	1.6	194	2.7	255	1.8	310
Gross margins agriculture (tk[3])	16859	105	10400	85	456	165	1685	238	10423	41
crops (%)	83		72		56		78		2	
cattle (%)	16		27		27		22		7	
small stock (%)	1		1		17		5		0	
fish (%)	0		0		0		−5		91	
Farm income (tk)	16893	104	10097	88	466	161	1672	240	10421	41
Off-farm income (tk)	6418	193	4188	135	4644	55	10635	110	0	0
Household income (tk)	23311	103	14285	68	5110	59	12307	93	10421	41

[1] c.v.: coefficient of variation.
[2] fte: full-time equivalent.
[3] tk: taka.

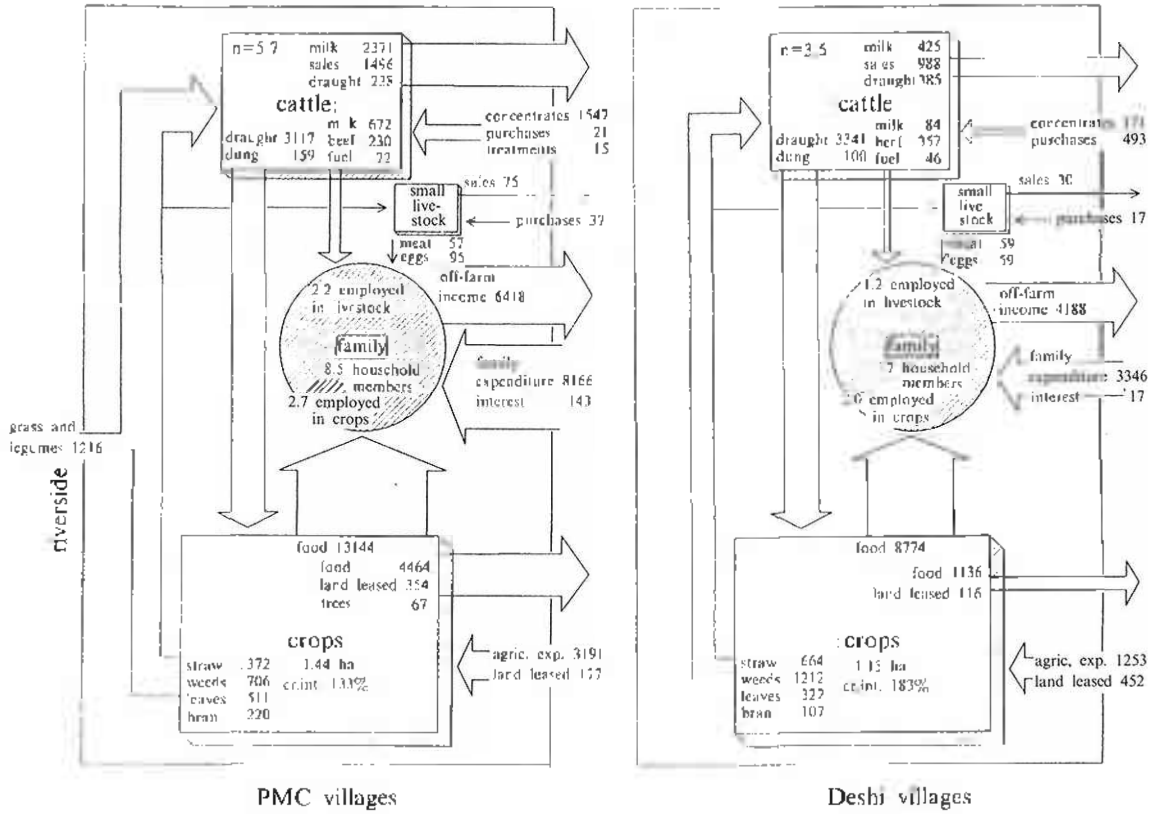

Figure 1. Internal flows and external cash flows of the cattle, small livestock and crop sub-systems, expressed in taka per year, for an average PMC and an average Deshi mixed farm.

– In the PMC villages the functions of cattle, support for crops, cash income and home consumption related to each other as 1:1.3:0.3; in the Deshi farms this ratio was 1:0.5:0.1.

