

Bio-Economic Modeling of Conventional and Organic Farming Systems in Chitwan Nepal

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DOI: [10.47760/cognizance.2023.v03i12.007](https://doi.org/10.47760/cognizance.2023.v03i12.007)

ABSTRACT:

A study in Chitwan, Nepal, aimed to compare economic and environmental factors between organic and conventional farming. Fifty-three farms (20 organic, 33 conventional) in Fulbari and Jagatpur villages of Chitwan district were surveyed for collecting data and analysis. Detailed data from 16 farms (eight from each organic and conventional farms) were used for modeling, focusing on input/output factors using linear programming. The average farm size of one hectare with sandy loam soil was selected for this analysis. An empirical analysis and a linear programming model were conducted to compare both organic and conventional farms. The model revealed that a cropping cycle involving carrots and other vegetables was key for achieving higher gross margins in both farming systems. Interestingly, a cropping cycle with 30% land allocated to legume crops showed higher variable costs and gross margins compared to one with 50% land dedicated to legume crops. Organic farming with a specific cropping cycle involving rice-broad bean-maize demonstrated superior environmental outcomes compared to the same cycle in conventional farming, particularly in terms of nitrogen and phosphorus surplus. Despite both types of farming being labor-intensive, the observed differences in labor use between organic and conventional farming were not significant for particular crops. However, when the model selected the optimal production plan, it showed that labor use was lower in organic farming than in conventional farming. The study concluded that while conventional farms exhibited higher economic performance, organic farming showcased better environmental outcomes, especially concerning nitrogen and phosphorus surplus. The continuation of organic farming is seen as crucial in supporting superior environmental performance at the farm level, rather than solely prioritizing increased production through conventional methods. To bridge the economic and environmental gap between organic and conventional farming for an optimal farm plan, further in-depth studies are essential, considering local factors such as labor availability, timely access to markets for organic products, and the specific cropping plans for optimal farm performance.

Keywords: Organic farming, Conventional Farming, Linear Programming, Farm plan, Economic analysis

I. INTRODUCTION

Nepal characterized as an agrarian country, agriculture made up 32.35% of the national gross domestic product (GDP) in the fiscal year 2008/09, while more than 60% of the nation's economically active population was engaged in this sector [1]. The predominant farming practices in Nepal involve subsistence farming by the majority of farmers, characterized by mixed farming (livestock and crops) on relatively small land holdings of less than 0.8 hectares [2]. Although numerous challenges exist in production and marketing, adoption of current agricultural technologies and market-oriented production systems remains

limited among farmers. In response to growing consumer awareness, there is an increasing demand for organic products in Nepal, leading to a rise in the number of organic farmers and an expansion of the area dedicated to organic farming [3],[4],[5]. Approximately 26% of Nepalese farming systems are considered organic by default, as these farms abstain from using agrochemicals due to restricted access to inputs and capital [6]. Consequently, these farms do not require a conversion period. However, most commercial farmers continue conventional production methods due to limited knowledge about organic farming, concerns about marketing risks, and substantial initial investments [7],[8].

Historically, the Green Revolution in Asia, including Nepal, relied significantly on chemical fertilizers, synthetic pesticides, irrigation, and improved cultivars to augment food production [9]. However, the sustainability of intensive chemical-based crop systems over the long term is now widely questioned. Furthermore, the higher market price of organic products serves as an incentive for farmers to gradually transition to organic farming, albeit reluctance persists due to the perceived risks associated with additional investment and reduced production during the conversion process [7],[8]. As a result of the government's strong emphasis on the organic sector, notably outlined in the National Agricultural Policy of 2003 [10] and the Three-years interim plan of 2008, along with the involvement of non-governmental organizations, organic farming has experienced increased popularity in Nepal in recent years. Consequently, the expansion of organic farming has been ongoing, albeit at a slower pace than initially anticipated. Several key factors contribute to this slower adoption, including the absence of a well-structured organic market, the scarcity of organic inputs, a lack of technical expertise, insufficient extension services, high initial investment requirements (particularly for certification), and a dearth of comprehensive studies.

