A Comparative Study of Conventional and Organic Farming Systems in Nepal in the Context of Climate Change

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Comparative study of effective management strategies for enhancing agricultural production system in Nepal in the context of climate change

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Abstract

*A study was carried out to explore and compare farming practices relevant to climate change. This study was conducted in Kavre and Chitwan districts representing mid hill and Terai ecosystems respectively. The study was conducted using personal interview, focus group discussion and soil analysis. The major variables resource use, farmers' practices and soil organic carbon were analyzed. The results showed that the average herd density was higher in organic (*3.40*) than conventional (*2.77*) farms and similar trend was observed in Farm Yard Manure application, 29.49 and 21.27t/ha, respectively. The study showed that significantly higher SOC% (1.73) was found in organic farms than conventional farms (1.23) and there was positive correlation between the amount of FYM and soil organic carbon. Most of organic farmers were practicing green manure, legume intercropping, proper FYM management and use of cattle and buffalo urine which are directly related with soil fertility and the amount of organic carbon. There was also negative correlation between nitrogenous fertilizers (urea and DAP) and SOC under farmers' managed condition. Moreover, 71% respondents considered that effect of climate change with erratic rainfall with low frequency, increased temperature and extensive drought than before. It was found that 75% farmers delayed transplanting of main season rice as well as the time of maize showing by 10 to 25 days because of the irregular rainfall and intermittent drought periods experienced in both the sites. This study concludes that the organic farming techniques offers greater and climate friendly options and contribute to minimizing the impacts of climate change on agricultural systems.*

Key words: *organic farming, conventional farming, SOC, Farmyard Manure, climate change*

1. Introduction

The majority of Nepalese farming system are subsistence type with mixed (crop and livestock) farms and relatively small (<0.8 ha) land holdings characterized by low productivity (CBS, 2007). On other hand, increasing human population and demanding more food for survival is existing challenge. In this context, increment of crop production through improved and commercial farming initiates to overcome this expectation. The existing farming explores high yielding varieties and intensive cropping system that needs higher use of external inputs for more yields. Conventional farming system is assumed to be any type of agriculture that requires high external energy inputs to achieve high yields and generally relies upon technological innovations, uniform high yield crops, and high labor efficiencies (Gold, 1999). In this system, high dose or imbalance use of chemical fertilizer and pesticides accelerate depletion of soil nutrient and degradation of natural environment. Furthermore, soil degradation can be severe, especially in the hilly regions due to improper soil management practices in agriculture and

erosion prone area. Thus, loss of fertile topsoil and nutrient leaching from runoff are a serious concern (Tripathi *et al*. 1999). On the other hand, organic agriculture (OA) is an agricultural system that promotes environmentally, socially and economically sound production of food, fibre, timber etc. In OA system, soil fertility is seen key to successful production. To optimise the all aspect of agriculture and environment, the organic farmers has to optimise the natural properties of plant, animal and the landscape (IFOAM, 2004). This system aims to enhance inherent soil fertility and is shown to be more resilient in sustaining food production and improving livelihood especially in the developing regions where climatic conditions are becoming increasingly uncertain (Jordan *et al.*, 2009). Bajracharya (2008) reported that the numerous agricultural practices such zero tillage, organic matter incorporation, improved composting, and agro-forestry enhanced the current soil conditions (SOC).

Moreover, agriculture is accountable for approximately 15% green house gas (GHG) such as methane (CH_4), nitrous oxide (NO_2) and carbon dioxide (CO_2) emission (Khanal, 2008). The use of nitrogenous chemical fertilizers, burning biomass; lowland rice cultivation and ruminants (animal waste management) contribute to GHG emission. The level of GHG increment is responsible for creating the enhanced green house effect which has affected precipitation and global temperature. Malla (2008) reported that annual temperature was increased by 0.06 ^{0}C yr-1 during 1975 to 2006 in Nepal while rainfall is also becoming more erratic which increases the risk of soil degradation. The impact of climate change has been directly and indirectly seen in agriculture production. It might be more severe where farmers have inadequate knowledge about those consequences. But few farmers are adopting some indigenous agriculture practices to overcome this circumstance. Thus, a comparative study was designed with the aim of characterizing farm resource endowment, inputs, current soil conditions and potential impacts of management practices in organic and conventional farming systems, and to elaborate potential impacts of different farming practices on agriculture performance and soil organic carbon.

