AGRICULTURAL EFFICIENCY IN MIXED FARMING HOUSEHOLDS: EMPIRICAL EVIDENCE FROM NEPAL

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Abstract

Mixed farming (crop-livestock system) has been dominant in South Asia for most of its history. With the rise of large-scale commercial farming in developed and a few developing nations, agricultural production has soared, which has challenged the sustainability of modern farming practices. In Nepal, mixed farming practices are still prevalent. Using the data from the Nepal Living Standard Survey 2010-2011, our paper notes that mixed farming practices have a negative effect on agricultural efficiency. In Nepal, it is crucial to consider the popular prevalence of mixed farming when developing policies and governance strategies to enhance the efficiency of these practices. As it helps to recycle resources within the farm and increase biodiversity, thus, promoting sustainability, as suggested by previous research. Its protection and promotion are vital for the conservation of resources and the maintenance of a balance in the ecosystem.

JEL Classification : Q12, Q56
Keywords: Agricultural Efficiency; Biodiversity; Mixed Farming; Nepal; PSM

1. INTRODUCTION

The mixed farming system (crop-livestock system) originated in the Bronze Age and was evolving even in the Late Neolithic Age. During the 18th and 19th centuries, mixed farming meant manure-intensive husbandry, the use of legumes, a reduction of fallows, and more. The integration of livestock into the farm has been strengthening the bond between men and livestock throughout the years. Now, several years later, we can see the word 'mixed farming' revived in the context of agriculture. Although this time with a much greater meaning and in a completely different context. In the 1960s, a great revolution took place in response to increasing food production, alleviating extreme poverty and malnourishment in the face of an impending famine.

The Green Revolution of the mid-1900s started the use of high-yielding varieties (HYVs) of wheat and rice to increase food crop production, especially in India, bringing about one of the most dramatic changes in agricultural practices in human history. It resulted in crop genetic improvements, increased fertilizer and irrigation use, and a tripling of cereal crop production since the 1960s. However, the efficiency of plants to absorb fertilizers rapidly declined during that period. This slowly led to the separation of grain and livestock production, favoring a shift towards industrial-scale farms. The monocultures created by the Revolution resulted in environmental disasters like pest outbreaks and had detrimental effects on soil health, soil biodiversity, and the ecosystem services supplied by soil ecosystems. Due to intensification and specialization, the livestock enterprises also kept on expanding.

A study focusing on the energy analysis of Quebec agroecosystems showed that in the 19th century, Quebec agroecosystems were characterized by a low dependence on external inputs, but a high dependence on biomass reused (livestock feed and crop seeds). After industrialization, the trend was the opposite in the case of external inputs, with a continued steady rise in amounts of biomass reused (due to livestock specialization and the decoupling of domesticated animals from crop farming). Consequently, the energy efficiency of agroecosystems diminished, although final produce and area productivity increased. Thus, it should be noted that agricultural production can be increased

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by using more fertilizers, pesticides, fossil energy, and marginal land, but all at the risk of serious degradation of croplands and urban/natural areas.

Fast forward to now, and the importance of sustainability has been highlighted in the agricultural context, more than ever. When livestock and crops are farmed together, resources are recycled as the fodder/forage is used as animal feed for the animals while the animal manure is used to provide nutrients to the soil as well as the utilization of animal power for tillage, which results in better produce of output in the farm. Due to this, studies are being conducted to discover farming systems that support sustainable development of land use.

Farming systems are considered sustainable if natural resources, essential for agricultural production, are conditioned in such a way that future generations have the same opportunities for production as the present generation has. Sustainability is not something absolute. It has a lot to do with what present generations want to leave for future generations.

Thus, this study revolves around the research question of 'how mixed farming systems affect agricultural efficiency'. Agricultural efficiency is calculated as the benefit-cost ratio in which the benefits from a farm include total crop yield, the value of home-produced livestock products sold, and so on. Whereas, the cost of the farm includes the sum of total agricultural expenditure, the total expense of rearing livestock, and more, which is discussed in detail in the 'data' section of the paper.

