Your Planet Needs You - UNite to Combat Climate Change

धरतीले खोजेको छ हामीलाई, एक हौं जलवायु परिवर्तन विरुद्ध जुध्नलाई

The Journal of

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EDITORIAL

Your Planet Needs You-UNite to Combat Climate Change has been the world Environment Day Slogan for 2009. The day's agenda are to give a human face to environmental issues, empower people to become active agents of sustainable and equitable development, promote an understanding that communities are pivotal to changing attitudes towards environmental issues and advocate partnership ensuring that all nations and peoples enjoy a safer and more prosperous future.

The day is celebrated through several events and activities such as street rallies, demonstrations, posters, pamphlets, plantation, TV and radio talks, recycling and cleaning-up campaigns and various competitions among school children. Gender Equity and Environment Division in the Ministry of Agriculture and Cooperatives has been publishing the ***Journal of Agriculture and Environment*** as a regular program to celebrate the world environment day. The journal covers agro-environmental issues in its scope. The division now has brought the journal's new issue, **vol.10**, in the hand of readerships. The volume essentially includes technical as well as review articles on agro-environment and population interrelationships. The issue is expected to be useful to various professionals, teachers, students and researchers in understanding the delicacy of mother nature and climate change issues on this planet.

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GUIDELINES TO AUTHORS: MANUSCRIPT PREPARATION AND SUBMISSION

The Journal of Agriculture and Environment is devoted to the cause of advancing understanding on the various aspects of Agriculture, Farming Systems and Environment through literature review, theoretical analysis, research and practical experiences. Besides research and review papers, the journal can arrange spaces also for case studies, methodological approaches, book reviews, reports on seminars and meetings, short communications and letters to the editors. The broad guidelines to the authors on preparation and submission of manuscript are as follows:

1. The manuscript must be an original work written in English and not published elsewhere.
2. The Title should be short and specific, but it should reflect the contents in the manuscript.
3. The abstract, as far as possible not exceeding 150 words, should concisely state major objective, methodology, major findings and conclusion. It it should not include diagrams, footnotes, equations or any parenthetical references.
4. Key words in alphabetical order not exceeding ten standard words
5. The author's identification should include the author(s)'s name, highest educational attainment, organization, title/designation and contact addresses including telephone, fax and e-mail.
6. Main text of the manuscript should include introduction, objective, theoretical framework, methodology, result and discussion and conclusion.
7. Use of footnotes should be minimized, and should not used for citation
8. All headings and subheadings should be capitalized.
9. Too many graphs and tables should be avoided. Supplementary tables should be placed back at the annex.
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POTENTIALS OF ORGANIC AGRICULTURE IN NEPAL

Gopal Datt Bhatta (M Sc)[1], Werner Doppler (PhD) and Krishna Bahadur KC (PhD)

ABSTRACT

Increasing use of agro-chemicals, higher production cost and deteriorating ecosystem health have advocated the need to change traditional and external input use agriculture towards safe and sustainable organic production. Current research focuses on the constraints and opportunities of organic agriculture and consumers' awareness and willingness to pay more for organic vegetables by selecting producers from Lalitpur and Bhaktpur districts using spatial sampling and consumers from Kathmandu valley randomly. Data obtained from structured questionnaire were subjected to descriptive and econometric analysis and willingness to pay analysis. Most of the farmers interviewed are aware about the negative repercussion of the indiscriminate use of agro-chemicals. Organic vegetables are either home delivered and/or sold to the specialized niche markets. All domestic organic products reach to consumers without labeling. Most of the organic consumers are willing to pay eight rupees more for labeled organic vegetables. Currently organic farmers rely only on consumers' willingness to pay more to obtain a compensation for lower yields. Family income, education, profession etc are key attributes of the consumers shaping their decision to buy organic vegetables. Organic industry is too small and a long way to go in Nepal. Political commitments such as avoiding conflicting drive to maximize production, hammering proactive policy, initiating organic technology research, providing market incentives and institutionalization of Nepalese organic movement are imperative to further enhance organic sector in Nepal.

Key words: awareness, consumers, marketing, organic vegetables, regression, willingness to pay

INTRODUCTION

Environmental pollution and food safety due to chemical contamination become a great concern worldwide. Food and Agriculture Organization (FAO) proposed "The World Food Summit Plan of Action (1999)" in recognition with the importance of developing alternative sustainable agriculture such as organic farming. Organic farming is an integrated farming system which involved technical aspects (soil, agronomy, and weed and pest management) and economic aspects (input, output and marketing) as well as human health. Organic farming claims to have the potential to provide benefits in terms of environmental protection, conservation of non-renewable resources, improved food quality, reduction in output of surplus products and the reorientation of agriculture towards areas of market demand (Lampkin, 1990). Sharma (2001) makes a case for organic farming as the most widely recognized alternative farming system for sustainable production without seriously harming the environment and ecology. Veeresh (1999) opines that both high technology and sustainable environment cannot go together.

Since consumption of organic food products is the best remedy to prevent the numerous health hazards caused by conventionally produced foods, the global market has experienced exceptionally high growth in organic foods in the United States, Europe, and in other countries, yet market shares remain quite small (Piyasiri and Ariyawardana, 2002). However, in developing countries, the growth of organic sector is quite slow and faces tremendous challenges. Nepal's organic agricultural production has a relatively short history. Adoption of organic farming is quite slow, market for organic products is not well developed and no market statistics are available in Nepal (Bhatta *et al.*, 2008a).

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Nevertheless, there is a growing trend among urban consumers to consume organic products from places where they could get an assurance about the quality of the products. Market features of organic products in Nepal show that it is still in the "formative stage" of the product life cycle (Bhatta *et al.*, 2008a). Despite these facts, there are some rays of hopes among the organic producers and traders in the country.

Growth of organic agriculture requires producers' and consumers' awareness, availability of sound infrastructures and consumers' willingness to pay for the organic products. Nepal, being a developing country, definitely majority of the consumers is not well off. However, a large chunk of consumers are clustered in and around urban areas of the country and they could pay for the organic products provided quality is assured. Market potentials are mainly determined by consumer expectations of the product attributes, which are attached to the product such as quality (Ramesh *et al.*, 2005), price (Roddy *et al.*, 1996; Fotopoulos and Krystallis, 2002), certification (Kotler, 2001), price and quality (Boyle and Lathrop, 2009). Also consumers' awareness of health, food safety, environmental, and technology issues related to food products as well as the industrialization of agriculture and globalization, have been identified as diversification factors of food consumption (Senauer, 1994). Some empirical evidences regarding consumers' preference for differentiated quality attributes are given by Bhatta *et al.* (2008b), Bower and Baxter (2000), Elliott and Cameron (1994), Lans *et al.* (2001) and Okechuku (1994). There is the need to investigate wider perspective of organic farming through producers' and consumers' view point.

OBJECTIVES

The broad objective of this study is to find out the potentials of organic farming in Nepal with following specific objectives:

1. To study the level of awareness among the farmers and consumers about organic farming and organic products respectively;
2. To find out the preference of the consumers and their willingness to pay more for organic vegetables; and
3. To explore the constraints and potentials of organic farming through critical examinations of strengths, weaknesses, opportunities and threats.

RESEARCH METHODOLOGY

The study was conducted in different Village Development Committees (VDCs) of Lalitpur and Bhaktapur districts. It was supposed that these districts represent urban and peri-urban environment of Nepal and modestly developed, and farmers with different types of farming practices have been available. For consumers' survey, some of the organic and inorganic vegetable markets within the Kathmandu Valley such as The Organic Village, Bhatbhateni Supermarket, Sale ways Supermarket and Summit Hotel along with some local markets have been selected. After selecting study boundary, spatial sampling has been applied in selecting 130 respondents. Random selection approach while selecting 90 consumers was attempted as much as possible. The consumers were randomly approached at the market and asked for their participation in an interview. This procedure was applied due to lack of alternatives. However, not all of the selected consumers agreed to be interviewed and replacement of previously selected consumers occurred frequently. The non-response variables were simply ignored in the process of data analysis.

Structured questionnaire was designed to collect primary information administered through interview and was pre-tested before executing interview. Collected data were subjected to descriptive and regression analysis. Additional willingness to pay analysis (AWTP) for different organic vegetable types was obtained by indicating the approximate prevailing prices of inorganically produced vegetables in the local markets as the base value. Strength, weakness, opportunities and threats (SWOT) analysis has also been rendered. Factors that influence the additional willingness to pay for different types of vegetables (unlabelled and labeled) were determined though multiple regression analysis as per Field (2005).

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \varepsilon$$

Where, Y is the dependent variable (here, AWTP measured in NRs)

β_0 is the intercept and β_1, β_2, β_3, β_4 and β_5 are the slope parameters of the model

X_1 years of education, X_2 age of the respondents, X_3 monthly family income (in NRs)

X_4 respondents' status (dummy), i.e. engaged in job or not (1= have job, 0 otherwise)

X_5 family size, ε error term

RESULTS AND DISCUSSION

UNDERSTANDING ABOUT ORGANIC AGRICULTURE

Though more than 50% of farmers expressed that they have heard of and known about organic farming, different farmers do have different levels of knowledge (Figure 1). Some farmers especially who are far from market centre and infrastructure have even not heard about organic farming. This envisages spatial difference in terms of organic farming development. Most of the producers are of the view that organic agriculture is chemical free production practice; some asserted that they are produced only using manure as fertilizer source. Along with that some considered organic farming as product of natural/traditional agriculture. Within this variability of knowledge about organic agriculture, farmers are found managing their farm as per their level of knowledge and skills. In some areas, it has been evident that they use modest amount of inorganic fertilizers and use huge amount of organic manure and name this practice as organic ones. Integrated pest management (IPM) has also considered organic farming in some areas. Variation in knowledge about organic farming is obvious because of lack of extension that deciphers the knowledge and skills of this farming method. Organic farming is the technique which calls for extension of knowledge vis-à-vis skills among the end users. Unfortunately government extension service remains quite rudimentary in the study area despite its peri-urban location. As a matter of fact many farmers have only vague ideas about organic farming and its advantages as against the traditional and modern farming methods. Albeit many farmers have been involved in organic production, their way of managing organic farm may not justify organic standards.

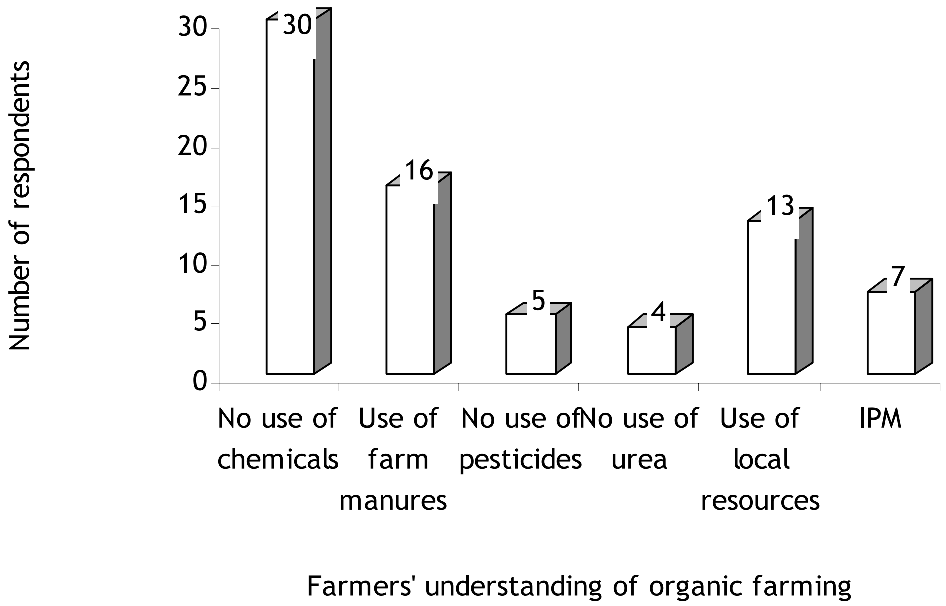

Figure 1. Farmers' definition towards organic farming

Similarly majority of the consumers replied that they had heard of organic vegetables and known the significance of it, however, most of them lack knowledge about their availability. This finding is in concordance with that of Sharma (2005) who reported that 63% of the respondents knew about organic products while 37% of the respondents did not. This indicates that awareness programs about organic products could be an effective way of promoting organic products among consumers. Piyasiri and Ariyawardana (2002) have also advocated that organic product marketers should develop awareness programs aiming supermarket shoppers in order to promote consumer-buying behavior.