2. Methodology

Kavre and Chitwan district were selected for this research. The selected two districts represent the two different locations with different climatic and topographic condition (Table 1). The three Village Development Committees (VDCs) Phulbari, Sukranagar and Jagatpur from Chitwan and the three VDCs Patlekhet, Panchkhal and Phulbari from Kavrepalanchok districts were purposively studied because of its potential of organic farming.

Table 1. Climatic variables and farming type in Kavre and Chitwan Districts

SN	Variables	Kavre (mid hill)	Chitwan (inner terai)
1	Altitude	1000-1400m	300m
2	Climate	Sub Tropical to warm Temperate	Sub Tropical Climate with high humidity
3	Average Annual Rainfall	1500-2000mm/yr	2000-2100mm/yr
4	Average Annual Temperature	12.2°C Min, 21.8°C Max	17.4°C Min 31°C Max
5	Major Crop	Maize followed by rice	Rice followed by maize
6	Farming type	Mixed Farming	Mixed farming

(Source: District and VDC profile of Nepal, 2008)

In total, 60 respondents were selected for household survey, interviewed with semi-structured questionnaire. Out of 60 respondents, 30 respondents were from Chitwan and 30 respondents were from Kavre districts. From each district 15 farmers selected were organic farms. In both sites, a series of focus group discussions were carried out. Several issues related with the agricultural system changes in the existing practices in relation to agriculture, livelihood, climate change and its impact were discussed. Forty-four soil samples were taken from top 30 cm depth of different fields of 44 farmers to assess soil organic carbon (SOC). All soil samples were analyzed at Agricultural Technological Center (ATC) Lalitpur, Nepal. Selected parameters were computed by a simple correlation, regression; pair T-test using Statistical Package for Social Science (SPSS) software.

3. Results

3.1 Resources and Farm Management

3.1.1 Livestock (cow and buffalo) distribution

The average livestock density (no. of livestock per ha) was higher in organic farms (3.40) than in conventional farms (2.77). The highest and lowest livestock density was found in Chitwan organic farms (4.36) and Kavre conventional farms (2.46), respectively. This indicates that farmers are keeping the livestock in order to prepare farm manure locally (Table 2).

Table 2. Livestock distribution

Category	**Chitwan (n = 30)**		**Kavre (n = 30)**		**Total (n = 60)**	
	Organic (n=15)	Conventional (n=15)	Organic (n=15)	Conventional (n=15)	Organic (n=30)	Conventional (n=30)
No. of Livestock	30	47	35	24	65	71
No. of livestock/ha	4.36±0.76	2.73±0.49	2.81±0.45	2.46±0.58	3.40±0.46	2.77±0.37

3.1.2 Manure and chemical fertilizer use

Most of the farmers are using imprudently inorganic manures like urea, DAP and murate of potash (MOP). In Chitwan, farmers were applying average 97.47, 120.07, 33.23, 29490 and 2850 kg of urea, DAP, Potash, Farm yard manure and poultry manure in one hectare respectively. Similarly, in Kavre farmers were applying 114.67, 101.40, 13.97, 21270 and 230 Kg of urea, DAP, Potash, Farm yard manure and poultry manure in one hectare annually respectively (Table 3).

Table 3. Use of different fertilizers per hectare per year

		Urea (Kg)	DAP (Kg)	MOP (Kg)	FYM (Mt)	PM (Mt)
Chitwan	Conventional	194.93±20.59	240.13±31.83	66.47±16.0	22.83±3.7	4.19±0.95
	Organic Farms	-	-	-	36.15±4.97	1.52±0.47
Kavre	Conventional	229.33±31.67	202.8±24.14	27.93±6.91	21.62±3.01	0.47±0.20
	Organic Farms	-	-	-	20.93±2.51	0.00

There was significant difference in the application of FYM between organic and conventional growers in Chitwan but the difference was non-significant in Kavre. On the other hand, conventional farmers were applying both inorganic and organic fertilizers.