The research objective is to identify the gaps in policy actions in Nepal to improve and promote the pre-existing practice of a mixed farming system which will, in addition, contribute to maintaining and conserving biodiversity. The remaining part of the paper is divided into a literature review section that discusses the meaning, and relation of the mixed farming system with biodiversity, the benefits and drawbacks of the system, its status in the world, and the dilemma of choosing between the two systems. This section also delves into the Nepali context of agriculture, the situation of mixed farming in the country, and its trend.

2. LITERATURE REVIEW

2.1. Mixed Farming

A mixed farm is an agricultural operation involving more than one enterprise, usually both crops and livestock. It is a collection of abiotic and biotic components where the by-products must become inputs for other farm processes (including restoration of natural resources) and is linked to form an ecologically cohesive network where self-organisation and self-regulation are essential. There are many types of mixed farming systems; the crop-livestock system is the one focused on in this study. Integrated mixed farming systems help to use resources efficiently and maintain soil fertility by recycling some nutrients through the use of home-grown, energy-rich feedstuffs with a low nitrogen content (like maize silage and fodder beets) and by-products like straw and potato waste, decreasing the risks of soil-borne pests and diseases, as it provides greater resilience against insect herbivores because vegetational diversity introduces heterogeneity into the insect community and stimulates the production and activity of natural enemies. It controls weeds on the land, reduces dependence on external inputs, maintains or improves soil biodiversity, and minimises soil erosion.

Mixed farming helps with nitrogen balance, as the problem of nitrogen surpluses is related to the segregation of animal and crop production (seen in Northwestern Europe as well). Mixed farming helps with nitrogen balance, as the problem of nitrogen surpluses is related to the segregation of animal and crop production (seen in Northwestern Europe as well). It uses animals as a power source, food, and source of animal manure and biogas, where animals are also valuable in converting feed to animal products that include meat, milk, fibre, and power. Approximately 80% of nitrogen (N) inputs to the soil occur through the manure pathway.

In farming, maintaining adequate ground cover is essential to retain soil moisture so Grain & Graze (a research initiative in Australia that delivers insights to increase profitability on mixed enterprises and maintain environmental health at the same time) included incentives that focused on encouraging farmers to establish small lots for confinement feeding of sheep in order to protect ground cover on most of the farm, which proved to be effective at some places as well. Mixed farming also does not involve land when attention is paid to correct planting dates, density, crop species, and varieties. Mixed farming makes a greater biochemical contribution to the diet and spreads the labour input and income risks by providing supplementary income and insurance.

2.2 Mixed Farming and Biodiversity

Biodiversity is defined as 'the variety of life, its composition, structure, and function, at a range of scales'. Despite the habitat losses inherent in agricultural development, mixed farming systems provide significant opportunities to preserve biodiversity on a landscape scale. This is due to their incorporation of diverse land uses and frequent retention of areas with native vegetation.

Mixed farming helps to maintain and, in fact, conserve biodiversity in several ways. The coexistence of both plants and animals together builds nutrients that promote biodiversity. Research has established links between biodiverse pastures and the quality of meat products in Europe and Australia. In Western Australian trials, a strong preference among sheep has been seen for secondary compounds in native saltbush plantings, which tells us that diverse pastures may be more beneficial to stock health than monocultures. The adoption of minimum tillage with livestock has been shown to impact soil micro- and macro-fauna, as this causes less disturbance in the soil. On the other side, an increase in soil microbiological diversity has also been linked to increased crop production in the Mallee region.