MARKETING PRACTICES

Two most prominent practices exist in selling organic vegetables in the Kathmandu valley. They are sold directly through producers and through middlemen (Figure 2). In case of direct selling consumers come to the farm gate and buy vegetables and this is not very common. Another practice is that producers deliver the products to the consumers, common for the affluent consumers who are ready to pay more.

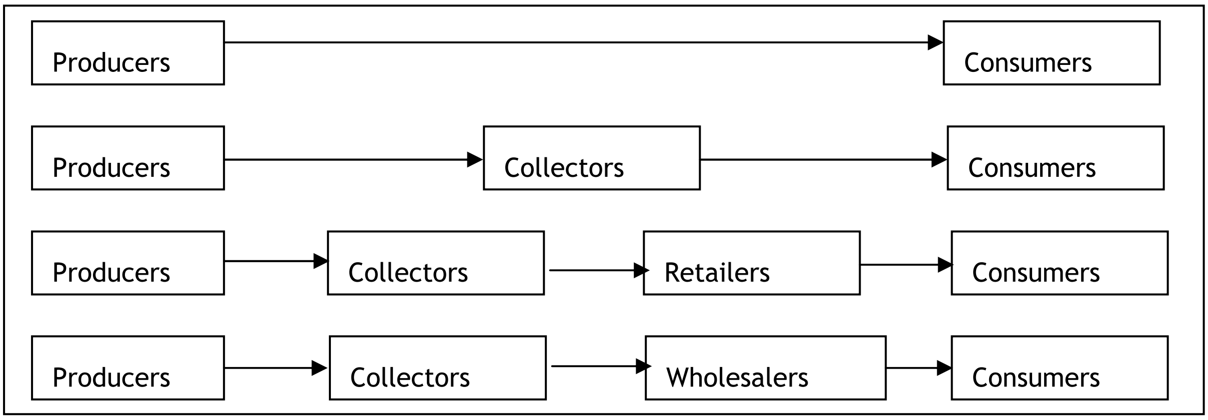

Figure 2: Common marketing channels for organic vegetables in the Kathmandu valley

Both of these practices promote the direct distribution of products from farm to consumer, and are based on the principle of the producers and consumers "shaking hands" and ‘supporting each other’. In another case some middlemen perform the job of collection of organic vegetables from the producers and they do perform the job of marketing either by delivering to the consumers’ place or selling to the specialized shops. Albeit depicted, very seldom does other marketing channel of organic vegetables exist. Nevertheless, it is much likely, in the future, that complex marketing channel will take momentum.

CONSUMPTION OF DIFFERENT TYPES OF VEGETABLES

Consumers’ personal attributes and consumption of three vegetables viz., tomato, cauliflower and broadleaved mustard have been analyzed.

Consumption of organic, inorganic and both types of tomato has been cross tabulated with educational levels of the respondents (Table 1) and it was evident that majority of the respondents with university degree consumed organic tomato and it was significantly different as per educational levels ($P<0.01$). The typical organic consumer belongs to the higher educated, higher income strata, often having young children (FAO, 2001).

Table 1. Educational levels and consumption of different types of tomato

Tomato Type	Education levels					Total
	No formal education	Primary	Secondary	Higher secondary	University	
Organic	1	0	0	1	26	28
Inorganic	4	5	3	10	22	44
Both	2	0	0	5	10	17
Total	7	5	3	16	58	89

Chi-Square value = 19.224**

**Significant at 0.01 level of probability

It is evident that most of the consumers with university degree consumed organic cauliflower (Table 2) and also broadleaved mustard. With the use of chi-square test, it is conspicuous that there was significant discrepancy ($P<0.05$) between education and consumption of different types of cauliflower, however, it fails to show significant discrepancy in between consumption of different types of broad leaved mustard and levels of education.

Organic commodities are expensive by nature; therefore, not all the consumers can afford to buy them. The average Nepalese consumer is price-oriented and thus not prepared to pay a higher price for a product, which he/she does not perceive as ‘better’. Therefore, personal and family incomes also play a crucial role in making decision about which type of products to be purchased. It is conspicuous that large numbers of the consumers with personal income more than NRs. 11,000 do consume organic tomato (Figure 3). Similar results have been attached with consumption of organic cauliflower and broadleaved mustard. This shows clear tendency in consuming organic vegetables by higher income group. Similar results have been obtained in consuming different types of vegetables as per family income.

Table 2. Relation between education and consumption of different types of cauliflower

Cauliflower type	Education levels					Total
	No formal education	Primary	Secondary	Higher secondary	University	
Organic	3	0	1	2	24	30
Inorganic	1	5	2	8	17	33
Both	3	0	0	6	14	23
Total	7	5	3	16	55	86

Chi-square value = 16.920*

*Significant at 0.05 level of probability

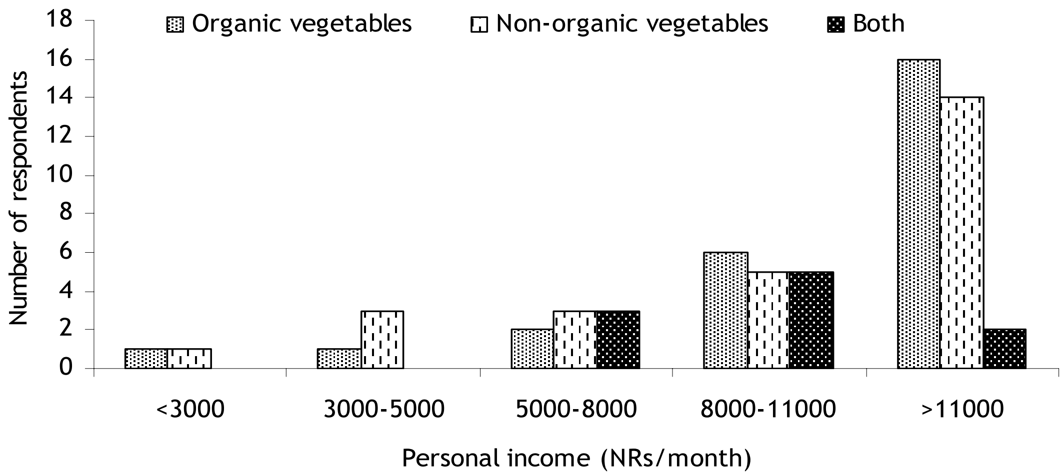

Figure 3. Personal income of the consumers and consumption of vegetables

ADDITIONAL WILLINGNESS TO PAY (AWTP) ANALYSIS

AWTP for organic vegetables values before and after labeling have been obtained by asking the respondents they would be willing to pay more rupees to the organic vegetables as compared to inorganic vegetables. Paired sample t test indicates that there has been significant difference in terms of AWTP for labeled and unlabelled organic vegetables. The mean rupees consumers are willing to pay for unlabelled organic vegetables is NRs 5.07 per kg while that is 8.47 per kg NRs in case of labeled organic vegetables (Table 3). This conspicuously demarcates the importance of certification and labeling. A price premium of 20 percent over conventional products seems to be the maximum accepted in many countries. Market studies show that majority of the consumers of Denmark would like to pay 10% extra for organic food, in France 30-35% and in Japan 10-20% (FAO, 2001). Misra *et al*. (1991) estimated that 40% of consumers would be willing to pay 10% more for a product free of pesticide residues, while Weaver *et al*. (1992) calculated that around 50% would pay at least 10% more for pesticide-free tomatoes.

A majority of the consumers are willing to pay or paying almost five rupees more to the unlabelled organic vegetables over inorganic while the percentage of consumers decreases with the higher range of additional price for unlabelled organic vegetables (Figure 4). AWTP would have been remarkably different if organic vegetables had been labeled. A majority of the consumers would be willing to pay five to 10 rupees per kg of labeled organic vegetables by those who are willing to pay less than five rupees per kg for unlabeled organic vegetables. Percentage of consumers willing to pay 10-15 and 15-20 rupees per kg of labeled organic vegetable is higher than that of the unlabelled counterpart. Labeled food products show all the information needed which is fundamental to give credence to the product. This could be done through certification and concomitantly through labeling. Certification process is expensive venture. Therefore, certified organic products are expensive. The consumers who have understood this reality would be willing to pay more premium for certified and labeled organic vegetables so that they have not to wonder whether the vegetables they consume is really organic.

Table 3. Summary of the AWTP

Organic vegetables	Mean AWTP (NRs/kg)	t-Ratio	p-value
Without label (present situation)	5.07 (4.61)	-30.423	0.000
With label (assumed situation)	8.47 (4.60)		

Values in the parenthesis indicate standard deviation

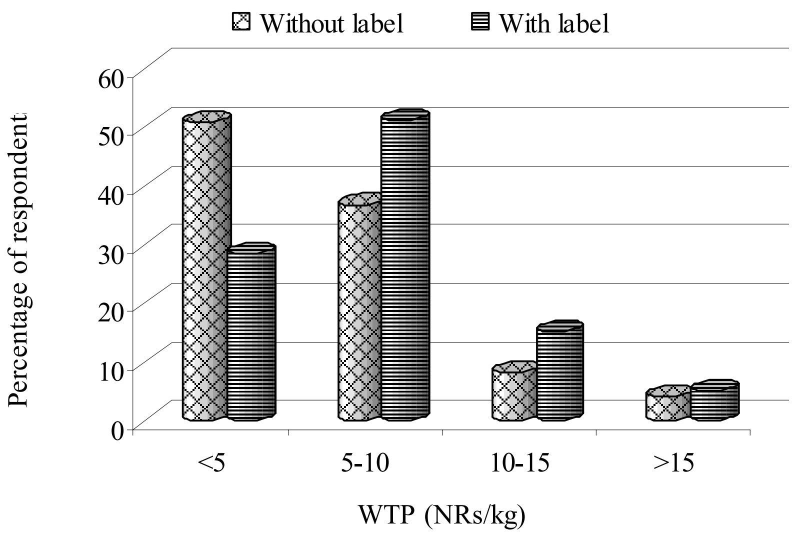

Figure 4. AWTP for organic vegetables before and after labeling

FACTORS INFLUENCING THE AVERAGE AWTP FOR ORGANIC VEGETABLES

Results of regression analysis depict that almost 58% and 63% of the total variation of the average AWTP for unlabelled and labeled organic vegetables respectively has been determined by the independent variables under study. Independent variables such as education and the involvement of the consumers in job or their enterprises are highly significant while family income is significant. Therefore, purchase decision of organic vegetables and willingness to pay has been governed by the personal and family income and level of education of the consumers. Same independent variables are found significantly contributing towards average AWTP for organic vegetables after being labeled. An increment of family income by 1000 NRs per month would increase average AWTP by NRs 0.116 for unlabelled organic vegetables and 0.111 for labeled organic vegetables (Table 4) compared to inorganic counterparts while keeping all other factors constant.

Table 4. Multiple regression results (Dependent variable is AWTP NRs)

Variables	Coefficients		t- Ratio		p-value	
	Without label	With labeling	Without label	With labeling	Without label	With labeling
Education	0.322	0.401	3.944	5.234	0.000**	0.000**
Age	-0.002	0.019	-0.057	0.668	0.955	0.506
Family Income('000 NRs)	0.116	0.111	2.466	2.514	0.016*	0.014*
Engagement	3.892	3.657	5.184	5.190	0.000**	0.000**
Family size	-0.070	-0.038	-0.498	-0.297	0.620	0.772
Intercept	-3.223	-1.568	-1.563	-0.810	0.122	0.420

R^2 = 0.579, AdjR^2 = 0.554 F= 23.067 p-Value= 0.000 N = 90 (For unlabelled organic vegetables)

R^2 = 0.630, AdjR^2 = 0.608 F= 28.599 p-Value= 0.000 N = 90 (For labeled organic vegetables)

Note. *, ** Significant at 0.05 and 0.01 level of probability respectively

One of the consumers' behavior studies conducted in Argentina and Denmark reports that organic consumers belong to relatively higher income strata, have knowledge about organic products and their quality and they are health conscious (FAO, 2001). Preference of buying organic vegetables by higher income group is obvious as organic products are relatively expensive but with high quality. So high income coupled with knowledge about health and consumption of quality products could motivate consumers to opt for organic consumption.