– The use of external inputs is low, particularly in the Deshi villages.

– The contribution of small livestock to home consumption and cash income is only marginal.

The very large coefficients of variation in the variables presented in table 1 indicate that the different strata are not very homogenous for the variables selected. In table 2 the variation in farm income for the mixed farms is analysed by least squares methods. Note that each component of the analystical model is adjusted for any other component of the model. There was a significant difference ($p < 0.05$) in farm income between the two cattle-keeping systems. The magnitude of the regression coefficients indicates the extent to which specific farm resources increase or decrease farm income. The greatest source of variation in farm income was land area ($p < 0.001$). The corrected mean for annual farm income was 13 292 taka. An increase in farm size of one ha was estimated to boost annual farm income by 6847 taka. Cropping intensity had a very significant ($p < 0.01$) positive effect on farm income. Cattle keeping also related positively to farm income. Cattle off-take percentage had a very significant ($p < 0.01$) positive impact. The number of cattle and the milk off-take per average cow had a significant ($p < 0.05$) positive effect. Calf percentage (indicating present fertility level of the herd) and bullock percentage (indicating the percentage of animals kept solely for draught) did not significantly affect farm income. The coefficient of determination for the model used was 71%.

Cropping intensity (table 3) was very significantly ($p < 0.001$) higher in the Deshi villages than in the PMC villages. Cash inputs per ha had a very significant ($p < 0.001$) positive effect on cropping intensity. Both labour employed in crop activities and cattle density had a significant ($p < 0.05$) positive effect on cropping intensity.

TABLE 2. LEAST SQUARES MEANS AND REGRESSION COEFFICIENTS FOR VARIOUS FARM RESOURCES WITH ANNUAL FARM INCOME (IN TAKA) AS DEPENDENT VARIABLE FOR THE 41 PMC AND 70 DESHI MIXED FARMS

	l.s. mean	s.e.[1]	regression	s.e.
Overall average	13,292	776		
Villages				
– PMC	15,512[a]	1,004		
– Deshi	11,073[b]	1,378		
Land area (ha)			6,847***	881
Cropping intensity (%)			25**	8
Labour force (fte)			311	446
Number of cattle			689*	296
Milk off-take per cow (kg)			7*	3
Bullock percentage			41	35
Calf percentage			−29	17
Cattle off-take (%)			50**	16
R^2 full model[2]: 71%				

[1] Standard error.
[2] Coefficient of determination.
l.s. means with different subscripts are significantly different ($p < 0.05$).
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TABLE 3. LEAST SQUARES MEANS AND REGRESSION COEFFICIENTS FOR VARIOUS FARM RESOURCES WITH CROPPING INTENSITY AS THE DEPENDENT VARIABLE FOR THE 41 PMC AND 70 DESHI MIXED FARMS

	l.s. mean	s.e.[1]	regression	s.e.
Overall average	153	9		
Villages				
– PMC	111[a]	15		
– Deshi	196[b]	11		
Land area (ha)			−6	8
Labour force in crops (fte)			15*	7
Cattle density (n ha^{-1})			5*	2
Cash inputs (taka ha^{-1})			0.03***	0.006
R^2 full model[2]: 25%				

[1] Standard error.
[2] Coefficient of determination.
l.s. means with different subscripts are significantly different ($p < 0.001$).
* $p < 0.05$, *** $p < 0.001$.

Still, an increase of one animal per ha was estimated to increase cropping intensity by only five percentage points.

The least squares analysis for average milk off-take (table 4) indicates that land area did not contribute significantly to average milk off-take. Labour employed in livestock production and the cash inputs per animal had very significant ($p < 0.01$ and $p < 0.001$, respectively) positive effects on average milk off-take.

Figure 2 shows the variation in cattle density in relation to land area. In both production systems the cattle density increased with decreasing farm sizes.