Among the several benefits of mixed farming systems, there are a few possible disadvantages of the system, such as the occurrence of soil-borne pests like wireworms, and leatherjackets. The complexities in decision-making are other cons of this system, as many factors must be considered; quantifying uncertain variables like climate and commodity prices, understanding the relationship with other variables, and deciphering the changing variables are all difficult tasks in decision-making in a mixed farming system. In addition, the relative complexity of such systems is increased if they are family - operated (which is mostly the case) as the professional - personal divide isn't perfectly clear. Despite the information on the advantages of mixed farming systems, it is crucial to note that many farmers are moving towards specialised farming. Even though mixed systems have physical and financial stability, specialized crop production provides farmers with favorable prices for crops relative to livestock products. Due to the simplicity of specialization and the expectation of greater financial return, farmers seem prepared to accept the higher risk associated with monoculture. Many livestock farmers and arable farmers, without considering other factors, have solely focused on economic factors to select their animal and crop types. Thus, disregarding the environmental factor, the recycling of waste and by-products is no longer a self-evident activity. Livestock farmers now import highly digestible concentrates to substitute for crop products and residues, and arable farmers manufacture fertilizers instead of using manure. In line with the aforementioned information on the rising shift to specialized farming, this paper moves on to discuss the most important part of the study, which explains whether the farmers would be willing to move to mixed farming or specialized farming. Would a mixed farming system continue because specialized farming is problematic in several ways? Or would people divert to specialized farming instead, disregarding environmental concerns?

This all boils down to the comparison of 'returns' that the individual would receive from both systems. A rational individual would want to continue with the farming system where they have greater returns to continue doing so. As mentioned earlier, the Green Revolution increased the yield and agricultural production substantially with the use of fertilizers but severely damaged the environment. In this case, people have to face the tradeoff between efficiency and sustainability. Whether to gain high efficiency and lose the idea of sustainability or choose sustainability by adjusting with moderate agricultural efficiency. Although this has been stated, a contrasting view in one of the studies states that in both the conventional (specialised) and mixed systems, crop production was approximately equally profitable and it was seen that in an organic system, the yields ranged from the same to only about 10 percent lower than on conventional farms.

2.3 MIXED FARMING IN THE CONTEXT OF NEPAL

2.3.1 Agriculture

Most Nepali people rely on agriculture for their livelihood and income. Approximately 60.4% of the 27.64% is attributed to the national gross domestic product (GDP). Livestock farming holds a significant position within Nepal's agricultural sub-sector, contributing around 11.5% to the GDP and 32% to the agricultural GDP. As seen globally as well, the demand for livestock products has increased, which can be attributed to the growing urbanization. As is the case with other developing countries, this sector is considered important in alleviating poverty and improving the nutritional status of the population of Nepal. However, it also contributes severely to environmental problems (climate change and global warming), as it is stated that livestock in developing nations accounts for 50–65% of the global GHG emissions from this livestock sector. Small ruminants, comprising goats and sheep, are essential components of livestock farming in Nepal, constituting a population of 13.6 million, which accounts for 51.7% of the total ruminant population. Despite this large population, there is a huge trade deficit in meat, milk, wool, and fibre products in the country. The improper farm management has caused the indigenous breed to be impoverished, contributing to low production.

Thus, this highlights the immediate need to shift to a sustainable approach to agriculture and livestock farming in Nepal. The continuous land fragmentation in both the Terai and Mid-Hills of Nepal also adds to the importance of better-integrating crop and livestock subsystems. The role of livestock in providing manure and draft power strengthens the integrated nature of farming systems in the Mid-Hills. Due to the constrained scope of large-scale commercial farming, the rising expenses of external inputs in chemical-intensive farming, and the historical tradition of mixed farming systems, this approach aligns well and is deemed suitable in the agroecological, biophysical, geographic, socioeconomic, and cultural context of Nepal.

2.3.2 Mixed Farming

Nepal's farming system is primarily a mixed one, with the most prevalent being the livestock-crop mixed farming system.

The high-pressure areas in the Himalayan region, particularly the middle hills of Nepal, are characterised by high livestock densities concerning cultivated land, grazing land, and forests. These regions predominantly feature mixed crop-livestock farming systems, with most farmers in the Himalayan subtropical mountains engaging in such integrated agricultural practices. Mostly resource-poor farmers are seen to be involved in this system who still use traditional methods of crop production and animal raising. Their production is mainly targeted for consumption, and only the surplus production is sold in the nearby markets. But that too is possible when they are integrated with the market. Most Nepali farmers are less integrated with the market and have low bargaining power. Additionally, they have poor access to extension services and institutional credit, with poor access to government support and subsidies, resulting in most of the farmers in a state of destitution, misery, and distress. There is an increasing trend of agrobiodiversity loss, and the productivity and profitability of the crop - livestock systems are low in the case of Nepal. Thus, most farmers in Nepal remain in agriculture because of compulsion and not by choice.