SWOT ANALYSIS

This section analyzes the Nepalese organic sector using SWOT-analysis: Strengths, Weakness, Opportunities and Threats. It provides the sector's strengths and successes, but also lists limiting factors.

Strengths

Organic production is feasible virtually throughout the country, without major adjustments to traditional production methods. Organic seed production, vegetable production, fruits production etc could be made easy under such a diverse topography, soil and climatic situations. Thanks to physical conditions that made this possibility easy. Direct market linkage with India could be other strength. Organic production has been started by the farmers themselves without government intervention. Commercial production under such private initiation could be not very difficult as these initiators have awareness and knowledge of organic farming. Market development, gradually increasing consumers' awareness about health and quality along with preference towards quality food products could provide better return to the producers. Emphasis given to the organic farming and certification in National Agriculture Policy 2061 is good strength of this sector.

Weaknesses

There exist some weaknesses limiting farmers' ability to take full benefit out of the above-mentioned strengths. Farmers' ability to invest is far below and there is virtually no support from the government in this arena. There is also dearth of technology in organic sector and many producers complain about the limited availability of bio-pesticides.

The organic sector is in embryonic stage while extension services are relatively hibernated resulting in lower than expected yields, especially during the initial years of production. Many producers start producing organically on a 'trial and error' basis, and adjust their farming methods every season until they reach an acceptable and stable level of output. Unfortunately no government support exists during the period of conversion, a practice that is common in, for example, many European countries in order to provide incentives to farmers to convert and keep them going ahead. Although number of organic consumers is increasing gradually these days, the number is still limited to justify commercial production with certification.

When deciding on whether to go for organic production and conversion thereafter, one should have a close scrutiny of different production and management methods needed in order to succeed. The generally needed conversion period of three year makes long-term planning indispensable. For such planning, a careful cost-benefits analysis should be carried out. However, none of the farmers have been found doing this. Mostly farmers do have small area under cultivation and it is uneconomical for small farmers to practice commercialization of the production. Furthermore, organic certification, which has yet to be practiced in Nepal, is too costly for small farmers to pay for it.

Opportunities

There exists good opportunity for organic farming in the urban and peri-urban areas of the country as most of the affluent consumers have been agglomerated around cities and cities are the popular destinations for the tourists. Some specialized markets have started selling organic products and some are willing to start selling organic products. There is immense scope for the organic products to be delivered to India and other countries provided quality standards have been maintained.

Growing awareness among the educated circle and increasing purchasing power could provide the ramification towards organic farming development. Organic farming requires more labour input than traditional and modern farming methods. Thus, Nepal which has a very large amount of labour unemployment and under employment will find organic farming an attraction. Moreover, the problem of periodical unemployment will also get mitigated because of the diversification of the crops with their different planting and harvesting schedules resulting in the requirement of a relatively high labour input. Eco-tourism is increasingly becoming popular and organic farms could turn into favourite spots. Protection of the ecosystem, flora, fauna and increased biodiversity and the resulting benefits to all human and living things are great advantages of organic farming which are yet to be properly accounted for.

Threats

One obvious threat factor is competition from other countries with similar advantages especially India. As Indian government provides subsidy to the farmers and they could produce same quality product in less cost and it is likely that such products could intrude Nepalese market.

Nepalese political situation is also one of the major threats in putting debar to the organic movement. Relentless government, lack of policies, weak governance system etc are exacerbating problem. No guarantee on the price of organic products is another threat to the organic growers. Until and unless farmers are assured with the handsome price of the organic products, farmers will not be motivated anymore and asking them to go through organic production remains another threat.

CONCLUSION

The interest in organic agriculture in developing countries is growing because it places more reliance on the natural and human resources available. Possibly, the greatest impact of organic agriculture is on the mindset of people. It uses traditional and indigenous farming knowledge, while introducing selected modern technologies to manage and enhance diversity, to incorporate biological principles and resources into farming systems, and to ecologically intensify agricultural production. By adopting organic agriculture, farmers are challenged to take on new knowledge and perspectives, and to innovate. This leads to an increased engagement in farming which can trigger greater opportunities for rural employment and economic upliftment. Thus through greater emphasis on use of local resources and self-reliance, conversion to organic agriculture definitely contributes to the empowerment of farmers and local communities.

Nepalese organic sector has been growing but in a sluggish manner. Private initiation and motivation by some of the NGOs are the key impetus in bringing organic sector in the mainstream agriculture development in Nepal. There is virtual lack of government support to the organic growers and marketers. It is found that before beginning cultivation of organic crops, their marketability and that too at a premium over the traditional and modern produce has to be assured. Inability to obtain a premium price, at least during the period required to achieve the productivity levels of the conventional crop will be a setback. High prices of these products remain a major deterrent for consumers. The constraints could be seen in three actors of organic production viz., at growers' level, marketers' level and government's level. Lack of awareness, lack of skills in managing complex problem in the farm land, lack of sufficient organic technology to support production, no certification and labeling, poor investment capacity, small holding, less risk bearing capacity etc are the key constraints at the growers' level. Lack of consumers' awareness about the organic products, quality and availability, lack of trust about the authenticity of the products, higher price of the products, lack of market infrastructure, no market regulation etc are the constraints at marketers' level. Failure to hammer out proper policy and poor implementation mechanism, political intervention, no subsidy to the farmers, no marketing research and technology generation to support organic sector etc are the constraints at the government's level. Despite these constraints, Nepal has ample opportunities to promote organic sector owing to its physical and natural endowment, prevailing farming practice, increasing economic profile and human and environmental health awareness and tourist destination. Although this research could open avenue for policy makers to consider key aspects in hammering policy and also for researchers to initiate further studies, there is also need to conduct research in the marketing segment as well to capture diversified consumers and benefit growers and marketers wherefrom.

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CONSUMERS' WILLINGNESS TO PAY FOR ORGANIC PRODUCTS: A CASE FROM KATHMANDU VALLEY

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ABSTRACT

This paper presents the consumers' willingness to pay a price premium for organic products in Kathmandu Valley. The Nepal Permaculture Group surveyed 180 consumers using semi-structured questionnaires to examine peoples' perception about organic products and assess their willingness to pay for such products. The study revealed that all respondents are willing to pay price premium, but the level of acceptability varied considerably. A total of 58% of the consumers are willing to pay 6- 20% price premium, whereas 13% are willing to pay up to 50% premium. The average premium was estimated about 30%. About 39% of the respondents feel the extra cost for organic products is reasonable, while 27% considered it too high. The survey also suggested that the consumption of organic products is increasing; however, product development and innovations in certification, processing, labeling and packaging are needed to further stimulate demand.

Key words: certification, consumer perception, organic products, price premium, processing, willingness to pay

INTRODUCTION

The role of organic agriculture in providing food and income is now gaining wider recognition (Van Elzakker *et al* 2007). The market of organic products is growing as the number of people willing to eat organic food and pay premium price is increasing. The future of organic agriculture will, to a large extent, also depend on consumer demand and their motive for paying extra price for organically grown food. Thus, a consumer-oriented approach to understanding the market for organic products is important for pursuing better management of organic farming. However, this is a complex process, which is determined by factors such as quality production, certification, infrastructure and market environment and policies (Aryal, 2008). It is also important to understand consumer decision-making regarding organically produced foods and seek strategies about how consumption can be promoted.

Production and marketing strategies are determined by consumer beliefs, attitudes, responses to organically grown products and the willingness to pay a premium price. Because organic products are credence goods, consumers may not know whether a product is produced using organic or conventional methods unless they are told so (Giannakas, 2002). Thus, awareness and knowledge about organically produced foods are critical in the consumer purchase decisions. Krissoff (1998) reported that consumers purchase organic products because of a perception that such products are safer, healthier and more environmentally friendly than conventionally produced alternatives. Human health, food safety along with several other product characteristics such as nutritive value, taste, freshness, appearance, and other sensory characteristics influence consumer preferences (Makatouni, 2002, Bonti-Ankomah and Yiridoe, 2006).

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In Nepal, consumption of organic foods hitherto constitutes only few percent of total food consumption of the country (Aryal, 2008 and Ranabhat, 2008). Nevertheless, the demand for organic products has increased during the recent times, especially in the Kathmandu Valley, Chitwan and Pokhara. The number of market outlets for organic products has also increased. Traders have reported that consumers are willing to pay price premiums. For further betterment of management, a more detailed study in understanding the perception of people about organic foods is required. It is also important to understand how willing people are to pay more price for organic products. A survey was initiated by The Nepal Permaculture Group (NPG) to understand consumers' perceptions on the organic products and their willingness to pay price premium. The survey was conducted in the Kathmandu valley.

OBJECTIVE

The aim of this study is to shed light on consumers' perceptions about organic products and their willingness to pay for such products. More specifically, the objectives of the study are:

- To increase understanding of consumers' awareness, attitude and perceptions towards organic products,
- To assess consumers' willingness to pay (WTP) for organic products,
- To identify factors influencing consumers' willingness to pay (WTP) for organic products, and
- To identify the major organic products and market outlets in the valley dealing with organic products.

THEORETICAL FRAMEWORK

In general, the willingness to pay a price premium decreases as the price premium increases, consistent with the law of demand. In consumer behavior theory, consumers make their own decisions to balance the marginal health utility and marginal price of one unit of quality-food products.

In this research, a simple framework was used (Fig.1) to analyze consumer behavior towards food products, which includes the willingness to pay a price premium. Consumers decide whether to buy a product or not based on three main aspects: Knowledge, Attitude and Intention. Knowledge about products and their benefits influences their willingness to pay for the products. Knowledge of people is affected by type and quality of information made available to consumers. Advertisement, quality packaging, labeling and certification play pivotal role in knowledge enrichment. Once a consumer is ready to buy, the next step is to see how much he or she is willing to pay for the product. Purchase behavior reflects the real WTP and the consumer gains positive or negative experiences which will reversely affect consumers' WTP in future. Knowledge and awareness have respectively direct and indirect effects on attitudes toward consumer to choose the products, and the willingness to pay a price premium, so they are important factors determining the demand. Thus, awareness and knowledge about organically produced foods are critical in the consumer willingness to pay more for the product.

Similarly, the framework presented in Figure 2 reflects the factors affecting consumers' attitude and willingness to purchase. Consumers' willingness to purchase is affected by exogenous factors like processing, packaging, certification and labeling and consumers' knowledge and awareness about the products. If an individual cannot clearly differentiate between two alternative products, a price premium on the organic product can confuse and/or affect the individual's purchasing decision. Consumers' education, occupation, household size along with product attributes affects their attitude and preference to buy the products. These factors further depend on consumers' household income and product price to make a decision for purchase.