Most existing studies on organic farming in Nepal tend to focus on its advantages, utilized techniques, and the marketing and exportation of organic products. However, there remains a notable absence of research that directly compares conventional farming methods with organic practices within the context of Nepal. Hence, the primary objective of this research is to undertake a comparative analysis of conventional farming and organic farming in Nepal, utilizing data analysis and bio-economic modeling as the principal methodologies.

II. RESEARCH METHODOLOGY

2.1 Study Sites

Fulbari and Jagatpur, two Villages in Chitwan district, Nepal, were chosen as the study sites due to the presence of both organic and conventional farmers. Among the 53 households sampled, 20 organic farms (OFs) and 9 conventional farms (CFs) were selected from Fulbari, while 24 conventional farmers were selected from Jagatpur and its surrounding areas. These areas have a warm subtropical climate with high humidity and sit at an elevation of 200 meters above sea level. Fulbari is acknowledged as an organic village due to widespread adoption of organic farming practices, whereas Jagatpur is renowned for its

commercial conventional vegetable production. The two villages are situated southwest of the district headquarters, Bharatpur, at distances of 10 and 20 kilometers, respectively. The average size of the farm is 1.002 ha [11] in the district with cropping intensity ranging from 154 to 300% [12]. Livestock is also an important component of farming system in the district. Cattle, buffaloes and goats are the major livestock and they are raised mainly for milk, meat and draft power (transportation and land preparation). The economy of the district mostly depends upon the agriculture and about 47.5% of the total households of the district are depending on agriculture. Chitwan District is relatively more accessible in terms of roads and market facilities than other districts. The organic market is not fully developed so, organic commodities are mostly supply through personal contacts.

2.2 Sampling and Data Analysis

The sampling population for this study comprised all organic farmers affiliated with the Organic Producers' Cooperative Limited in Fulbari, alongside inorganic producers from both Fulbari and Jagatpur. The selection of organic producers was based on the farmers' roster provided by SECARD Nepal, reflecting approximately 100 households engaged in organic production, with about 20 farmers practicing organic methods for over a decade. Notably, the majority of these organic producers catered primarily to household consumption. Consequently, a purposive selection process was employed to choose 20 households associated with the Organic Producers' Cooperative Limited. Random selection, facilitated by a random number table, was utilized to choose 33 conventional producers (Nine from Fulbari and 24 from Jagatpur). The survey encompassed all farms to gather primary data on farming practices, landholding, crop types, cropping areas, yields, livestock units, and other relevant aspects. However, due to time constraints and limited data availability concerning production costs, reliable information was sourced from only 16 farms, evenly split between organic and conventional farming practices. Primary data was collected from selected farmers using a pre-tested interview schedule via face-to-face interviews between August and September 2010. Initially, the gathered data underwent tabulation, coding, descriptive analysis followed by linear programming model.

Table 1. Main cropping season in Chitwan district

Rainy season crop (June-August up to Nov 15)*	Winter season crops (Sept-Feb)*	Summer season crops (March-May)*
Rice (main), some vegetables (Okra)	Vegetables (cabbage, cauliflower, tomato, radish), carrot, wheat, bitter guard, lentil, broad bean, Mustard	Maize, green manure, cucurbits (<i>Luffa</i> spp., ash guard, bottle guard)

*Some vegetables are grown late or early depending on the type of variety, rainfall, expected market price etc. Thus, the winter and summer crops may overlap some duration.

2.3 Model Specification and Data

The general structure of the conventional and organic mixed farm models is shown in table 2 and has the mathematical form of the standard linear programming model [13].

Maximize: $\{Z = c'x\}$

Subject to $Ax \leq b$

and $x \geq 0$

where:

x = vector of activities

c = vector of gross margins or costs per unit of activity

A = matrix of technical coefficients

b = vector of technical right hand side coefficients.

Activities and constraints are grouped in Table 2. The main difference between the two models is that purchase of fertilizers and pesticide concerns only conventional production. In the case of OF the nutrient activities includes FYM/compost, poultry manure (PM) and green manure in addition to N-fixation by legume crops.