2.3.3 Mixed Farming System Trend

One study shows that the mixed farming system is quite dynamic in mountainous areas of Nepal, with varying degrees of commercialization. There is now a strong incentive to keep livestock because of the accessibility to road networks and a market for milk, which helps the farmers generate income through the sale of livestock products and extend their functionality beyond their traditional roles 43. Other research 44 states that the trend of crop-livestock integration is decreasing due to the decreasing trend of maintaining livestock herds. (i.e. there's a decreasing trend of using farmyard manure (except poultry manure) compost and incorporating biomass into the soil, as well as a decreasing trend of using local green fodder crops to feed animals and rising reliance on purchased dry matter and concentrate feedstock). Instead, there's an increasing end of specialised livestock and poultry farm enterprises, despite a limited scale. While the world is returning to its roots by experiencing the hazardous effects of chemicals on soil, it is only now that Nepal is witnessing the increasing trend of using hybridseeds and improved open-pollinated crop varieties, including the increasing trend of dependence on chemical fertilizers. The land abandonment and land fallow trends have been growing, and the trend of vegetables growing in some pockets with market linkage is also increasing. New types of fruits and plantation crops such as tea and large cardamom are seen to be growing increasingly. There is also an increasing trend of agricultural mechanisation for tilling purposes and an increased burden of farming on the shoulders of females in the family with the outmigration of male counterparts. Finally, the practice of labour exchange in farming has been decreasing, and employing wage labourers has been increasing.

3. RESEARCH METHODOLOGY

3.1 Empirical framework

To estimate the causality between a household practicing mixed farming and agricultural efficiency, this paper refers to the empirical method of Propensity Score Matching (PSM). Randomised studies have the advantage of having a balanced distribution of covariates due to the random assignment of subjects. Observational studies, which are more practical and feasible, lack random assignment, leading to potential confounding due to systematic differences between treated and control subjects. Propensity score matching (PSM) is a quasi-experimental tool that reduces confounding effects.

In such experiments, the propensity score, which is of great importance, is the probability of assignment to treatment given a set of observed baseline covariates. Propensity score analysis aims to mimic the advantages of a randomised study by balancing covariates.

PSM is widely used in time series and panel data analysis; however, its effectiveness in isolating the effect of treatment on outcome variables is evident in cross-section analysis as well. Such analysis is helpful in reducing the possible effects of selection bias on estimation by best possible replication of random assignment in observational data.

3.2 Data

This study uses cross-sectional data from the Nepal Living Standards Survey 2010/11 (NLSS-III) (Third Round), a survey conducted by the Central Bureau Statistics (CBS) Nepal. The methodology of the Living Standards Measurement Survey (LSMS), developed and promoted by the World Bank, was followed in all three rounds of the survey. Round 3 enumerated 7,020 households, of which 5,988 households are from the cross-section sample and the remaining 1,032 are from the panel sample. The survey consists of multiple topics related to household welfare. (demography, consumption, income, access to facilities, housing, etc.) and was carried out with assistance from the World Bank.

The sample used in this study consists of self-employed households with subsistence agriculture and fishery as their main occupations. The sample was further reduced to those having at least one type of agricultural land (sharecropped or owned). This ensured that the study focused only on the lands that have been reported, and the effect of mixed farming was also tallied on the same.

A dummy was created to indicate whether the household practices mixed farming or not. Mixed farming households have the following properties:

- Own livestock
- Collect fodder for their livestock from their own land.