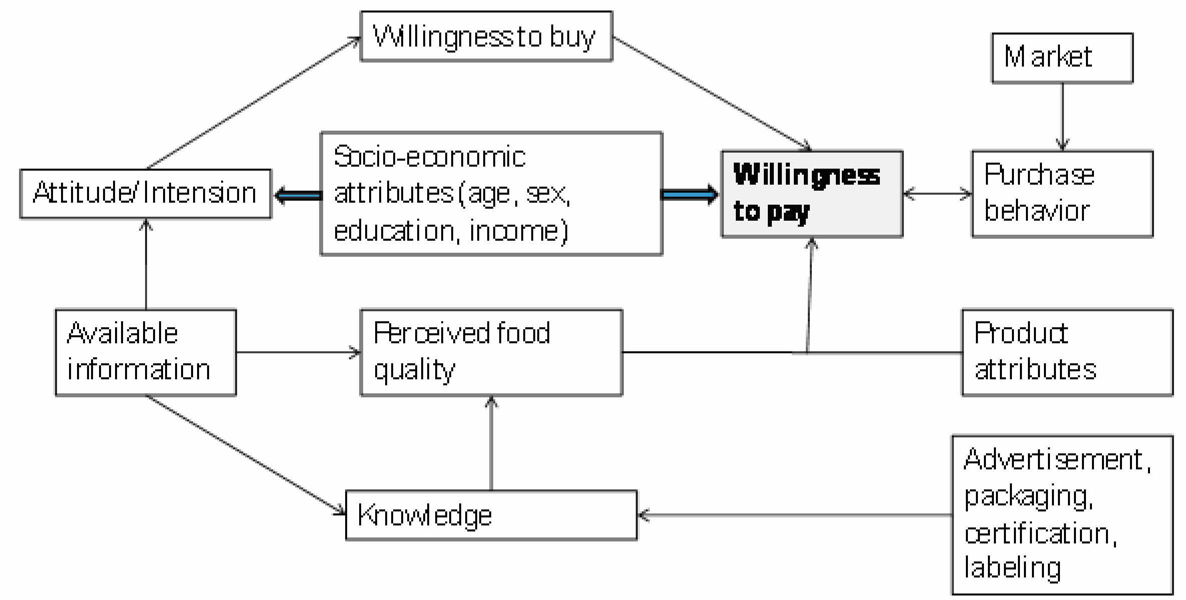


Figure 1: Framework reflecting consumer behavior towards food products (adopted from Millock (2002) and Bonti-Ankomah and Yiridoe (2006)

METHODOLOGY

The data were collected during October and November 2008 from a stratified random sample of 180 consumers in Kathmandu valley. In general, sample size depends on the characteristics of the population, the sampling techniques and selection of variables and statistical confidence levels. A general rule is that 30 individuals are sufficient for individual survey although homogenous populations require smaller samples than heterogeneous populations (Salkind 2003).

The process of individual selection was made in two stages; first, Stratified proportionate random sampling was done for identifying the consumers category within the Kathmandu valley because the study population is heterogeneous in terms of their socio-economic status. Six types of consumers with different professions were identified, based on the assumption that their profession affects their attitude, awareness, preference and willingness to pay. Our quick observation and rapid appraisal on identifying type of organic food consumers showed that there are, in general, six types of organic food consumers namely, teachers, NGO/INGOs workers, health professionals, government officials, general public buying vegetables at the Kalimati Fruit and Vegetable Wholesale Market and businessmen. Secondly, 30 individuals were randomly selected from each category for the individual interview.

A total of seven traders from Organic Village, Organic World and Fair Future (OWF), Prakriti Ghar, Appropriate Alternative Asia (AAA), Café U, Caroline Restaurant and Mikes breakfast including staff working in the outlets, were interviewed to know more about the different products available in the outlets and their current marketing status in the valley.

The purposive sampling was done to identify the traders on the basis that they are the leading supplier of organic products in the valley.

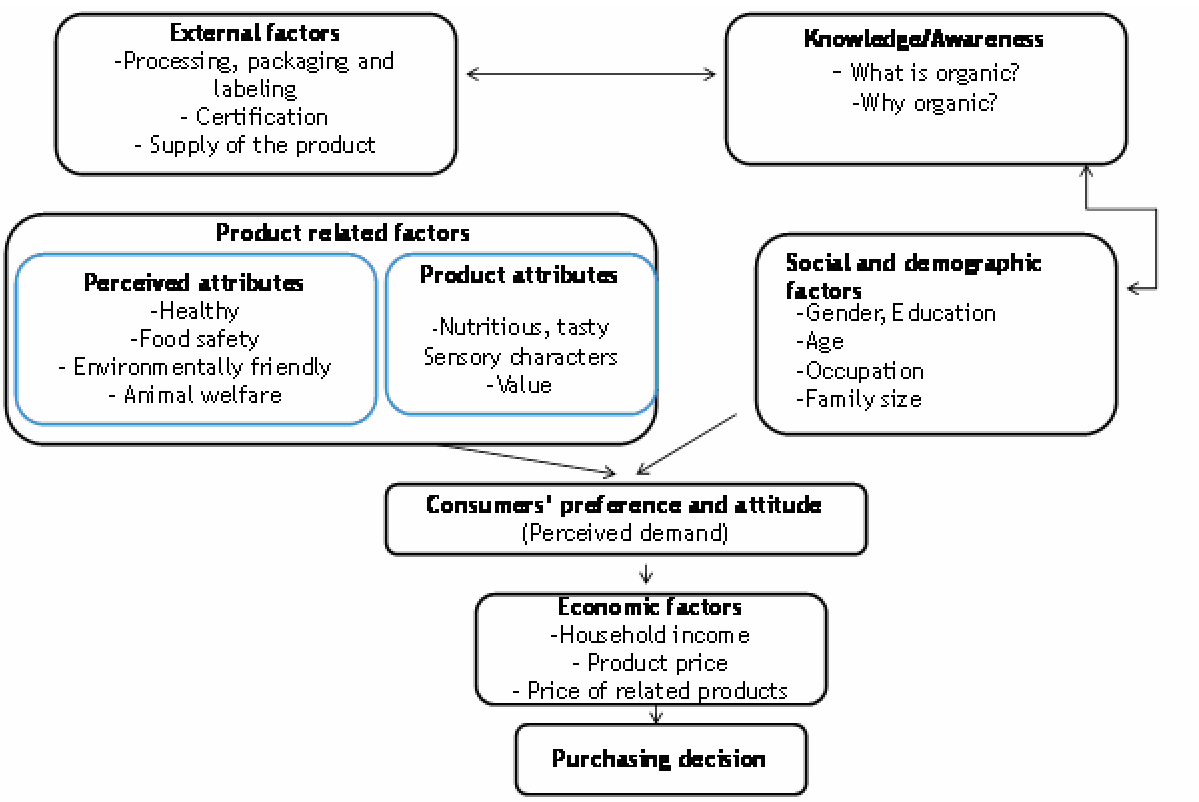


Figure 2: Framework of factors affecting organic consumers' attitudes and willingness to purchase, adopted and modified from Bonti-Ankomah and Yiridoe (2006).

The questionnaire was developed through pre-testing of each question via personal interviews with the consumers. The interviewed individuals were asked to state their interpretations of a series of suggested questions.

Data enumerators were hired for the survey. The enumerators were oriented about the questionnaire and data collection technique before they were deployed in the field. The collected data were then analyzed both quantitatively and qualitatively.

RESULTS AND DISCUSSION

MAJOR PRODUCTS MARKETED AS ORGANIC IN KATHMANDU VALLEY

The diverse ranges of organic products are marketed in Kathmandu Valley. Mr. Samir Newa, Manager of Organic village reported that they are currently selling about 40 different vegetables, 8 fruits varieties, 6 rice varieties, 6 varieties of beans and pulses and 6 items of milk products. Similarly, Juice of seabuckthorn and jam from lapsi are other highly demanded organic products available in the outlets. The major products marketed in the valley are vegetables followed by cereals and pulses. Mostly the vegetables are seasonal and the highly demanded are lettuce and tomato for salad purpose. Similarly, spinach, turnip, carrot, cabbage, leek are the major vegetables currently available as organic. In fruits, avocado, kiwi and banana are the major products available in the outlets. In rice, red rice is the most demanded product not only in country but also exported in Europe and South Africa. Mr. Newa reported that, he is selling on an average of NRs. 30,000 per day from his three outlets located in Baluwatar, Bakhundole and

Kupandole. Similarly, he has just started exporting some of the organic products like red rice, white and turtle beans, garlic and zinger powder in South Africa and earning foreign currency. According to Mr. Newa, he is able to earn around US$ 15,000 in just four months of his debut. Similarly, Mr. Prasad Chhetri, Managing Director of Organic World and Fair Future (OWF), recently established organic market outlets in the valley, mentioned that the demand for organic products is increasing in recent days. The major products available are seasonal vegetables like cauliflower, cabbage, potato, green leafy vegetables (high demand). Six varieties of rice, five different varieties of beans are the products available in both market outlets (Jhonche and Basundhara). Rhododendron juice, orange juice and seabuckthorn juice are the popular products of their outlets. Likewise, honey, coffee, sliced dry apple, zinger and garlic (both powder and fresh) are some of the better selling products. He further reported that they are selling organic products on an average of NRs 3 lakhs per month.

CONSUMER KNOWLEDGE ABOUT ORGANIC PRODUCTS

The study found that a majority (90%) of the surveyed consumers had heard about the organic products. However, they are often not sure which products are organic and which are not. This finding is in concordance with that of Bhatta *et al.* (2008), who report that about 92% of the consumers knew about organic agriculture.

The perception and understanding about organic products varies depending on the type of consumer. Business people perceived that the product will be organic if producer did not use chemical pesticides. Government officials and NGO/INGO people perceived that products are organic if there is a total absence of chemicals (fertilizers and pesticides), but there could be a use of Farm Yard Manure (FYM) and compost. Hill and Lynchehaun (2002) also reported similar findings on their study. The study found that organically produced foods are those which are naturally grown and produced by using local resources. Similarly, Teachers perceived that the product should be free from pesticide use. While the health professionals and consumers buying at vegetable market at Kalimati mentioned that organic product should be free from chemical use and other external contamination.

The results show that the knowledge and awareness level among the surveyed consumers are fairly good but not adequate. Hence, awareness raising programmes among existing and new consumers on organic products could be an effective mechanism for the promotion of organic products in future. Awareness can be increased through campaign, demonstration, public gatherings, etc. The extension services as well as government-led institutional supports in promoting organic farming are very limited (Pokhrel and Pant, 2008). Product certification is also not properly done by the government agencies. Therefore, institutional support from the government is required to develop certification process as well as branding of the products.

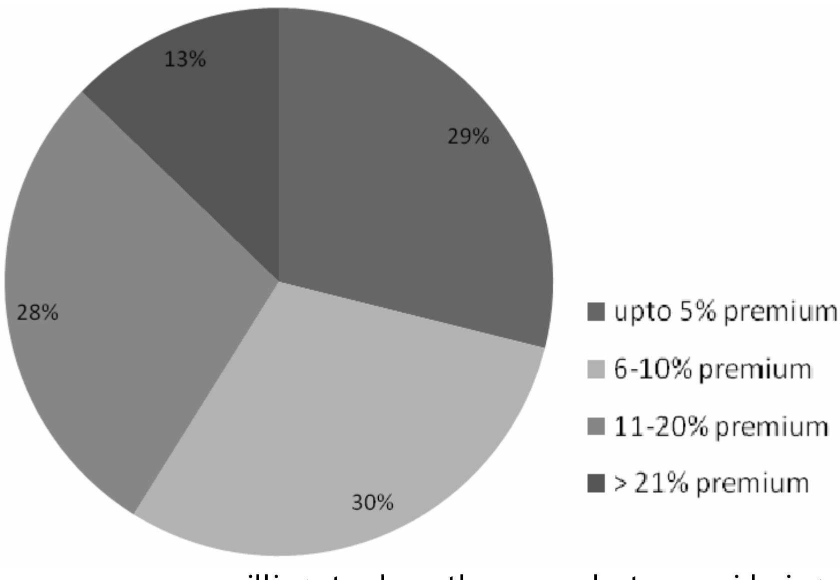
CONSUMERS' PREFERENCE ON ORGANIC PRODUCTS

We examined whether people have any preferences on crop products that are organically grown. About 42% of the respondents reported that vegetables are their first choice followed by pulses(28%) and fruit (20%). Only 10% consumers preferred rice as their first choice. The main reasons given for their preferences are health (75%), taste and palatability (18%) and good appearance and freshness (7%). The reason of health was most important for the respondents from the (I)/NGOs and health sector, followed by the government officials and teachers. It could be because educated people are more conscious about health problems caused by chemical fertilizer and pesticides.