TABLE 4. LEAST SQUARES MEANS AND REGRESSION COEFFICIENTS FOR VARIOUS FARM RESOURCES WITH MILK OFF-TAKE PER AVERAGE COW (kg) AS THE DEPENDENT VARIABLE FOR THE 41 PMC AND 70 DESHI MIXED FARMS

	l.s. mean	s.e.[1]	regression	s.e.
Overall average	136	25		
Villages				
– PMC	157	34		
– Deshi	116	48		
Land area (ha)			5	21
Labour force in cattle (fte)			89**	27
Cash inputs per animal			0.3***	0.07
R^2 full model[2]: 28%				

[1] Standard error.
[2] Coefficient of determination.
** $p < 0.01$.
*** $p < 0.001$.

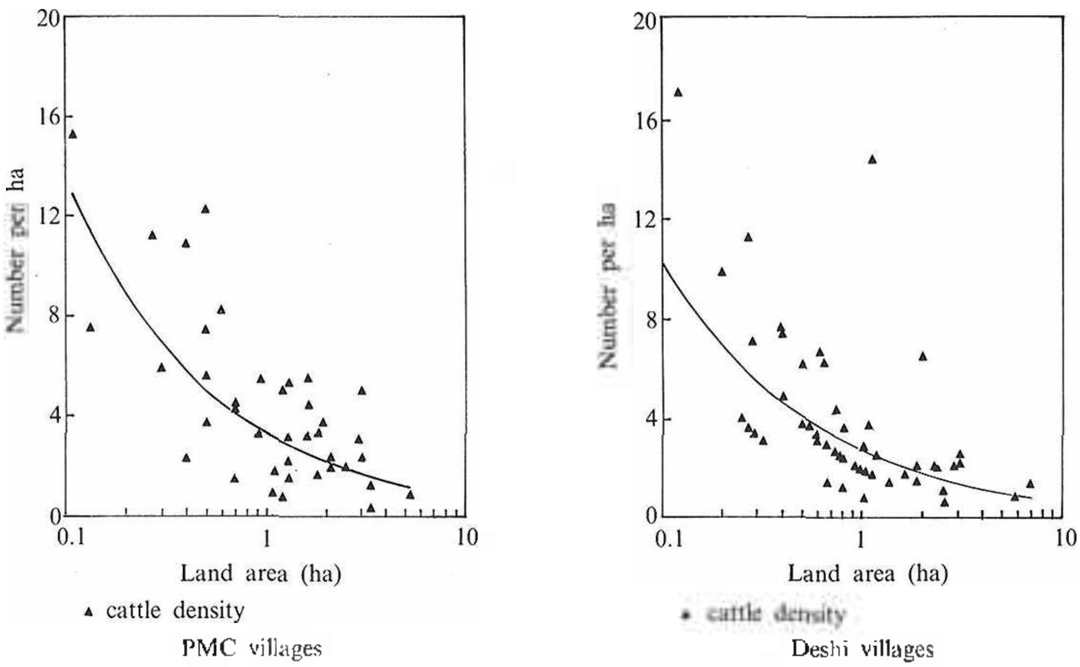

Figure 2. Cattle density in relation to land area (log scale) for the 41 PMC and 70 Deshi mixed farms.

Discussion

Cattle monitoring in Pabna indicated that the traditional milk production system with PMC cattle and based on seasonal grazing is viable and productive for Bangladeshi conditions (Hermans et al., 1989; Udo et al., 1990). Crop production was also more productive in the PMC villages (figure 1). As a result, farm income (home consumption and cash income) was higher in the PMC villages than in the Deshi villages (table 2). There was a tremendous variation in farm income, largely because of land area.

Cropping intensity also influenced farm income.

Increasing cropping intensity, by introducing high-yielding varieties and boosting fertilizer use, is one of the most important strategies the Government of Bangladesh uses to try to raise agricultural production. Table 3 shows that cropping intensity can be increased by increasing both the cash inputs in crops per ha and the labour employed in crop production. In both cattle keeping systems a main function of cattle is to support crop production. Cattle density, an index of the draught power and manure available per ha, also correlated positively with cropping intensity. Draught animals also supply a small cash income; they work on land belonging to households that have too few draught cattle or none.