The outcome variable of interest is the benefit-cost ratio. Benefits or gains from a farm are the sum of the total crop yield, the value of home-produced livestock products sold, the value of home-produced livestock products consumed, and value of gains from livestock sold over one agricultural year. Cost or expenditure in the farm is the sum of total agricultural expenditure (seed, fertilizer, irrigation charges / maintenance, transportation of crops, storage facility) and total expense of buying livestock over one agricultural year. Thus, the benefit-cost ratio in the context (bc) is the benefits accrued by the farmer upon the total costs. Details on other variables used in the study are listed in Appendix A.

Table 3.1.1: *Probit Model*

mix	Coef.	St.Err.	z	p>|z|	[95% Conf	Interval]	Sig
fem	.092	.072	1.29	.198	-.048	.233	
fert_spend	6.03e-06	8.61e-06	0.70	.483	0	0	
majority	.361	.063	5.75	0	.238	.484	***
rep_income	-6.16e-07	7.21e-07	-0.85	.393	0	0	
capitalvalue	-5.51e-08	5.08e-07	-0.11	.914	0	0	
urbrur	.093	.087	1.07	.284	-.077	.264	
foodinsec	-.517	.126	-4.10	0	-.764	-.27	***
neveratt	-.15	.06	-2.48	.013	-.267	-.032	**
grad	-.273	.373	-0.73	.463	-1.004	.457	
hhsize	-.05	.014	-3.54	0	-.077	-.022	***
avgdist	-.003	.004	-0.77	.443	-.012	.005	
tlabor	.004	.001	4.29	0	.002	.006	***
totland	.45	.072	6.24	0	.308	.591	***
irpr	.079	.082	0.97	.332	-.081	.239	
sharecrop_ratio	-.455	.093	-4.89	0	-.637	-.272	***
cropsland	-.001	.001	-1.97	.049	-.002	0	**
llratio	-.276	.09	-3.07	.002	-.452	-.1	***
Constant	.199	.115	1.73	.084	-.027	.426	*
Mean dependent var	0.574		SD dependent var			0.495	
Pseudo r-squared	0.079		Number of obs			2066	
Chi-square	223.927		Prob > chi2			0.000	

*** $p<.01$, ** $p<.05$, * $p<.1$

Source: Author's calculations.

4. RESULTS

Conditional probabilities for participation in mixed farming are computed by estimating a probit model. The model is statistically significant as measured by the log likelihood. This analysis shows that households of the major ethnic groups are more likely to be mixed farming households. It is also observed that households having more sharecropped land of their total land, are less likely to be in a mixed farming household. There is also significantly less likelihood of households with smaller land area, less labour engagement, and more low land of total land being in the treatment group. (Table 4.1)

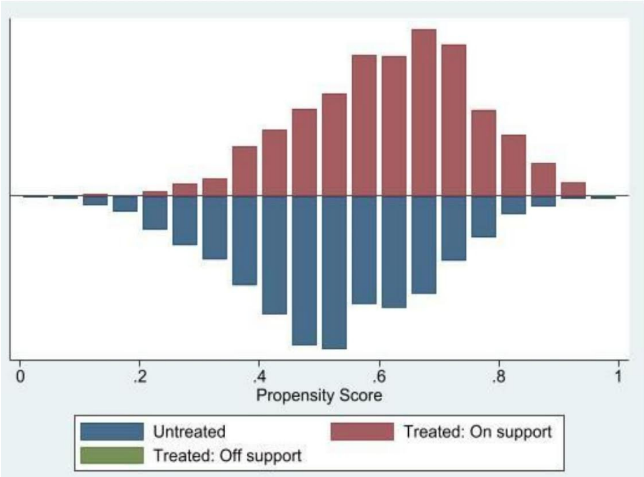
$$\Pr(Y_i = 1 \mid X_i) = \Phi(\beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_k X_{ik}) \quad (1)$$

In Equation (1), $\Pr(Y_i = 1 \mid X_i)$, represents the probability that the *i*-th household participates in mixed farming, where Y_i is the binary outcome variable indicating participation, and X_i is the vector of independent variables associated with the *i*-th household. $\mathbf{\Phi}$ denotes the cumulative distribution function (CDF) of the standard normal distribution, mapping the linear combination of covariates to a probability value.