Similar findings are reported in past by some other researchers. Bourn and Prescott (2002) reported that besides health, food safety and environmental considerations, several other product characteristics such as nutritive value, taste, freshness, appearance, color and other sensory characteristics influence consumer preferences. Bhatta *et al.* (2008) found that the majority (53%) prefer organic vegetables because of health and safety reasons, and 12% for their better taste.

CONSUMERS' WILLINGNESS TO PAY FOR ORGANIC PRODUCT

The result showed that in case of product availability, all the consumers are willing to pay higher prices for organic products. The price premium is ranging from 5% - 50% depending upon the products and consumers' willingness to buy. The current average premium is about 30%. The consumers survey revealed that 28% of the interviewed consumers (N=180) are willing to pay up to 20% price premium compared with non-organic. Similarly, 13% of the consumers like to pay between 20-50% price premiums. In comparison, 59% of consumers are not willing to pay more than 10% price premium for any organic products (Figure 3). Similar study by Asadi *et al.* (2009) in Iran reported that majority of the consumers are not willing to pay a price premium higher than 20%. The similar study by Millock (2002) in Denmark reprotedthat, 35% of the consumers are willing to pay more for any type of organic products compared to 18% of consumers who are not willing to pay for all kind of products. In this case, organic products also depends with the consumers preference which product to buy or not. Menon (2008) on his paper organic agriculture and market potential mentioned that the organic product are gaining price premium from 5% to as high as 60% in some products.



The study signaled that among the surveyed consumers category of professional, government officials and those working in NGO/INGOs are willing to pay more (Figure 4).The Government officials' willingness to pay is almost double price premium of those who are paying more than 10% premium (20 out of 30 consumers) than teachers (10 out of 30). Even if the price goes higher consumers are willing to buy these products considering less risk to their health. Sandalidon et.al (2002) has mentioned that health is the main reason for purchase of organic, followed by quality characteristic such as taste, colour and flavor. Even if the part these "safe products" play in the food consumption budget is still small, they are considered a market niche of great potential growth. The demand for such products in Kathmandu valley is increasingly growing (Aryal 2008); however, for further promotion of such products, the lack of information available to consumers; cheaper prices over those of conventional foods; and the limited and erratic domestic supply are some of the factors to be taken into consideration in future. Besides, many consumers do not trust the products which do not have well labeled and certified by established certified agencies (Ranabhat, 2008; Rodriguez et. al, 2007).

Figure 3: Consumers' willingness to pay premium price for organic products (N=180)

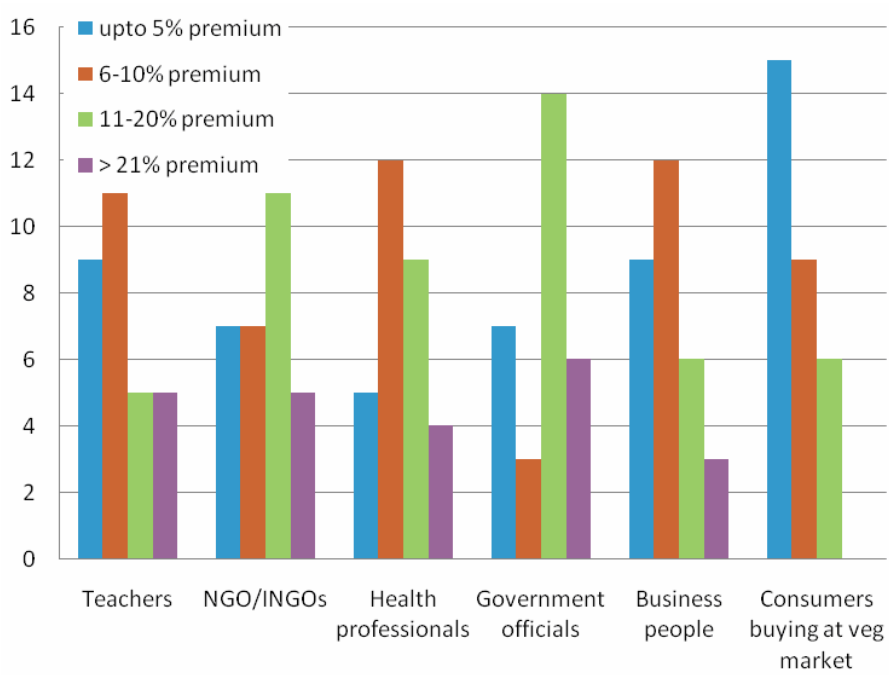


Figure 4: Consumers' willingness to pay premium price for organic products by different professions (N=30 in each category)

CONSUMERS' PERCEPTION ABOUT THE PRICE

In general, consumers' perceptions about the current price of organic product are very positive. Nearly 40% of the consumers reported that the price of organic products compared with conventional one is reasonable. In the recent days, organic products compete with conventional alternatives in the market. Consumers feel that the price depends on the market and the specific goods. Majority of the consumers reported that fresh vegetables specially the leafy one have higher price compared with other. About 27% consumers (49 individual out of 180) perceived that the average price of organic product is higher compared to conventional ones (Figure 5). The comparison with inorganic product by the consumers might be the main reason for their perception that the organic products expensive. The study findings further showed that despite of having higher price compared to conventional alternatives, many consumers continue to buy organic products. This is further supported by the study findings like consumers who usually buy organic food were more concerned about food safety than price (Shakya, 2005; Aguirre, 2001).

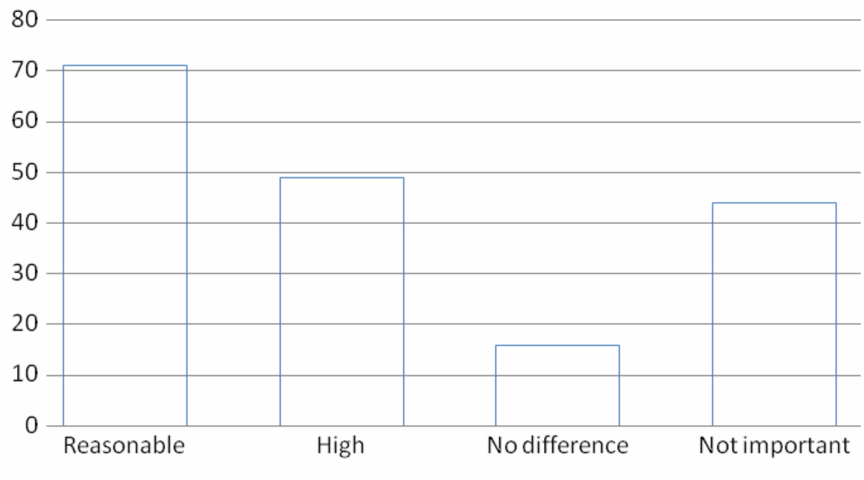


Figure 5: General perception of consumers about the price of organic products (N=180)

On the other hand, the segregated data showed that those who used to go for Kalimati think that organic products are higher in price compared with inorganic. Fifty percent of the vegetable buyers at the Kalimati Fruit and Vegetable Wholesale Market perceived that the price is higher as against 16% of government officials (Table 1). About 33% of consumers from business category and those working in NGO/INGOs expressed that higher price doesn't matter if the product is really organic. Various study supported that consumers will give second priority to the price of the products and they always look for the quality organic food. They feel that the price of organic food becomes the cost of investment in “good health” (Aryal, 2008, Menon 2008, Sandalidou et.al, 2002). Can you further elaborate why these differences among the different categories of consumers occur?

Table 1. Consumers’ perception about the price of organic products for different categories (N=30 in each category)

	Reasonable	**High**	**Not Important**	**No Difference**
Teachers	14	6	7	3
NGO/INGOs	10	8	10	2
Health professionals	10	9	8	3
Government officials	18	5	5	2
Business people	10	6	11	3
Vegetable buyers at Kalimati Market	9	15	3	3

MAJOR MARKET OUTLETS FOR ORGANIC PRODUCT MARKETING IN THE VALLEY

Organic Village and Organic World and Fair Future (OWF) are two major organic companies dealing with organic products in the valley. Besides Baluwatar, Bakhundole, Kupandole (predominantly the domain of Organic Village), Jhonche and Basundhara (OWF’s domain),there are few other market outlets for organic products. Love Green Nepal, Farmers cooperatives Gamcha, Bhatbhateeni Supermarket, Namaste Supermarket, Caroline Restaurant Mike’s Breakfast, Bluebird Super market, Kathmandu Guest house, Summit Hotel and HASERA agriculture farm are also involved in marketing different forms of organic products. Organic Bistro is a restaurant where almost all the food products are organic.

FACTORS AFFECTING CONSUMERS’ WILLINGNESS TO PURCHASE

Consumers’ willingness to purchase is influenced by various factors. The major factors identified by the consumers are lack of information available to consumers, higher prices over those of conventional foods, and the limited and erratic domestic supply. The majority (88%) of the consumers reported that they are not getting regular supply of the products which makes them frustrated to go to buy again. Besides, most of the consumers (60%) also mentioned that they do not trust the product as pure because there is no mechanism that differentiates organic from inorganic. This means there is no certified products with well label and full information. Business people reported that the organic vegetables and fruits are having less appeal. This is also supported by the study conducted by Bhatta et.al (2008). Organic products brought to market places are some time rejected by consumers due to their poor external appeal.

CONSUMERS’ VIEWS FOR THE PROMOTION OF ORGANIC PRODUCTS

Increased demand of organic foods signals that willingness of the people to pay price premium for organic products is increasing. While asking the consumers what are the key areas needed to be improved for the promotion of this sector, the answer from majority of them (89%) was that quality is the number one priority area which needs to be improved to increase the demand for organic products. The quality of the present products is not satisfactory though consumers are using such products mainly due to the health reasons. Similarly, about 75% of the consumers reported that there is urgent need to work on processing, packaging and labeling to inform the consumers. At present, consumers are buying the goods based on their trust with the traders and producers. In such cases, consumers have put forward their opinion for the certification of the products with authorized certification body. Ranabhat (2008) advocated that certification can help differentiate the organic products from other products, which can be helpful to promote organically grown products in the market. Information on the products including the nutritive value, origin, manufacture and expiry date as well as brand name whether it is pure organic or not are the important aspects of the product development and meantime will also encourage consumers to buy without any hesitation. The interviewed traders have same feelings about the information package on the product (Aryal 2008, Bhatta et.al. 2008).

The survey revealed that many people are not well aware about the availability of the organic products in the market. Those who are aware about this and buying from one store are also not well aware about other outlets where they can buy the products. It is therefore, necessary to disseminate and publicize the information widely so that all the people can have access to information and can make their own decision. More than half (60%) of the surveyed consumers reported that the supply of organic products is very low and season specific. There are various cases where consumers could not get leafy vegetables as it was finished within two hours. So, there is a very good scope to go for organic farming even in off-season production.

CONCLUSION AND RECOMMENDATION

Organically grown products are available in the markets of Kathmandu valley but in limited amounts though the growing demands are there for such products. Consumers are willing to pay price premium of 5-50% for organic products which can be viewed as the cost of investment in human health. Knowledge and awareness about organic products can affect attitudes and perceptions about the product and, ultimately, buying decisions of the consumers. Vegetables followed by fruits and beans are the most preferred and highly demanded crops at present and the price of vegetables specially the leafy ones are higher than other normal vegetables. But, quality characteristics affect consumers' preferences for organic products; with the most important including health and nutritional value, taste, and fresh and general appearance. Consumers' willingness to purchase are influenced by limited and erratic supply, higher price of the products and very limited access and information.

ACKNOWLEDGEMENTS

We wish to thank all the consumers and traders who patiently shared their time, insights and views about the organic products. Special thanks are due to Ms. Elisabeth Kerkhoff, Agro-forestry Specialist of International Centre for Integrated Mountain Development (ICIMOD) for providing comments and inputs on the paper. Finally, Nepal Permaculture Group is highly acknowledged for providing financial and logistic support for this study.