3.1.3 Local agricultural practices adopted by farmers

Farmers were adopting diversity of improved practices at their farm (Table 4). Out of 60 respondents, 25% were producing green manure for at least of one season in two-year period. Most of organic farmers (73%) were practicing green manuring in farm field to increase the soil physical and chemical properties. Similarly, 68% respondents were practicing legume intercropping in upland and sometime in low land also. Among them, most of the practitioners were of organic grower (63%).

Table 4. Response farmers on different management practices

Category	**Chitwan (n = 30)**		**Kavre (n = 30)**		**Total**	
	Organic (n=15)	Conventional (n=15)	Organic (n=15)	Conventional(n=15)	Organic (n=30)	Conventional (n=30)
Green manure	9	6	2	0	11	6
Legume Intercropping	13	6	13	9	26 (63)	15(37)
Chemical fertilizer use	15	0	15	0	30 (100)	0
Pesticide use	0	15	0	15	0	30(100)
FYM protection	10	0	8	1	18 (95)	1 (5)
Urine use	13	1	10	2	23 (88)	3 (12)
Use of bio-pesticide	13	0	12	0	25	0
Conventional tillage	14	15	10	15	24	30
Minimum till	1	0	4	0	5	0
No-tillage	0	0	1	0	1	0

Figures in parenthesis indicate the percentage.

Only 32 % respondents protected their FYM from sunlight and heavy rainfall by covering it. Higher responses were recorded from the organic growers (95%). In this study, only 43% farmers were using cattle urine properly in the study area, 88% were organic farmers. Out of 60 respondents, only 25 organic growers were using bio-pesticides on their farm. Tillage practices can be grouped into three categories: 90% use conventional methods, 8.33% use minimum tillage; and 1.66% does not practice tillage at all, and they are removing crop residues from the land for livestock. Very few organic growers have started minimum and no-tillage practice, which is mainly due to type of crops they are growing.

3.1.4 Use of urine and FYM

It was found that total livestock used for urine collection and FYM management was 61 and 48 respectively (Table 5). Out of 61 livestock used for urine collection and use, 51% livestock were from Chitwan and 49% livestock were from Kavre. Similarly, out of 48 livestock used for FYM protection in Chitwan and Kavre were 52% and 48% respectively. In total, livestock used for urine collection was found to be more (45% than

FYM protection (35%). Urine collection and FYM protection is mostly carried out by organic farmers.

Table 5. Number of livestock used for urine and FYM protection

Category	Chitwan (n = 77)		Kavre (n = 59)		Sub Total		Total (n =136)
	Organic	Conventional	Organic	Conventional	Chitwan	Kavre	
Urine	29	2	26	4	31(51)	30 (49)	61 (45)
FYM	25	0	20	3	25 (52)	23 (48)	48 (35)

Figures in parenthesis indicate the percentage.

3.2 Farmer, Agriculture and Climate Change

3.2.1 Community experiences on climate change

Majority of the respondents (71%) reported that climatic factors have significantly changed from its normal trend over the past years. Ninety-two percent of the respondents perceive higher temperature while 87 percent of the respondents perceive that rainfall intensity has been increasing. All interviewed respondents and focus group discussion (FGD) participants agreed upon decrease on rainfall frequency and indicated that this is becoming a major problem during planting season. Ninety-seven percent respondents observe increasing drought frequency and severity.

3.2.2 Effect of climate change in agriculture

The severity percentage of crop damage due to drought was higher compared to than other factors. Damage due to drought, especially winter drought, was 53% and 63% in Chitwan and Kavre respectively (Table 6). According to the farmers the effect of drought was remarkably higher in maize crop: 40% and 50% in Chitwan and Kavre, respectively. The damage caused by drought on vegetables was 27% in Chitwan and 17% in Kavre.

Table 6. Response on reason of crop damage and effect of drought

District	Reason of crop damage				Effect of drought	
	Drought	Rain	Pest	Disease	Maize	Vegetable
Chitwan	53	3	10	4	40	27
Kavre	63	3	10	10	50	17

From the FGD in both sites farmers expressed that rainfall is irregular and they are experiencing long duration of drought followed by heavy rainfall and freezing winter. This has caused many problems including high infestation of pest and diseases. And in recent year conventional growers are compelled to use more pesticides than normal.