The objective function of the LP model is to maximize the gross margin, i.e. total returns from crops sold minus variable costs. The fixed cost is not used in the model. The output of the model includes the corresponding optimal production plan. To get the optimal solution for the LP model, Excel solver was used in Excel 2010.

Major Assumptions

Farm characteristics are diverse in the research site in terms of farm size, area under each crop, farmer's preference on different crops, cropping cycle, cropping rotation. It is difficult to get the optimal production plan from many activities and limited resources. So, due to some technical and practical applications and to make calculation easily understandable some assumptions were made:

- For this study ten cropping cycles found in OF and seven cropping cycles found in conventional farming are considered (See Table 4).
- There was no separate market other than conventional for livestock products (meat and milk). Therefore, livestock productions are ignored in the model.
- For comparison farm size of one ha is considered as an ideal size for modeling analysis for both organic and conventional farms, there was difference in average farm size though.

Table 2. The general structure of the conventional and organic farm models.

Activities	Crop production in terms of cropping cycle	Manure at home	Purchase of manure	Purchase of fertilizer	Nutrient surplus	Total pesticide use	Hired labour	Right hand side
<i>Constraints</i>								
Land	+1							≤ Av. land
Total labour requirement	+a _{ij}						-1	≤ available labour
Available labour days	+a _{ij}						-1	≤ supply labour
Crop rotations	+1							≤ max. ha of each crop or group of
Nutrient requirements	+a _{ij}	-a _{ij}	-a _{ij}	-a _{ij}				≤0
Nutrient balances at farm	-a _{ij}	+a _{ij}	+a _{ij}	+a _{ij}	-a _{ij}			=0
Linking land use and	+a _{ij}					-1		=0
Objective function	G.M. (NPR/ha)		Costs NRs Kg ⁻¹	Costs NRs t ⁻¹		Costs NPRha ⁻¹	Costs day ⁻¹ person ⁻¹	

a_{ij} = the technical-environmental coefficient that relates activity i to the constraints j; Av = available; Max. = Maximum; G.M. = gross margin; NPR = Nepalese rupees

The data used for modelling is collected from primary (field survey) and various secondary sources.

2.4 Limitation

This study relied primarily on memory-based data from respondents at the research site, potentially introducing errors due to farmers' memory biases despite extensive efforts to validate the information. Additionally, limitations exist in generalizing the findings nationwide due to the study's limited coverage, constrained by time. However, despite these constraints, the study offers valuable insights for policymakers and stakeholders, aiding efforts in promoting organic farming, environmental sustainability, and livelihood enhancement. Notably, the comparison between farms of varying sizes, fixed costs, and marketing channels limits insight into individual farmers' potential outcomes upon changing practices.

III. RESULT AND DISCUSSION

3.1 Farm Characteristics Data used in Modelling

Most of the organic and conventional farms in Chitwan are mixed farm (crops and livestock) where land is used for mostly arable crop production. Crop residues and crop byproducts are used for livestock feeds. The farm sizes were very diverse in study site for

both type of farming systems. From the survey it was found that, the average size of organic farm (OF) was about the half the size of conventional farms (CF). The soil type of this region is sandy loam and average land holding for CF and OF was found 1.3 ha and 0.62 ha, respectively. For this analysis, average land size of one ha and sandy loam soil is considered as a standard. Livestock manure (FYM) is the main source of organic fertilizer in both farming type where organic farmers were applying 56% higher FYM/compost than conventional farms. Instead of organic fertilizers application, conventional farms were using high dose of chemical fertilizer. The average livestock unit (LU; 1 cattle = 0.7 LU, 1 buffalo = 1 LU, 1 goat = 0.25 LU, (Tropical livestock unit, no. of animals per ha [31]) was higher in OFs (2) than in CFs (1.5). Table 3 represents general resource use of the both farming type in the study area.

Table 3. Farm characteristic and average resource use in organic and conventional farms.