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ECONOMICS OF ORGANIC VS INORGANIC CARROT PRODUCTION IN NEPAL

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ABSTRACT

During February-April 2008, a study was conducted to compare the yield and economics of organic and inorganic carrot production and its profit volume in Chitwan district of Nepal. Face to face interview method was used to collect the primary information from randomly selected organic and inorganic carrot producers. Among the cost components, per unit cost on female labor and organic fertilizer were found to be higher in organic production system where as higher per unit cost on seed, tillage operation and male labor were found in inorganic production system. Higher cost and higher revenue was found in inorganic production system but higher benefit cost ratio was found in organic production system. This revealed that adoption of organic carrot production system was economically profitable than inorganic production system.

Key words: Benefit cost ratio, carrot, cost, gross margin, organic agriculture

INTRODUCTIOIN

In Nepal, organic agriculture is getting wider attention by government, private sector, NGOs and farmers. Previous Five Year Plan (10th FYP) and currently active National Agriculture Policy 2061 BS and Three Year Interim Plan have encouraged the cooperatives and private sectors for adoption of sustainable organic agricultural practices. Modern organic farming in Nepal is gradually increasing in terms of area coverage and production where various agricultural commodities are being produced organically and exported to the foreign market. There are about 26 organic farms registered up to 2005 covering about 45 ha of land while more than this land is estimated to be under organic farming practice as unregistered farms (Shakya, 2005). There are many farmers who are adopting the modern organic farming practices individually or through group and cooperative in Nepal but their database are not available. Among them, Organic Agriculture Producers Cooperative is probable the first cooperative in organic agriculture sector in Nepal where more than 80 farmers are organized and are adopting the organic farming practice and supplying the produce to the local and national market. Organic Agriculture is cost effective, affordable and does not require expensive technical investment but provides more employment opportunity. It is a viable solution to preventing global hunger by providing comparatively higher yields from low input agriculture in food deficit regions (Lue, 2004).

Comparative profitability of conventional or inorganic and organic agricultural production practices varies due to wide range of production methods used in different regions and with different crops, and because of the variable organic price premiums (Cook *et al.*, 1989). In most instances, costs per unit area are generally, but not always, higher for conventional methods. The profitability of organic methods usually depends on price premiums. In a study of grain farms, Cacek and Langner (1986) found that organic farming equaled or exceeded conventional farming in economic performance. Similarly, Scialabba (2006) found that the productivity of organically grown carrot yield is found higher (27.97ton/ha) than that of inorganically grown carrot (26.30 ton/ha).

Some people view organic farming as a primitive, inefficient method but today's organic farmers utilize some of the latest technologies including genetically superior plants,

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biological pest controls and advanced mechanization. In some situations organic farmers may be less vulnerable to natural and economic risks than conventional farmers since their systems are usually more diversified (Olson *et. al.,* 1982). It is claimed that the widespread adoption of organic farming methods could result in rural revitalization, regional self-sufficiency in food production and changes in the existing "capital-intensive structure of agriculture".

Carrots (*Daucus carrota* var. *sativus*) have been successfully produced and marketed in Chitwan for the past 20 years especially for fresh consumption in salads. It is grown in cool winter season after harvest of rice in low lands while after maize in rainfed upland areas. Since last 4/5 years, both organic and inorganic carrot production system is common in Chitwan however the market is same for both categories of the carrot. Despite the lack of separate market and premium price for good quality organic carrot, farmers are encouragingly practicing organic production system. This study was intended to compare the cost associated with different factors of production and the return from organic and inorganic carrot production system in the region.

METHODOLOGY

This study was mainly based on primary information collected from the farmers of Phoolbari, Shivanagar and Mangalpur Vilage Development Committees (VDCs) of Chitwan district of Nepal. Those VDCs were purposively selected for the study due to availability of organic and inorganic carrot growers. Sampling frame was prepared from key informants interview and record of Organic Agriculture Producers Cooperative, Chitwan. Out of 55 organic carrot growers from three VDCs, 30% from each VDCs were selected as study sample by using simple random sampling method. For comparison, equal numbers of inorganic farmers were taken from each VDC.

Table1. Population and sample of organic and inorganic carrot growers

Area	Organic		Inorganic
	Population	Sample	Sample
Phoolbari	40	12	12
Shivanagar	9	3	3
Mangalpur	6	2	2
Total	55	17	17

Primary information was collected by using pre-tested interview schedule, applying face-to-face interview method. The collected information were first tabulated, coded and entered onto computer. All the local measurements were converted into standard unit and final analysis was done by using computer software packages: Microsoft Excel and Statistical Package for Social Science (SPSS).

COST OF PRODUCTION AND GROSS MARGIN

Carrot is a short duration crop and does not require fixed cost bearing inputs except land. So, sum of total variable costs was assumed as total cost of production and it was calculated by using following formula.

$C_p = C_{seed} + C_{fert} + C_{tillage} + C_{labor} + C_{others}$

Where,

C_p = cost of production

C_{seed} = cost on seed

C_{fert} = cost on fertilizer

= [cost on organic fertilizer (C_{of}) + cost on inorganic fertilizer (C_{iof})]

$C_{tillage}$ = cost on tillage operation

= [cost on bullock (C_b) + cost on tractor (C_t)]

C_{labor} = cost on human labor

= [cost on male labor (C_{ml}) + cost on female labor (C_{fl})]

C_{others} = cost on other inputs like herbicides, growth regulators, packaging, and transport

The gross margin is the difference between the gross return and the total variable cost incurred i.e.

Gross margin = Gross return - total variable cost

BENEFIT COST RATIO ANALYSIS

Benefit cost ratio is the ratio between gross margin and total cost of any enterprise. In this study, benefit cost ratio was calculated by using the formula:

$$B/C \quad ratio \quad = \quad \frac{Gross \quad margin}{Total \quad cost}$$

RESULT AND DISCUSSION

COST ANALYSIS

Comparing the cost on different inputs by production system, per hectare cost on tillage operation was lower in organic production system but cost on bullock was significantly higher (NRs. 11295.06/ha) than inorganic system (NRs. 8221.90/ha). On the other hand, cost on tractor use was significantly higher in inorganic system (NRs. 13622.05/ha) than organic system (NRs. 7538.97/ha). Only organic fertilizes were used in organic production system while both organic and inorganic fertilizers were used in inorganic production system. Comparing the cost on fertilizers, per hectare cost on organic fertilizer was significantly higher (NRs.26302.73) in organic production system and cost on inorganic fertilizer was found significantly higher (NRs.6203.38/ha) in inorganic production system. However, per hectare total cost on fertilizer was found to be higher in organic production system (NRs.26302.73) than that of inorganic system (NRs.21770.91).

The study showed that per hectare cost on seed was found significantly higher in inorganic production system (NRs.14743.87) than organic production system (NRs.12230.04). Similarly, per hectare cost on labor was higher (NRs.31630.35) in organic production system than inorganic production system (NRs.32054.82) within which female labor cost was higher in organic production system and male labor cost was higher in inorganic production system. Cost on other inputs like herbicides, growth regulators and growth promoting hormones was found to be significantly more in inorganic production system (NRs. 4442.15/ha) than organic production system (NRs.1409.66/ha).

Table 2. Contribution of different cost items to total cost of carrot production (NRs/ha)

Cost items	Organic system	Inorganic system	t-statistics
Tractor cost (C_t) [a]	7538.97	13622.05	-2.984*
Bullock cost (C_b) [b]	11295.06	8221.90	2.316*
Total tillage ($C_{tillage}$) [c = a+b]	18834.03	21843.96	-1.387
Organic fertilizer (C_{of}) [d]	26302.73	15567.52	4.627*
Inorganic fertilizer (C_{iof}) [e]	0.00	6203.38	-17.721*
Total fertilizer (C_{fert}) [f = d+e]	26302.73	21770.91	1.929
Seed (C_{seed}) [g]	12230.04	14743.87	-1.829
Male labor (C_{ml}) [h]	5505.35	6834.05	-1.568
Female labor (C_{fl}) [i]	26125.00	25220.76	.715
Total labor cost (C_{labor}) [j = h+i]	31630.35	32054.82	-.359
Other cost (C_{other}) [k]	1409.66	4442.15	-4.56*
Total Cost of production (Cp) [C_p = c + f + g + j + k]	90406.84	94855.73	-1.156

Note: figures in parenthesis indicate the percentage

*significant at 95%level of confidence ($P \le 0.05$)

RETURN ANALYSIS

From the study, it was found that carrot production was 284.85 quintal per hectare in organic system which was insignificantly lower than that of inorganic production system (i.e. 290.71Q/ha). Average per unit price for both organic and inorganic carrot was found equal i.e. NRs. 798.52 /quintal. Per hectare revenue from carrot production was found to be lower in organic system (Nrs. 227832.77) than that from inorganic system (NRs. 231383.58) though the difference is insignificant. In contrast to production and revenue, higher gross margin was found in organic production system (NRs.137425.92/ha) than inorganic production system (NRs.136527.84/ha).

Table 3. Comparison of output and revenue in organic and inorganic carrot production

Particulars	Organic	Inorganic	t-statistics
Production (Q/ha)	284.84	290.71	-.387
Average price	798.52	798.52	0.00
Revenue (NRs/ha)	227832.77	231383.58	-.226
Gross margin (NRs/ha)	137425.92	136527.84	.074

BENEFIT COST RATIO ANALYSIS

Benefit cost ratio is the quick and easiest method to determine the economic performance of farm business. Though, average total cost, average production and average total revenue were higher in inorganic production system, the gross margin i.e. difference between average revenue and total cost is higher in organic production system. From this study, higher benefit cost ratio was found in organic carrot production system (1.52) than that of inorganic carrot production system (1.44).

Table 4. Benefit cost ratio analysis of organic and inorganic carrot production

Particulars	Organic	Inorganic
Gross margin (NRs./ha)	137425.92	136527.84
Total cost (NRs./ha)	90406.84	94855.73
Benefit-cost ratio	1.52	1.44

MARKETING

From the study, it was found that there were no separate market, marketing channel, marketing system and premium price for organic carrots. Therefore, both organic and inorganic carrot follows the same marketing system. Selling of carrot from the farm gate to the contract buyers was most commonly practiced followed by selling to wholesale market. Contract buyers transport carrot right from the field. While in selling to wholesale market, farmers transport the produce by cycle, tractor or auto. Following was the most common marketing channel for both organic and inorganic carrot marketing for the study site.

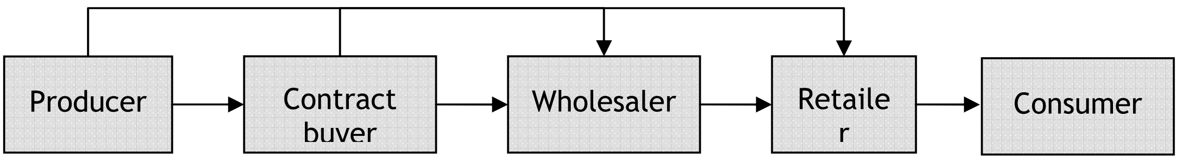

Figure1. Marketing channel of carrot in Chitwan

CONCLUSION

This study revealed that growing carrot is a remunerative and successful agro-enterprise during cool winter season in Chitwan district of Nepal. While comparing the organic and inorganic carrot production system on per unit area basis, cost of production, productivity and gross revenue was higher in inorganic system which favors the adoption of inorganic agricultural practices. But, In contrast with these figures, higher gross margin (or profit margin) in organic production system suggests for the adoption of organic farming practice for carrot production. More than this, from economic view point, higher benefit cost ratio in organic production system recommends for widespread adoption and commercialization of it. In short, this study concludes that adoption of organic carrot production is economically profitable and holds comparative advantage than inorganic production system. Thus, adoption of organic carrot production system is recommended. On the other hand, governments policy and plan for separate market establishment and fixing the price premium are also recommended for wider adoption of organic agricultural practices in general and organic carrot production in particular.