The β_0 coefficient serves as the intercept, while $\beta_1, \beta_2, \dots, \beta_k$ represent the coefficients corresponding to each independent variable for the i-th $X_{i1}, X_{i2}, \dots, X_{ik}$ Moreover, the propensity scores are calculated using the estimated coefficients Equation (1) from the probit model (Table 4.1). Psmatch' suit in Stata is employed for matching treated and control units based on their propensity scores.

We utilised the 'teffects' to assess treatment effects, and the 'pstest' to conduct balance diagnostics.

Figure 4.1: *Overlapping Propensity Scores for Mixed and Non - Mixed Farming Households*



Source: Author's calculations.

Table 4.1: *Propensity Score Matching Analysis of treatment on outcome: Unmatched and ATT Samples*

Sample	Treated	Controls	Difference	S.E.	T-stat
Unmatched	26.151	31.804	-5.653	3.114	-1.820
ATT	26.199	34.477	-8.279	5.114	-1.620

Source: Author's calculations.

Table 4.2: *Nearest neighborhood matching analysis*

n.treat.	n.contr.	ATT	Std. Err.	t
1186	513	-6.362	.4.953	-1.285

Source: Author's calculations.

Table 4.1 analyses the effects of mixed farming on the main outcome (benefit-cost ratio). The analysis for unmatched and ATT samples. Results show that the benefit-cost ratio is significantly different in the treated sample. The difference in the ratio is -8.279. The "Difference" column indicates the difference between the means of the treated and control groups. In the "Unmatched" sample, the treated group has a benefit-cost ratio that is lower by approximately 5.653 units compared to the control group. In the "ATT" sample, the treated group has a benefit-cost ratio that is lower by approximately 8.279 units compared to the control group. The "S.E." column provides the standard error associated with the difference in means. In the "Unmatched" sample, the standard error is 3.114. In the "ATT" sample, the standard error is 5.114. The "T-stat" column presents the t-statistic, indicating how many standard deviations the observed difference is from the expected difference under the null hypothesis of no effect. In the "Unmatched" sample, the t-statistic is -1.820, suggesting that the observed difference is statistically significant. Similarly, in the "ATT" sample, the t-statistic is -1.620, indicating statistical significance.

In Table 4.2, PSM in nearest neighbour matching is analysed. In nearest neighbour matching, where not all controls are necessarily used in the computation of the ATT. It can be observed that 1186 of the treatment and 513 of the control group were matched and used. The effect is in line with the previous, as the average effect of treatment on the treated is -6.362.

The results of this study suggest that there is a significant difference in the benefit-cost ratio between the mixed and the non-mixed households. This indicates a potential negative impact of mixed farming practices on the scope of agricultural efficiency. Moreover, when return to expenditure is measured, being a mixed household meant that the returns were negatively different from the returns received by the non-mixed households.

However, the conclusion is in consideration with the fact that PSM has its own limitations. Propensity Score Matching (PSM) has been demonstrated to elevate issues related to model "inefficiency, model dependence, and bias"—a characteristic not shared by many other matching methods. PSM is also criticised for its limitations in addressing latent characteristics. PSM solely considers observed (and observable) covariates, neglecting factors that impact both assignment to treatment and the outcome but remain unobservable. This exclusion of unobserved variables from the matching procedure can lead to incomplete control over potential sources of bias.

5. CONCLUSION AND POLICY IMPLICATIONS

The world is in hindsight of the years of specialised farming, while Nepal is just beginning to touch the advances of modern agricultural technology and specialized/intensive farming. While this might portray Nepal as being laid behind by the progress of others, it may be fair to say that this puts the country in an advantageous position. The already popular and years-old system of mixed farming can continue to pave its path towards sustainability while other countries are on their way to restoring their soil quality with means like mixed farming practices. There is a unique opportunity for the country to absorb the innovation that has taken place between these times.