Parameters	Organic farms	Conventional farms
Land area (ha)	0.62 (0.31)	1.30 (0.77)
Livestock units (LU/ha)	2.0 (1.26)	1.5 (0.75)
Farm Yard Manure/compost (mt/ha)	26.1 (14.5)	16.7 (12.5)
Poultry manure (mt/ha)	1.3 (1.7)	5.9 (5.0)
Urea (kg/ha)	-	179 (89)
DAP (kg/ha)	-	182 (114)
Murate of potash (kg/ha)	-	52 (53)

3.2 Cropping Cycle and Production

Cropping cycle include different (two or three) crops that are grown successively same piece of land during a year. From the survey it was found that several crops were grown in different parcel in the OF. Typical crops in the study site for conventional farming include rice, maize, wheat, carrot, vegetables and very few were growing green manure crop (*Sesbania sp.*). Besides these crops, sunflower, legume crops (broad bean, lentil, beans, and pea) and green manure crops (*sesamum sp.*) were also found in OF. Green manure crops are grown mostly before rainy season rice to maintain soil organic matter (SOM) content and fix nitrogen to the main crop: rice. In OF during summer, maize was grown up to 60% of their total land. Similarly, other crops like vegetables, green manure crops, summer legumes were grown up to 40, 30 and 50%, respectively of the total land. During the winter, some farmers used their land for carrot (up to 30% of total land), wheat (up to 40%), and legume crop 30-50% of total land. Except rainy season some farmers were leaving their land fallow for a season. Table 4 shows that three seasonal crops can be grown in a year.

Table 4. Cropping cycles in organic and conventional farming at the study sites and their gross margin

Organic farm's cropping cycle	Gross margin NPR/year	Conventional farm's cropping cycle	Gross margin NPR/year
Rice – lentil – maize	95028	Rice – cabbage – maize	156337
Rice – carrot – maize	330343	Rice – carrot – maize	374775
Rice – wheat – maize	91663	Rice – wheat – maize	105925
Rice – carrot – cucurbits	394181	Rice – carrot – cucurbits	574498
Rice – carrot	313806	Rice – wheat – cucurbits	305648
Rice – carrot – green manure	311560	Rice – Cabbage –Cucurbits	356060
Rice –Broad bean – Maize	141979	Rice – Cabbage – Green manure	119733
Rice – pea – maize	93854		
Rice – wheat – green manure	72880		
Rice - pea - cucurbits	157692		

In case of conventional farmers, they were growing higher proportion of each crop in a season and legume crop was not a major component of their cropping pattern. Instead of summer legume some farmers were growing green manure crop which is not common. Thus, there is less crop diversity in CFs than in OFs. It was found that small pea and lentil were sown inside rice field either at last week before harvesting date or just after the rice harvesting. In case of winter season, pea was occasionally found mixed with wheat crop. Among the various crops, rice is the main crop during the rainy season in both farming system which is followed by other crops or vegetables or combination of both.

The production, productivity and total output data were collected during the survey and are used for modelling. Total production data includes home consumption, livestock feed and quantity sold. Based on the most common cropping cycles prevailed in the research area (see Table 4), crops were grouped in cropping cycles and then gross margin of each cropping cycle without labour costs, fertilizer costs and PM costs was calculated. Gross margin of each cropping cycle is presented in Table 4.

The organic and conventional farms were diverse in terms of land size, livestock holdings and resources use (both external and internal). To fulfil the nutrient requirement conventional farmers were applying high doses of chemical fertilizers: urea (179 Kg/ha), DAP (182 Kg/ha) and MOP (52 Kg/ha) and PM in their farm. The chemical fertilizer applications are quite high than national average. The application of fertilizer increases the production in short term but in the long run it may destroy the soil quality, thereby reduces soil bio-physical and chemical properties. This may not be sustainable for long run. Moreover, conventional farms were using high dose of chemical pesticides for the crop protection. Excessive application of chemical fertilizers and chemical pesticides create a risk of soil degradation and cause environmental pollution [14],[15],[16],[17],[18],[19]. Due to more supply of inputs especially chemical fertilizers and chemical pesticides, CF has higher average productivity of carrot, maize and cucurbits. But the productivity of organic rice is higher than the conventionally produced rice. It may be due to better management of resources and better soil quality at OFs. The higher application of FYM/compost in the field

increases SOM which helps to increase the crop production. This might be another reason for higher organic rice production. The productivity of organic and conventional rice at the research site is 39 and 29% higher than the average productivity of the district, respectively. OFs have less nutrient supply. Thus, there is less nutrient surplus in OF than conventional farm. According to Pandey *et.al.*, [20] N loss in sandy loam from rice-wheat cropping cycle at Chitwan was ranged from 47 to 73 Kg N ha⁻¹. If we consider this loss, conventional farms have higher N loss which is also assessed [21] where they reported that average soil N and OM% were significantly higher in OFs than in CFs from the same area.