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HYPERACCUMULATION AND MOBILITY OF HEAVY METALS IN VEGETABLE CROPS IN INDIA

Nirmal Kumar J.I.[1]*, Hiren Soni[2], Rita N. Kumar[3] and Ira Bhatt [4]

ABSTRACT

The heavy metals or trace elements play an important role in the metabolic pathways during the growth and development of plants, when available in appreciable concentration. The heavy metal concentration of Cadmium (Cd), Cobalt (Co), Copper (Cu), Iron (Fe), Nickel (Ni), Lead (Pb) and Zinc (Zn) was analyzed using Inductive Coupled Plasma Analyzer (ICPA) (Perkin-Elmer ICP Optima 3300 RL) in 18 vegetable crop plants and their parts along with their soil, collected from various agricultural fields around Anand province, Gujarat, India. The vegetables crop plants were Anthem (*Anthum graveolens*), Beat (*Brassica oleracea*), Bitter Gourd (*Momordica charantia*), Brinjal (*Solanum melongena*), Cauliflower (*Brassica oleracea* var. *botrytis*), Chilli (*Capsicum annum*), Coriander (*Coriandrum sativum*), Fenugreek (*Trigonella foenum-graceum*), Garlic (*Alium sativum*), *Coccinia indica*, Lufa (*Luffa acutangula*), Lady's Finger (*Abelmoschus esculentus*), Mint (*Mentha piperata*), Radish (*Raphanus sativum*), Spinach (*Spinacia oleracea*), Tomato (*Lycopersicum esculentum*), Vetches (*Cyamopsis soralioides*) and White Gourd (*Lagernaria vulgaris*). The Accumulation Factor (AF) and Mobility Index (MI) were calculated for assessment of mobility of heavy metals from soil to various plant parts: roots, stems and leaves through different levels: Level 1 (Soil-Roots), Level 2 (Roots-Stems) and Level 3 (Stems-Leaves) in studied vegetable crop plants. The results showed concentration dependent variables of heavy metal levels among vegetable crop plants. The lower and higher concentration gradient alongwith their mobility gradient was also determined. A perusal of data reflects that accumulation gradient of each crop plant component vary according to their nature, properties and podsol climate of a particular crop plant. The data on accumulation and mobility of heavy metals such as Cd, Co, Cu, Fe, Ni, Pb and Zn from soil to leaves through roots and stems, suggested that all the metals were highly mobile.

Key words: Vegetable crop plants, heavy metals, accumulation factor, mobility index

INTRODUCTION

The accumulation of metal ions by root systems is a key function in terrestrial plants, which exhibit extensive ramifications through soil. Distribution of heavy metals in plant body depends upon availability and concentration of heavy metals as well as particular plant species and its population (Punz and Seighardt, 1973). For instance, roots usually show higher heavy metal concentration than shoots, because they are the origin, which comes into contact with the toxic metals present in the soil (Breckle, 1991).

In recent past, Bunzl *et al.* (2001) investigated soil to plant transfer of heavy metals like, Cu, Pb and Zn by vegetables. Studies on heavy metal uptake reveled that vegetables grown at environmentally contaminated sites in Addis Ababa, Tanzania, could take up and accumulate metals at levels that are toxic to human health. Metal uptake differences by leafy vegetables are attributed to plant differences in tolerance to heavy metals (Itanna, 2002). Cadmium, copper and nickel levels in vegetables from industrial and residential areas of Lagos City, Nigeria was studied by Yusuf *et al.* (2002), which revealed that levels of Cd, Cu and Ni in different edible vegetables alongwith its soils on which they were grown were

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higher in industrial areas than those of the residential areas due to pollution. Trace element and heavy metal concentrations in fruits and vegetables of the Gediz River region were intensively studied by Delibacak *et al*. (2002). Also edible portions of five varieties of green vegetables *viz*. Amaranth, Chinese Cabbage, Cowpea leaves, Leafy Cabbage and Pumpkin leaves collected from several areas in Dar Es Salaam, Africa were analyzed for Pb, Cd, Cr, Zn, Ni and Cu. There was a direct positive correlation between Zn and Pb levels in soils with levels in vegetables. The relation was absent for other heavy metals (Othman *et al*. 2002).

In India, similar kind of study was undertaken. Somasundaram *et al*. (2003) conducted research on heavy metal content of plant samples of sewage-irrigated area of Coimbatore district, Karnataka. Leafy vegetables were found with very high levels of heavy metal contamination including Cd, Zn, Cu, Mn and Pb. A similar research conducted at Delhi on `Vegetables eating up vegetarians' found the presence of deadly heavy metals in vegetable samples collected across the capital (The Hindu, 2003).

Rana and Nirmal Kumar (1988) observed heavy metal concentration through Energy Dispersive Analysis of X-Rays (EDAX) in certain sediments in Central Gujarat and noticed that Fe content was found highest in sediment of Undeva region, followed by presence of Si and Al., and Nirmal Kumar *et al*. (1989) have also investigated elemental composition of certain aquatic plants by EDAX, and found high level of heavy metals such as Al, Si, Mn and Fe accumulated in *Vallisnaria spiralis*, *Hydrilla verticillata and Azolla pinnata*. Nirmal Kumar and Rita Kumar (1997) investigated elemental composition of certain economically important plants by EDAX, and encountered the greater accumulation of heavy metals like Fe, Cu and Zn in *Mangifera indica*, *Annona squamosa* and *Manilcara hexandra*, respectively. Nirmal Kumar *et al*. (2007, 2008) analysed concentrations of different heavy metals (Cd, Co, Cu, Ni, Pb, Zn) in market vegetables of Anand vegetable market, Anand town, Gujarat, India, and found that accumulation of heavy metals were higher in *Alium cepa* (Cd, Pb), *Brassica oleracea* var. *botrytis* (Co, Cu, Fe), *Cyamopsis soralioides* (Ni), *Cucumis sativus* (Zn). Leita *et al*. (1991), Prince *et al*. (2001) and Nivethitha *et al*. (2002) have emphasized utilization of heavy metal accumulating plants in reclamation of contaminated soil with heavy metals and assessment of heavy metal mobility in terrestrial ecosystem particularly trophic level of higher plants. However, scanty literature is available on the accumulation and mobility of heavy metals from soil to different vegetable crop plant components. Therefore, the present study was undertaken to visualize the trend of heavy metals in vegetable crop plants and their mobility in various vegetable crop plant components through soil gradient in Anand province, Gujarat, India.

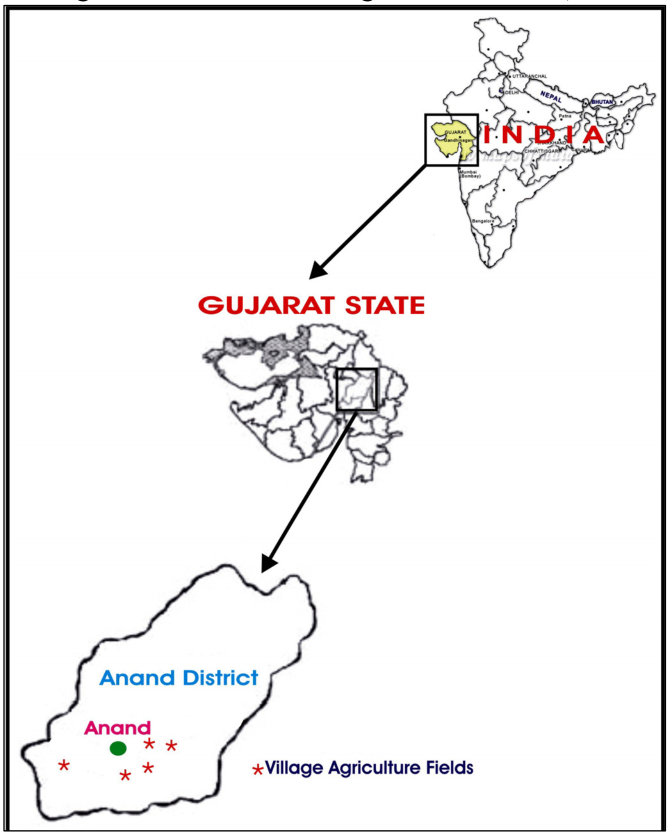

Figure 1: Map showing collection sites

MATERIALS AND METHODS

In the present study, 18 fresh vegetable crop plants were collected alongwith their soil from various agricultural fields around Anand province, Gujarat, India (Fig. 1) and brought to the laboratory. The common vegetable crop plants were *Abelmoschus esculentus*, *Alium sativum*, *Anthum graveolens*, *Brassica oleracea*, *Brassica oleracea var. botrytis*, *Capsicum annum*, *Coccinia indica*, *Coriandrum sativum*, *Cyamopsis soralioides*, *Lagernaria vulgaris*, *Luffa acutangula*, *Lycopersicum esculentum*, *Mentha piperata*, *Momordica charantia*, *Raphanus sativum*, *Solanum melongena*, *Spinacia oleracea* and *Trigonella foenum-graceum*. Rhizosphere soil samples for extractable element analysis were also collected from 0 to 20 cm depth from selected agricultural fields and extracted with DTPA (Di-ethylene Triamine Penta-acetic Acid), filtered through Whatman filter paper No. 42, and analyzed for element concentration (Lindsary and Norvell, 1978).

All vegetable crop plants were rinsed in double distilled water gently; moisture and water droplets were removed with the help of blotting papers; separated into roots, stems and leaves, and dried before grinding to fine powder. Approximately 0.5 gm of dry powder was weighed by electronic digital monopan balance (Shimadzu Co. BL 22 OH E-455000083, Japan), and digested with HNO_3, H_2SO_4 and H_2O_2 at the ratio of 2:6:6 as prescribed by Saison *et al*. (2004). Towards the end of digestion, the flasks were brought to near dryness. The solutions were made to 20 ml each in a measuring cylinder with double distilled water. The blanks were run with set; the samples were then ready for analysis in Industrial Coupled Plasma Analyzer (ICPA) (Perkin-Elmer ICP Optima 3300 Rl). The concentration of heavy metals such as Cd, Co, Cu, Fe, Ni, Pb and Zn were analyzed and calculated in $\mu g\ g^{-1}$ in duplicate samples.

As total heavy metal concentration of soils is poor indicator of metal availability for plant uptake, accumulation factor was calculated based on metal availability and its uptake by a particular plant (Brooks *et al*., 1977). The whole experiment was divided into three categories: Level 1 (Soil-Roots), Level 2 (Roots-Stems) and Level 3 (Stems-Leaves).

Accumulation Factor for plants was calculated as:

$$\text{Accumulation Factor (AF)} = \frac{\text{Mean Plant Concentration } (\mu g\ g^{-1}) \text{ (Roots+Stems+Leaves)}}{\text{Mean Soil available } (\mu g\ g^{-1}) \text{ Concentration}}$$

Mobility Index (MI) was calculated for each level by using the formula:

$$\text{Mobility Index (MI)} = \frac{\text{Concentration of Metal } (\mu g\ g^{-1}) \text{ in the receiving level}}{\text{Concentration of Metal } (\mu g\ g^{-1}) \text{ in the source level}}$$

RESULTS AND DISCUSSION

Accumulation and mobility of heavy metals (Cd, Co, Cu, Fe, Ni, Pb and Zn) in vegetable crop plants as a function of concentration are presented in Table 1.

ACCUMULATION OF HEAVY METALS

During the present study, heavy metals such as Cd, Co, Pb, Ni, Cu, Zn and Fe were accumulated in particular crop plant components in a very high concentration. It was observed that high content of Cd was accumulated in roots of *C. sativum* (0.048), Co in *B. oleracea var. botrytis* roots (0.318), Pb in roots of *C. sativum* (0.401), Ni in *C. sativum* roots (1.63), Cu in *A. sativum* roots (2.10), Zn in roots of *C. sativum* (7.55) and highest concentration of Fe was found accumulated in roots of *C. sativum* (83.70). Heavy metals also accumulated in stems at different concentrations. Present study revealed that Cd content was found greater in stems of *C. annum* (0.021), Co in stems of *C. sativum* (0.076), Pb in *A. graveolens* stems (0.500), Ni (0.875) in *B. oleracea var. botrytis*, Cu (1.26) in stems of *M. piperata*, Zn (3.95) in stems of *A. graveolens* and maximum content of Fe was recorded in stems of *C. sativum* being 25.78. High content of Cd was accumulated being 0.015 in leaves of *A. esculentus*, Pb (0.325) in leaves of *R. sativum*, Co (0.387) in *C. sativum* leaves, Ni (1.50) in *M. charantia* leaves, Cu (1.78) in leaves of *C. sativum*, Zn (9.43) in leaves of *T. foenum-graceum* and high content of Fe was accumulated being 89.14 in *C. sativum* leaves. Thus higher accumulation factor of heavy metals in various plant components particularly in roots, stems and leaves could be found as Cd > Co > Pb > Ni > Cu > Zn > Fe (Table 1).