3.2.3 Community based adaptation to minimize the effect of climate change

Significantly ($p=<0.00$) higher response was observed in change in the planting date by the respondents. From the data it was found that 71% farmers have changed planting date for different crops in different time period by 10 to 25 days (Table 7). This change in date was due to irregular rainfall.

Table 7. Response on change in planting date of different crop.

Category	Chitwan (n = 30)	Kavre (n = 30)	Total (n = 60)
Planting date change	23 (77)	20 (67)	43 (72)
Maize	15 (50)	10 (33)	25 (42)
Rice	18 (60)	14 (47)	32 (53)

Figures in parenthesis indicate the percentage.

The study revealed that a majority (77%) of the surveyed respondents had changed planting date for at least in one crop season for one or more crops in Chitwan. Response on change in planting dates for upland rainy season maize and rainy season rice were 47% and 53%, respectively. Previously most of the maize sowing was done before 20th April, but in recent year planting date is delayed at least 10 days to 25 days. Unlike the past, March/ April are too dry, the soil moisture during this month is very low and the dried underground water sources less contributes in initiation of water sprouts. Delayed monsoon or insufficient rainfall during the transplanting season and not having proper irrigation facility are the major reasons changing the planting date. The rainy season rice transplanting is being delayed by 10 to 15 days and farmers are forced to transplant old seedling.

3.2.4 Rainfall Pattern during the planting time of rice and maize

Figure 1 shows the rainfall pattern for 40 years during the month of May to August in Chitwan. In general May-June is the time for sowing maize in Chitwan whereas July-August is the rice transplanting period. The rainfall in July-August shows regularity for the first 20 years but has been inconsistent for the next 10 years. The rainfall is more inconsistent in the later years from 1997-2007. The pattern shows some relation with the fact of farmers that in last 10 years they are adjusting the planting date of rice in relation to the rainfall occurrence. The adjustment of the date is different for the different year.

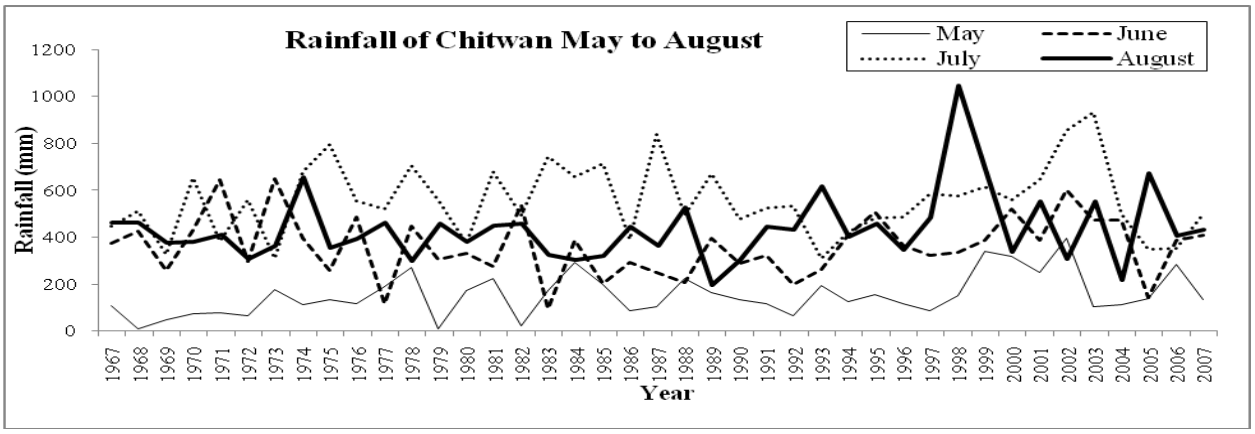

Figure 1: Monthly rainfall pattern in Chitwan during the planting time of maize and rice.

Figure 2 shows the rainfall pattern for 40 years during the month of April to July in Kavre. In general April-May is the time for sowing maize whereas June-July is for rice planting period. The monthly rainfall pattern of Kavre in the month of June-July does not show a uniform trend. Since the rainfall data of 5 years are missing, it does not warrant to defining exact trend. However, in the duration of 40 years the monthly rainfall patterns seems to change in the recent years in comparison to the past ones. The graph shows that the rainfall

in May, June and July is decreasing in the recent years. This decreasing trend of rainfall in some way is responsible for the change in planting date of rice.