3.3 Crop Rotation

Crop rotation includes growing a different cropping cycle in successive years on the same piece of land. Outlines of the most common cropping rotation in the study site for OF and CF are shown in figure 1 and 2, respectively.

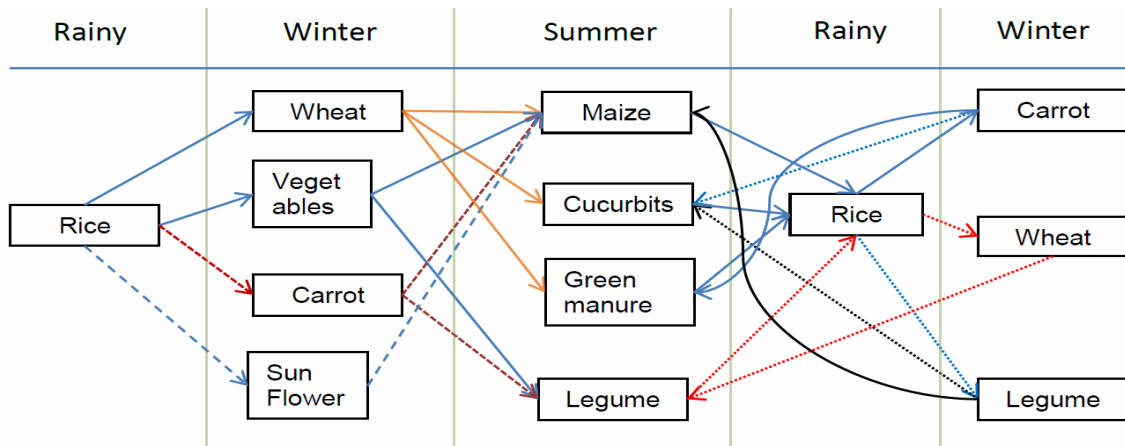


Figure 1. An outline of most common cropping rotation in organic farming in the study site.

In case of OF, farmers were growing several crops in rotation during winter and summer season in the successive years whereas conventional farming system mostly grown only one crop cycle (single rotation).

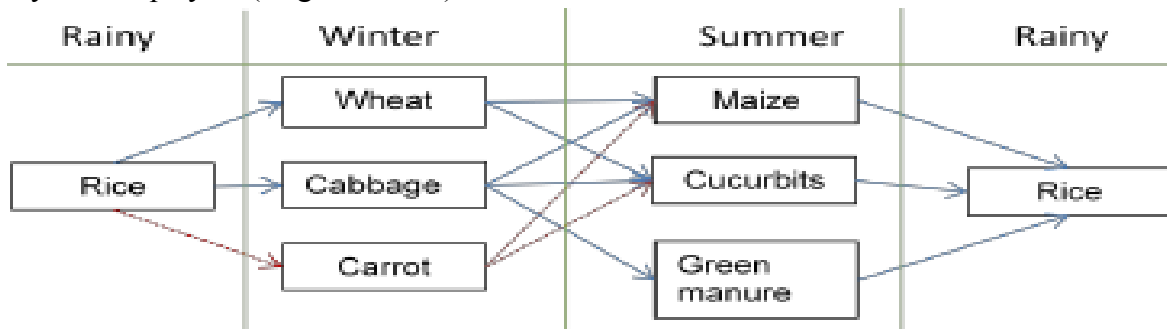


Figure 2. An outline of most common cropping rotation in conventional farming in the study site.

It was observed that 60% of the organic farmers were practicing two- or three-year's crop rotation including legume crops, and the corresponding value for conventional farm was 12% (Table 5). These cropping activities help to enhance the soil fertility.