The results of our study concluded that mixed farming households have less efficiency as compared to non-mixed farming households Mixed farming may thus be efficient only on the environmental front, whereas specialised farming may deteriorate the environment but substantially increase the yields and production. A rational farmer would want to tally the returns from both the mixed and specialised systems in this case. The question arises, 'How can policies be developed and actions be taken to fill the gap of efficiency in mixed farming systems so that farmers are encouraged to continue the sustainable method of farming while also making it efficient for them?' If at all they are possible. Since Nepal is just the advent of technologies and beginning to use agriculture machinery, different types of innovations and mechanisms that are developed as a policy result on promoting sustainable farming can change the direction of agriculture in Nepal.

In the 'Nepali Context' part of the literature review section of this paper, it was stated that mostly resource-poor farmers are seen to be involved in this system who still use Traditional methods of crop production and animal raising. This highlights an important opportunity to better the existing farming system with the promotion of agricultural mechanisation. Market integration of the farm is linked with farmer's bargaining power; filling agricultural infrastructure gaps thus seems important.

Mechanisation and capital induction should provide additional effectiveness and lower the burden on labour. The problems of improper farm management that caused the indigenous breed to be impoverished, contributing to low production, could be solved by such technologies as well. The mixed farming that is revived in developed countries as a highlight of sustainability is not different from the mixed farming in Nepal that has been prevalent for decades. While these countries are trying to regain soil fertility, we still have good soil quality, so we can learn from their mistakes and their successes in making this mixed farming system a comprehensive system of agriculture, where this gives birth to a completely new definition of a mixed farming system that is both efficient and sustainable.

Since there is no separate policy focusing on the mixed farming system , a more specific policy could be a way forward to start with. Holistic research on mixed farming systems involving crops and animals is also weak and most past research in Asia has been on cropping systems. More research on the inclusion of animals in mixed farming systems could be very helpful in contributing to this topic. And very little attention is still being paid to issues like forms of manuring, the situation and size of the fields, the cultivation methods employed, etc. which are especially important 'if we wish to make well-founded statements on the meaning of the landscape and man's conscious shaping of his surroundings.' Celtic field system.

In conclusion, the multifaceted benefits of mixed farming extend beyond mere productivity gains to encompass resource recycling and biodiversity conservation. The inherent promotion of diversity within mixed farming systems featuring a blend of crops and diverse livestock creates a harmonious coexistence that enriches the ecosystem. Studies focusing on biodiversity also showed that biodiversity and the quality of meat products were related, underscoring the role of mixed farming in fostering nutritional richness through interconnected plant-animal relationships.

Moreover, mixed farming emerges as a key contributor to habitat conservation, serving as a residence for invertebrate species diversity across varying agricultural land-use types and regions. As native biodiversity faces escalating disturbance levels, mixed farming stands as a sustainable solution that not only enhances productivity but also plays a pivotal role in preserving the delicate balance of ecosystems. Recognising these ecological benefits, it becomes imperative to integrate mixed farming into agricultural policies, acknowledging its potential contribution to resource conservation and the maintenance of biodiversity by improving its efficient landscape.

APPENDIX

Table A1 : *Data Description*

Data code	Var	Description	Unit
totland	Land	Information on the hectares of land and seasons (dry, wet) of agriculture in a year were given for both own and sharecropped land. If the land was used for only one season, then the land was halved.	in ha
irpr	Irrigation	Since some households also have 3/4 lands, for the irrigation information We have calculated irrigated ratio as the area od irrigated land/ area of total land.	ratio
sharecrop_ratio	Sharecropped	In the same way, for the information on sharecropped land, sharecropped ratio has been calculated as the area of sharecropped land/ total land.	ratio
llratio	Lowland	Two types of land: lowland, upland are given. For the information on lowland, lowland ratio has been calculated as the area of lowland/ total land.	ratio
tlabor	Labor	Exchange: Information on the exchanged labor has been given in (days per month). We simply sum the number of days female worker and male worker worked. Permanent workers: We selected the households that hired permanent workers. Number of workers hired were multiplied by 25. Because 25 is the average number of days a worker works in agriculture Hired to tend livestock: Households that hired workers to tend livestock were selected then the number of workers hired were multiplied by 25 again. Household labor: Information on the number of individuals involved in subsistence agriculture from the household is given days per month) Then the total labor is calculated by summing hired labor and household labor.	days/month