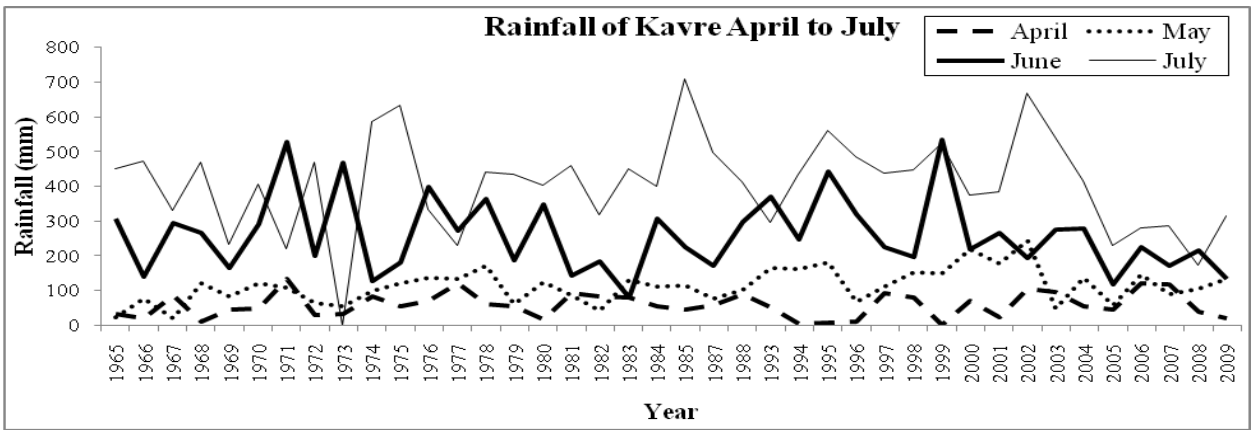

Figure 2: Monthly rainfall pattern in Kavre during the planting time of maize and rice.

3.3 Production of Major Crops and SOC Content

Production of major crops, rice and maize were observed and it was found that a slightly higher production in conventional farming system in both district but non-significant different with organic farming system. On other hand, maize production was significantly higher in conventional (2.31 t/ha) than organic (1.45 t/ha) farming practice (Table 8). But it was not significantly different in Chitwan condition.

Table 8. SOC percentage and production of rice and maize in different farming system.

District	Rice (t/ha)		Maize (t/ha)		SOC (%)	
	Conventional	Organic	Conventional	Organic	Conventional	Organic
Kavre	3.14	2.00	2.29	1.14	1.25±0.31	1.77±0.70
Chitwan	2.97	2.87	2.33	1.76	1.20±0.21	1.69±0.29
Average	3.05	2.43	2.31	1.45	1.23±0.27	1.73±0.53

Table 8 shows the average SOC content in different farming system in Chitwan and Kavre. There was a significant difference in SOC accumulation in organically managed and conventionally managed farm within the district and organic and conventional farms between the districts ($P < 0.05\%$). These differences in SOC under similar soil type, climatic condition and topography within the district indicates that soil management factors like inputs used and other management factors were accountable to compare the farming types under farmers managed condition for a specific location.

3.4 Influence of FYM and Nitrogenous Fertilizers on SOC Under Different Farms

There was a significant difference between FYM application in conventional and organic farms in Chitwan ($P = 0.062 < a = 0.05$) but its difference was non-significant in Kavre. Moreover, the analysis of variance revealed that there was a significant effect of FYM/ha per year on SOC in Chitwan but its effect on SOC was non-significant in Kavre. Organic growers in Chitwan were applying more FYM (36 mt./ha) annually than conventional farmers (22.8 mt) but its application was almost similar in organic and

conventional growers in Kavre (Table 3). The result also showed that there was a significant effect of nitrogen fertilizers on SOC in Chitwan but their effect was non-significant in Kavre and correlation between application of chemical fertilizers and SOC was negative in both districts.