Table 5. Number of farmers growing green manure crop and crop rotation in two different farming systems.

	Organic farms	Conventional farms
Green manure crops	14 (70)	11 (33.3)
No Crop rotation	8 (40)	29 (88)
Crop rotation > 1 year	12 (60)	4 (12)

- **at least two season crops are grown in a year. Figures in parenthesis indicate the percentage.*

3.4 Rotation Requirements

In organic farm (OF), legume crops were part of rotations during either the winter or summer seasons, occupying between 30% and 50% of the land in each season. The LP (linear programming) model for OF aimed for a 30% to 50% inclusion of leguminous crops (specifically broad beans) in a cropping cycle involving rice, broad beans, and maize. Constraints related to labor availability, marketing issues, and domestic consumption led to a maximum allocation of 30% of the total land for cultivating carrots and cucurbits in the rice-carrot-cucurbit production cycle within the LP model. Crop rotation in OF served purposes such as weed, pest, and disease control, as well as nutrient management, drawing on research by Stockdale et al., 2001; cited [8]. Conventional growers faced time constraints during rice transplanting and labor availability for summer cucurbit growth, resulting in many carrot producers neglecting cucurbit cultivation. However, among carrot producers, some allocated up to 30% of their land for summer cucurbits.

Notably, organic farmers integrated legumes into their crop cycles, a practice less common among surveyed conventional growers. Despite organic legume productivity being 22% lower than the district's average legume yield, it yielded a higher gross margin than maize and wheat. Additionally, leguminous crops in organic farming facilitated biological nitrogen fixation, reducing the need for external fertilizer application. However, organic farming's crop cycles, particularly with legumes, yielded lower gross margins compared to conventional farming, which predominantly focused on vegetable and carrot cultivation. The lower productivity in organic farming led to reduced competitiveness. Organic growers followed multi-year crop rotations, frequently incorporating legumes, while conventional farms emphasized vegetables and carrots, leading to more specialized and intensive farming. Greater crop diversity in organic farming potentially reduces intensity and associated risks compared to conventional farming. Extended cropping rotations improve soil quality by enhancing soil organic matter (SOM), augmenting nutrient retention, and benefitting from additional nutrients from legume crop rotations [22], [23]. The outcomes suggest that organic farms exhibit higher average nutrient use efficiency, greater nutrient retention, and potentially less environmental pollution compared to conventional farms.

3.5 Labour

Table 6 illustrates the labor demands across various cropping cycles. To standardize available labor, both farms are presumed to possess equal labor capacities, although accurately gauging home-based labor availability posed challenges. Labor utilization involved two classifications: regular and seasonal labor. Farmers typically disbursed an average of NPR 150 per person per day for regular labor and NPR 220 for seasonal labor. The model exclusively factors in the cost of seasonal hired labor.

Table 6. Labour required (in days/ha) and pesticide costs (NPR) for different cropping cycle in both types of farms.

Cropping cycle	Labor requirement			Pesticide used	
	Organic farm	Conventional farm	Family supplied	Pesticide costs	Units
Rice – lentil – maize	207		85		
Rice –Broad bean – maize	233		85		
Rice – carrot – maize	513	495	110	12000	4.8
Rice – carrot – green manure	457		83		
Rice – carrot	455		80		
Rice – carrot – cucurbits	654	711	125	47000	8.8
Rice – pea – maize	207		85		
Rice - pea - cucurbits	348		100		
Rice – wheat – maize	225	194	90	2500	1
Rice – wheat – green manure	169		65		
Rice – wheat – cucurbits		410	105	37500	15
Rice – cabbage – maize		290	105	23000	9.2
Rice – cabbage –cucurbits		506	125	58000	23.2
Rice–cabbage–green manure		239	80	23000	9.2

The availability of labor days fluctuates across seasons, contingent upon the workload intensity during distinct phases such as planting, sowing, weeding, and harvesting, coupled with the involvement of family members in farm operations. Each farming activity presumes a designated number of days contributed by the family. Both farming systems were characterized by their reliance on labor, resulting in minimal disparity in labor demands between OFs and CFs. OFs generally exhibit slightly higher labor requirements than CFs, except notably in cucurbit production, where organic growers utilized fewer laborers.