capitalvalue	Capital	Data on the types of capital is available. Reported value is also given: For how much would you sell it today? We calculate the Total value of the Capital by summing all the values.	Rs
avgdist	Agricultural Facility	Distances of Haat bazaar, Market center and Agricultural center are given. The average distance has been calculated here.	Kms
grad/neveratt	HH Head Edducation	at least Graduated Bachelors/ not; Never attended school/Attended school (Dummy) variables	[1 0] dummy
majority	HH Head Ethnicity	Brahmin, Chhetri, Newar (Looking at the data, We separated these three ethnicities as the majority population)	[1 0] dummy
fem	Female ratio	Household head is female	[1 0] dummy
cropsland	Crop diversity	Number of crops planted in a season per land ha	ratio
hhsize	Household Size	Number of members in the household above age 10	Number of people
foodinsec	Food Insecurity	Answered yes to the question: In the past 30 day, have there been times when the household members didn't have enough food or money to buy food?	[1 0] dummy
urbrur	Urban	Household in urban area	[1 0] dummy
rep_income	Reported Income	Reported income by housheold over one agricultural year	Rs
fert_spend	Fertilizer spent	Amount spent on purchasing chemical fertilisers over one agricultural year	Rs

Source: CBS. "Living Standards Survey, 2010-2011," 2016.

Table A2: *Summary of variables, by mixed or non-mixed*

mix : 0

	N	Mean	SD	Min	Max
value	880	154122.63	227364.830	0	2515465.4
con value	880	16568.4	22443.445	0	194760
netlivesales	880	3074.015	12350.182	-45000	83140
fem	880	.26	0.439	0	1
fert spend	880	2440.453	3549.820	0	42000
majority	880	.273	0.446	0	1
rep income	880	10476.226	84538.301	0	2400000
rep expenditure	880	5885.622	7230.887	39	56140
capitalvalue	880	7182.248	63805.158	0	1500000
urbrur	880	.139	0.346	0	1
foodinsec	880	.092	0.289	0	1
neveratt	880	.573	0.495	0	1
grad	880	.006	0.075	0	1
hhsize	880	5.266	2.361	1	19
avgdist	880	7.064	5.709	0	43.333
tlabor	880	51.14	35.133	1	285
totland	880	.507	0.482	.002	2.967
irpr	880	.513	0.435	0	1
sharecrop ratio	880	.256	0.364	0	1
cropsland	880	46.342	118.045	1.846	3145.135
llratio	880	.648	0.409	0	1
netliv income	880	306.527	16131.080	-52000	351300

mix : 1

value	1186	193864.51	226466.001	.337	2613715.1
con value	1186	22940.266	26066.179	0	191160
netlivesales	1186	3602.854	15092.124	-80000	152000
fem	1186	.253	0.435	0	1
fert spend	1186	2972.331	4500.534	0	65000
majority	1186	.43	0.495	0	1
rep income	1186	11956.073	27206.741	0	392000
rep expenditure	1186	7426.32	10236.982	22	125100
capitalvalue	1186	10019.92	49131.798	0	1073000
urbrur	1186	.142	0.350	0	1
foodinsec	1186	.034	0.181	0	1
neveratt	1186	.492	0.500	0	1
grad	1186	.006	0.077	0	1
hhsize	1186	5.126	2.369	1	20
avgdist	1186	7.238	7.397	0	173
tlabor	1186	61.231	39.472	1	315
totland	1186	.678	0.523	.013	2.946
irpr	1186	.513	0.405	0	1
sharecrop ratio	1186	.175	0.289	0	1
cropsland	1186	35.162	46.102	1.737	1048.348
llratio	1186	.588	0.392	0	1
netliv income	1186	-1582.823	12244.667	-96000	116300

Source: CBS. "Living Standards Survey, 2010-2011," 2016.

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