4. Discussion and Conclusion

Considering application of inorganic fertilizers; DAP and MOP application by conventional farmers per unit area is higher in Chitwan than Kavre but opposite trend was observed in urea. It showed that there was negative correlation between nitrogenous fertilizers (urea and DAP) and SOC in both districts. Conventional farmers were increasing the rate of application of chemical fertilizers to achieve the previous level of crop production. Higher the application of nitrogen fertilizer increases microbial biomass in soil especially fungi and actinomycetes which causes carbon mineralization and oxidation from soil resulting into low soil organic carbon with higher doses of nitrogen (Tiwari et al., 2000). Organic farmers' practice FYM protection from sunlight and rainfall is anticipated to minimize the loss of nutrient especially nitrogen and potash. Farmers were covering manures either by thatch/tin or by plastic sheets. Covering FYM with plastic sheets is supposed to increase N and protect the loss due to volatilization and leaching of nutrients (N, P, K) contents, crop yields maize and upland rice (Tripathi and Elis-Jones, 2004). Weber (2003) reported that traditionally-prepared FYM has lower (0.5-1.0%) nitrogen compared to well prepared (protection from sunlight and water) FYM (1-1.5%). Though, urine contains much higher nitrogen than dung (Weber, 2003) it was not properly utilized by all respondents. But, organic farmers' are applying higher organic fertilizer compared to quantity applied by conventional farmers and majority of organic farmers' are involved in the proper use of FYM and urine. Nepalese livestock sector is also contributing 0.25% of the total methane emission in Nepal (Paudel and Aryal, 2008). Farmers' good, manure and urine, management practice can minimize the GHG emission (Jordan *et al*., 2009). FYM protection also checks the nitrogen losses from volatilization and leaching. These practices help to add more nitrogen as well as other nutrients in the soil through organic resources. Therefore, farmers by protecting urine and FYM not only save the money but also protect the emission of Nitrous oxides to the environment. Nitrous oxides pollutions are due to excessive use and losses of nitrogen in the field (IFOAM, 2009). Poulton (1995, cited in Ghani et al., 2009) reported that continuous application of manure (35 Mt./ha/years) on the upper soil surface (0-30 cm) has increased total carbon percentage on wheat cultivated land in England.

On the other hand, the adoption of minimum and no-tillage practice by the organic farmers' can contribute to improve the soil biophysical properties. These practices help to increase the SOC because conventional tillage has the least potential of SOC sequestration which also depends upon the soil texture. Sandy soil (4.2 mg Cg^{-1}) with conventional tillage has the least SOC than red soil (14.9 mg Cg^{-1} soil) (Chivenge et al., 2007). Chitwan has sandy loam soil where as in Kavre sandy brown soils are common. It is observed that there was maize and rice based cropping pattern in Bari (upland) and Khet (lowland), respectively, which needs heavy tillage. And removing crop residues from land accelerate SOC decline in conventional tilled soil (Yang and Wander, 1999; Mann et al., 2002, cited in Chivenge et al., 2007). So, it should be taken into account while implementing the tillage methods and selecting crops for particular soil type in a specific region.

Seventy-seven percent of the respondents have changed the planting date for the major crops. Survey and FGD showed that the planting date delayed in rainy season rice and maize by 10 to 25 days. The monthly rainfall data during maize and rice planting period in Chitwan and Kavre showed some changes in the

pattern in the recent years, which somehow correlates the farmer's perception of rainfall being irregular and erratic.

The production result reflects that rice production was not affected by farming practices in both districts but the maize production was different in Kavre by farming type. Irrigation and high application of FYM in organic farming in Chitwan is fulfilling the nutrient requirements. Though there was no difference in organic fertilizer application. In case of Kavre district soils inherent fertility and FYM and urine protection practices (Tripathi and Elis-Joines, 2004) may have maintained productivity in organic farming in lowland. Though the production in organic farming system is lower (Table 8), organic farming system is accelerating organic carbon content in soil which indicates that the carbon dioxide emission can be reduced to some extent. Organic farming can also contribute to sustainable production, biodiversity conservation, and ecological harmony. This suggests that policy needs to focus on adaptation strategies to minimize the effects of the climate change on agriculture through a combination of farmers' knowledge and applied research.

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