3.6 Pesticides Costs

The annual cost of pesticide usage is standardized at NPR 21,256, derived from the average pesticide expenditure per hectare among Conventional Farms (CFs) as outlined in Table 6. Notably, pesticide usage varies across different crops, with vegetable farming recording the highest pesticide application. To facilitate modeling, the minimum pesticide application cost in rice, set at NPR 2,500 per unit, serves as the baseline. The costs for other pesticide requirements are extrapolated based on this benchmark value.

3.7 Nutrient Requirement and Supply

For both farming LP model was set to select two nutrient balance level: the first, nutrient balance is equal to nutrient requirement minus nutrient removal, and the second, nutrient balance is equal to nutrient supply minus nutrient removal. Home produced FYM/compost is limited to 22 mt and 16 mt in the model for organic and conventional farms, respectively. These are the maximum limit of FYM/compost that famers can prepare and use annually. Data for nutrient requirement (nitrogen and phosphate (P₂O₅)) were taken from different sources. Due to lack of data for OF, nutrient requirement for various crops in both farming is used same data. For rice, wheat, maize and legume crops, N and P₂O₅ requirement were considered the standard nutrient requirement for Chitwan condition [24]. For other crops like cabbage, carrot and cucurbits, the nutrient requirements were taken from fertiliser recommendations for horticultural crops [25]. The nutrient requirement, supply and removal for various cropping cycle for both organic and conventional farming is given in tables 7 and 8, respectively.

Table 7. Nutrient requirement, uptake and supply situation of organic farming in different cropping cycle (Kg/ha).

Cropping cycle	N requirement	N removal	Total N supply	Phosphate requirement	P2O5 removal	P2O5 supply
Rice – lentil – maize	240	137	203.5	110	78.2	117.5
Rice –Broad bean – Maize	260	157	203.5	110	87.4	117.5
Rice – carrot – maize	250	157	178.7	95	94.3	129.5
Rice – carrot – green manure	170	104	216.8	75	78.2	128
Rice – carrot	150	104	176.8	55	78.2	128
Rice – carrot – Cucurbits	300	144	178.7	100	96.6	129.5
Rice – pea – maize	240	137	211.1	110	78.2	123.5
Rice - pea - cucurbits	270	124	209.2	115	80.5	122
Rice – wheat – maize	280	137	157.8	120	121.9	113
Rice – wheat – green manure	180	84	197.8	80	105.8	113

Table 8. Nutrient requirement, uptake and supply situation of conventional farming in different cropping cycle (Kg/ha).

Cropping cycle	N requirement	N removal	Total N supply	P2O5 requirement	P2O5 removal	P2O5 supply
Rice – carrot – cucurbits	300	210.5	543.306	100	125.35	457.482
Rice – carrot – maize	270	167.5	343.676	115	100.05	266.472
Rice – wheat – maize	280	137	141.86	120	121.9	104.62
Rice – wheat – cucurbits	310	180	351.49	105	147.2	305.63
Rice – Cabbage – maize	340	177	289.385	110	87.4	212.245
Rice – Cabbage –Cucurbits	370	220	547.94	95	112.7	451.88
Rice – Cabbage – Green manure	240	124	260.985	70	71.3	202.245

Nitrogen and phosphorous removed by different crops and vegetables were calculated based on the productivity of each crop and vegetable. To calculate the nutrient removal by various crops different secondary data sources were used. The N output values for rice, maize and wheat were 54, 53 and 30 kg/ha, respectively (Sthapit *et al.*, 1987, cited [26]). Similar

findings in maize – legume and maize – vegetable cropping cycle [27] reported that N-uptakes were 90 and 122 kg/ha, respectively.

The detailed description of the nutrients and their contents from different organic and chemical fertilizers are presented in Table 9. Farmers were using organic amendments especially FYM/compost and poultry manure. Apart from the organic amendments conventional farmers were applying chemical fertilizers like urea, di-ammonium phosphate (DAP) and murate of potash (MOP).

Table 9. Nutrient and OM content in different manures and fertilizers (percent Dry matter basis).