In mixed farms manure is often considered to be one of the main benefits of cattle. Figure 1 indicates that the role of cattle in providing manure is very small in economic terms. Evaluating manure in terms of N-content will underestimate its role. However, we could not quantify the contribution of cattle in supplying soil organic matter. A small part of the manure is used as fuel. Dolberg (1981) valued the manure from a Bangladeshi cow on the basis of the extra kg of fish that can be produced by applying dung and urine to a fish pond. In his evaluation manure contributed considerably (40%) to the estimated output from one animal. However, it is unrealistic to assume that all the manure will be applied to a fish pond. In Zambia, Baars and de Jong (personal communication) valued manure according to its effect on maize yields. They estimated that in areas where manure was used it contributed only 6% in terms of benefits from cattle. In Zambia, the area which can be manured is limited and the value of crops is low. Newcombe (1989) used fertilizer response curves for cereal crops in Ethiopia to value the nutrient supply of manure. More research is needed to develop a proper methodology for valuing cattle manure for mixed farms.

Milk and cattle sales are important revenues from cattle. Flood prevention measures are allowing land use to change in the PMC villages, resulting in a rapid loss of grazing ground. It is inevitable that the PMC system will increasingly come to resemble the Deshi system and that throughout Pabna cattle production will become farmyard-based. Crop production dominates livestock in terms of contribution to the daily food supply of the family and to agricultural gross margins, and it is less labour intensive (table 1). So, it is not surprising that grazing land is sacrificed for crop production. A major consequence of the trend towards farmyard-based cattle production will be that the role of cattle in supplying a cash income will be considerably reduced. And less milk will become available for the dairy cooperatives in the region. When cattle dynamics were modelled it was found that herd growth was mainly related to the production system; the PMC cattle herds could increase whereas the Deshi herds could not maintain their size in the long run (Hermans et al., 1989). This means that in future there will be no surplus animals available for sale in the Deshi villages. So, here too the cash output from cattle will decline.

Milk off-take for the average cow had a positive effect on farm income. Milk off-take is an indicator of the efficiency of milk production of the herd. It combines the milk off-take from lactating cows with the percentage of cows in milk. Cattle management influences milk off-take. Households who spent more time on livestock had relatively higher average milk off-takes. Average milk off-take also responded significantly to cash inputs per animal. These inputs came almost exclusively from feed supplements. This suggests that farmers who invest more in feed supplements obtain a higher average milk off-take. A nutrition survey in Pabna (Udo et al., 1992) indicated that feed quality is the major constraint to increasing cattle production. It was concluded that there is little room for manoeuvre; the only short-term way to improve the straw-based diets is to feed more supplements rich in crude protein (CP). The very significant positive effect of cash inputs per animal on average milk off-take per animal supports this conclusion. In production systems with no grazing areas, cows are increasingly being used for draught, at the same time the quality of the feed implies that their nutritional requirements cannot be met, hence productivity and reproductive rates suffer, resulting in more dependence on cows for draught work. Feeding more CP-rich supplements might break this vicious circle. However, because of the expected decline in cash outputs from the mixed farms it is questionable whether farmers will be able to invest in good quality feed for their animals. The feasibility of growing legume trees needs to be investigated more thoroughly. This could partly overcome the lack of protein sources.

Land is the major resource of mixed farms. It is expected that the continued population pressure will mean continued decrease in farm sizes. Jackson (1981 and 1983) claims that as farm size decreases cattle density increases, but only up to a certain point, a point after which it declines again because of the reduction in feed sources. We found no evidence for such a "point", their was a marked increase in cattle density as land area of the mixed farms decreased. Jackson (1981 and 1983) also states that there will be a certain point beyond which farmers will keep no livestock at all and resort to hired ploughing or dig their fields by hand. In Pabna, small farms with no cattle invariably belonged to labourer and business households who relied mainly on off-farm income.

In Pabna, in both cattle systems emphasis in the role cattle will shift more and more towards support for crops. Cattle also figure as living "savings" that can be converted into cash when the need arises. This is probably why farmers invest relatively more labour in cattle and why the cattle density increases with decreasing land area (figure 2). Development strategies have to adapt to the importance of cattle on mixed farms that are becoming smaller. So far, research and development have had little impact on the productivity of livestock, largely because they were based on technologies, such as conventional breeding programmes, inappropriate to local conditions (Jackson, 1982; Shahjahan, 1983). Multidisciplinary and participatory approaches to research and development are needed to identify effective interventions for mixed farm systems.

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