Nutrients and OM	Manure/ compost	Poultry manure	Urea	DAP	Source
N%	0.7	1.9	46	18	
P ₂ O ₅ %	0.5	1.5		46	
OM%	25	45			[34]

OM = organic matter

Biological nitrogen fixation (BNF) by legumes exhibited a range of 27 to 56 kg/ha in Nepal [28]. Additionally, Bokhtiar et al. [29] noted a nitrogen fixation or incorporation rate of 40 kg/ha specifically with *Sesbania aculata* as green manure. Consequently, an average nitrogen fixation of 40 kg N/ha is attributed to legumes and green manures. The price for manures and chemical fertilizers was obtained from the survey. The prices of FYM/compost and PM were NPR 1000/mt and 2.4/kg, respectively and for the chemical fertilizer retail price (NPR/Kg) were 25, 40 and 25, for urea, DAP and MOP, respectively. Environmental and economic performance of farming systems depends on maintenance of soil fertility [22] which can be enhanced by increasing organic matter in the soil [30], [7]. Thus, maintaining an optimal level of organic matter in the soil is crucial.

3.8 Model Output

LP model shows that cropping cycle with carrot, along with other vegetables are important for higher gross margin in both farming systems. Though cropping cycle rice-carrot-cucurbit (vegetable) has highest gross margin than other cropping cycles in both farming systems, farmers were not adopting this cycle on their whole land. This is due to lack of labour and poor mechanization at farms. The cropping cycle with 30% land under legume crop has higher variable cost and higher gross margin than the cropping cycle with 50% area under legume crop. This is because less productive area (area under broad bean) is substituted by higher productive crop: carrot. From the LP model results, it can be concluded that considering local specific factors cropping cycles: rice-broad bean-maize, rice-carrot-cucurbit and rice-carrot-maize in organic farming and rice-carrot-cucurbit and rice-carrot-maize in conventional farming show a better economic result in respective farming. Among two farming systems, OF has better environmental result in model selected cropping cycles. Moreover, organic farming with 30% area under rice-broad bean-maize has shown the highest environmental result than the cropping cycle with 50% area under that cropping cycle and CF.

OFs have lower income as compare to conventional farms because of low nutrient inputs, there is no market guarantee. So, farmers were using limited land under different crops, farmers are not receiving the premium price as reported in various studies [33], [3] and another study [35] in the eroded soil in Georgia, organic productions were lower than the conventional production. In contrary to the above finding, another study [36] reported that most of the North American OFs are performing better due than CFs because of lower input costs, product diversification, well-structured marketing channel, higher premiums etc. But those are either lacking or operating at minimal level in Nepal [37], [38]. Therefore, OF may have lower income in the research site. OFs may have high insect pest damage during the production because CFs are close to OF where they are using excessive pesticides to control insect pests. These insect pests may attack (during the pesticide application in CFs) to organic field nearby which may damage the organic crops heavily thereby reducing the yield of organic crops. Similarly, low farm income at OF may be due to the effect of economic of scale that is due to small size of OFs as compare to CF.

IV. CONCLUSION

Farming, pivotal for local sustenance and jobs, varies between organic and conventional methods at the site. Organic farms, smaller on average, rely solely on FYM/compost and PM for crop yield. Though limited, these resources may dent profits. They adopt longer crop rotations and integrate legumes, making their system less intensive. Conventional farms, larger and more specialized in veggies like carrots, pose higher risks due to intensity. Financially, conventional farming prevails, while environmentally, organic farming excels in managing N and P₂O₅. Optimal legume incorporation in cycles could improve margins. Trade-offs exist: conventional farming prospers economically, while organic practices shine ecologically. Encouraging organic farming in the region merits attention.

ACKNOWLEDGEMENTS

I'm immensely grateful to Dr. Paul Berentsen from Wageningen University for his invaluable guidance and encouragement throughout my study. The National Adaptation Plan of Action (NAPA) project and its supporters made this study possible, and I deeply appreciate their assistance. Special thanks to the hospitable farmers of Chitwan for sharing their insights, and to SECARD Nepal for facilitating a conducive working environment during my field study.

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