On the other hand, it was observed that heavy metals such as Cd, Co, Pb, Ni, Cu, Zn and Fe were present in a low concentration in particular crop plant component. The lowest concentration of Cd was found in roots of *B. oleracea var. botrytis* (0.003), Co content in *C. indica* roots (0.005), Pb in roots of *B. oleracea var. botrytis* (0.031), Ni in *C. indica* roots

(0.282), Cu in *R. sativum* roots (0.361), Zn in roots of *A. esculentus* (1.29) and low level of Fe was found in roots of *L. acutangula* (4.10). Stems also accumulated heavy metals upto certain concentration. Present findings revealed that Cd content was found lowest in stems of *M. charantia*, *C. indica* and *M. piperata*, Co in *A. esculentus*, Pb in *M. charantia*, Cu in *C. annum*, Ni in *A. sativum*, Zn in *L. acutangula* and Fe in *M. charantia* (2.01). Cd content was very low in leaves of *L. acutangula* (0.001), Co in *A. esculentus* leaves (0.004), Pb in leaves of *M. charantia* (0.042), Cu in leaves of *M. piperata* (0.058), Ni in *A. graveolens* leaves (0.199), Zn in leaves of *B. oleracea* (1.82) and low concentration of Fe was found in *A. sativum* leaves (5.62). Thus, poor accumulation factor of heavy metals in different crop plant components particularly in roots, stems and leaves could be shown as Cd > Co > Pb > Ni > Cu > Zn > Fe (Table 1).

In all vegetable crop plants, heavy metal content in plant components was found higher compared to available metal concentration in soil. Cd content was found lowest (0.14) in *M. charantia* and highest (4.27) in *L. vulgaris*. Low values of Co and Cu were observed in *C. indica* being 0.04 and 0.21, respectively, while high content of both the elements were recorded in *C. soralioides* being 3.59 and 2.66, respectively. Poor concentration of Fe was observed in *A. sativum* (0.02), and high Fe conent was noticed in *C. soralioides* (2.40). On the other hand, *S. oleracea* was found to contain low concentration (0.19) of Ni, while high content (1.25) of the same metal was registered in *C. sativum*. *M. charantia* exhibited low concentration of Pb and Zn being 0.22 and 0.15, respectively, while higher content (6.81) of Pb was found in *M. piperata* and low content was observed in *T. foenum-graceum* being 1.98. Thus heavy metal content (µg g^{-1}) in vegetable crop plants ranged from 0.14 to 3.69 (Cd), 0.04 to 0.42 (Co), 0.21 to 1.17 (Cu) and 0.02 to 0.40 (Fe), while in case of Ni, the concentration ranged from 0.39 to 1.25, Pb (0.22 to 6.81) and Zn (0.15 to 1.98).

In all vegetable crop plants, Cd content was higher in plant components compared to available Cd level in soil, which might be due to the high uptake and accumulation rate. Similar findings were noticed by Prince *et al.* (2001). Among all vegetable crop plants, Fe concentration was higher in all three-plant components, could be due to iron-rich soil (Nivethitha *et al.*, 2002; Nirmal Kumar *et al.*, 2007). Mechanism of metal accumulation was found significant in terms of accumulation factor of a particular plant component. Roots showed high accumulation of heavy metals (6.39), followed by moderate

Table 1: Accumulation and mobility indices of heavy metals in vegetable crop plants colleted from village farms around Anand province, Gujarat, India

Sr. No.	NAME OF THE PLANT (µg g⁻¹)	Cd*	Transport of Cd S-R L1	R-S L2	S-L L3	AF	Co*	Transport of Co S-R L1	R-S L2	S-L L3	AF	Cu*	Transport of Cu S-R L1	R-S L2	S-L L3	AF
1.	*Anthum Graveolens*	0.006	0.023	0.020	0.008	2.82	0.329	0.100	0.064	0.021	0.19	1.359	0.910	0.947	0.239	0.51
	MI		3.90	0.85	0.39			0.30	0.64	0.32			0.67	1.04	0.25	
2.	*Brassica oleracea*	0.009	0.013	0.010	0.008	1.13	0.400	0.135	0.015	0.050	0.17	1.322	1.066	0.636	0.567	0.57
	MI		1.44	0.73	0.84			0.34	0.11	3.29			0.81	0.60	0.89	
3.	*Momordica charantia*	0.045	0.015	0.002	0.002	0.14	0.271	0.045	0.004	0.013	0.08	1.768	0.692	0.344	0.266	0.25
	MI		0.33	0.13	1.30			0.17	0.09	3.25			0.39	0.50	0.77	
4.	*Solanum melongena*	0.011	0.009	0.009	0.010	0.86	0.288	0.214	0.015	0.022	0.29	1.323	0.984	0.721	1.031	0.69
	MI		0.83	0.96	1.20			0.74	0.07	1.51			0.74	0.73	1.43	
5.	*Brassica oleracea var. botrytis*	0.007	0.003	0.008	0.008	0.93	0.324	0.318	0.051	0.022	0.40	1.089	1.424	0.450	0.369	0.69
	MI		0.45	2.61	0.99			0.98	0.16	0.43			1.31	0.32	0.82	
6.	*Capsicum annum*	0.008	0.014	0.021	0.006	1.72	0.400	0.124	0.010	0.047	0.15	1.396	0.944	0.139	0.236	0.32
	MI		1.75	1.52	0.28			0.31	0.08	4.60			0.68	0.15	1.69	
7.	*Coriandrum sativum*	0.007	0.048	0.019	0.013	3.69	0.578	0.258	0.076	0.387	0.42	1.267	1.724	0.965	1.777	1.17
	MI		6.63	0.40	0.69			0.45	0.29	5.13			1.36	0.56	1.84	
8.	*Trigonella foenum -graceum*	0.015	0.026	0.014	0.014	1.18	0.351	0.223	0.045	0.036	0.29	1.164	1.193	0.419	0.508	0.61
	MI		1.70	0.55	0.96			0.63	0.20	0.81			1.02	0.35	1.21	
9.	*Allium sativum*	0.007	0.016	0.007	0.007	1.51	0.483	0.189	0.047	0.019	0.18	1.711	2.102	0.186	0.545	0.55
	MI		2.48	0.40	1.04			0.39	0.25	0.40			1.23	0.09	2.93	

Sr. No.	NAME OF THE PLANT (µg g⁻¹)	Fe*	Transport of Fe S-R L1	R-S L2	S-L L3	AF	Ni*	Transport of Ni S-R L1	R-S L2	S-L L3	AF	Pb*	Transport of Pb S-R L1	R-S L2	S-L L3	AF	Zn*	Transport of Zn S-R L1	R-S L2	S-L L3	AF
1.	*Anthum Graveolens*	55.23	30.767	18.724	5.980	0.33	1.528	1.012	0.790	0.199	0.44	0.147	0.284	0.500	0.069	1.93	4.89	5.130	3.948	3.026	0.82
	MI		0.56	0.61	0.32			0.66	0.78	0.25			1.93	1.76	0.14			1.05	0.77	0.77	
2.	*Brassica oleracea*	265.05	36.630	8.838	15.160	0.08	0.809	0.664	0.389	0.351	0.58	0.155	0.160	0.143	0.101	0.87	5.16	3.477	1.970	1.816	0.47
	MI		0.14	0.24	1.72			0.82	0.59	0.90			1.03	0.90	0.70			0.67	0.57	0.92	
3.	*Momordica charantia*	128.63	18.055	2.009	13.041	0.09	0.702	0.705	0.230	1.496	1.15	0.291	0.123	0.031	0.042	0.22	28.41	6.518	1.192	4.659	0.15
	MI		0.14	0.11	6.49			1.00	0.33	6.50			0.42	0.25	1.35			0.23	0.18	3.91	
4.	*Solanum melongena*	71.99	75.670	5.344	5.670	0.40	0.581	0.609	0.750	0.501	1.07	0.083	0.262	0.189	0.203	2.62	13.53	2.892	2.666	4.732	0.25
	MI		1.05	0.07	1.06			1.05	1.23	0.67			3.14	0.72	1.07			0.21	0.92	1.77	
5.	*Brassica oleracea var. botrytis*	106.66	38.965	6.606	21.197	0.21	0.676	0.765	0.875	0.237	0.93	0.100	0.031	0.152	0.249	1.44	3.59	3.613	2.078	2.350	0.75
	MI		0.37	0.17	3.21			1.13	1.14	0.27			0.31	4.90	1.63			1.01	0.58	1.13	
6.	*Capsicum annum*	279.77	11.263	6.053	23.076	0.05	0.854	0.750	0.435	1.436	1.02	0.164	0.147	0.072	0.111	0.67	5.44	2.949	2.295	7.809	0.80
	MI		0.04	0.54	3.81			0.88	0.58	3.30			0.90	0.49	1.54			0.54	0.78	3.40	
7.	*Coriandrum sativum*	693.02	83.704	25.782	89.145	0.10	0.856	1.628	0.673	0.918	1.25	0.164	0.401	0.094	0.184	1.38	2.98	7.549	3.094	3.831	1.61
	MI		0.12	0.31	3.46			1.90	0.41	1.36			2.45	0.23	1.95			2.53	0.41	1.24	
8.	*Trigonella foenum -graceum*	351.87	75.155	11.695	20.261	0.10	0.556	0.962	0.339	0.386	1.01	0.184	0.212	0.163	0.273	1.17	3.14	5.292	3.940	9.430	1.98
	MI		0.21	0.16	1.73			1.73	0.35	1.14			1.15	0.77	1.68			1.68	0.74	2.39	
9.	*Allium sativum*	643.88	26.177	15.411	5.622	0.02	0.735	0.820	0.197	0.357	0.62	0.196	0.315	0.137	0.147	1.02	2.81	4.052	3.766	2.459	1.22
	MI		0.04	0.59	0.36			1.12	0.24	1.81			1.61	0.43	1.07			1.44	0.93	0.65	

* Concentration of heavy metal in soil, S-R: Soil to Root, R-S: Root to Stem, S-L: Stem to Leaf, L1: Level 1, L2: Level 2, L3: Level 3, AF: Accumulation Factor, *MI*: Mobility Index

\# All the values are expressed in $\mu g\ g^{-1}$

Table 1 continued...

Sr. No.	NAME OF THE PLANT ($\mu g\ g^{-1}$)	Cd*	Transport of Cd			AF	Co*	Transport of Co			AF	Cu*	Transport of Cu			AF		Transport of Fe			AF	Ni*	Transport of Ni			AF	Pb*	Transport of Pb			AF	Zn*	Transport of Zn			AF
			S-R L1	R-S L2	S-L L3			S-R L1	R-S L2	S-L L3			S-R L1	R-S L2	S-L L3			S-R L1	R-S L2	S-L L3			S-R L1	R-S L2	S-L L3			S-R L1	R-S L2	S-L L3			S-R L1	R-S L2	S-L L3	
10.	*Coccinia indica*	0.005	0.005	0.002	0.003	0.75	0.313	0.005	0.016	0.014	0.04	1.845	0.408	0.323	0.456	0.21	49.53	7.265	11.093	25.137	0.29	0.775	0.282	0.378	0.359	0.44	0.229	0.108	0.105	0.148	0.53	3.21	1.541	1.728	2.212	0.57
	MI		1.14	0.40	1.44			0.02	3.34	0.88			0.22	0.79	1.41			0.15	1.53	2.27			0.36	1.34	0.95			0.47	0.98	1.40			0.48	1.12	1.28	
11.	*Luffa acutangula*	0.005	0.007	0.006	0.001	0.87	0.347	0.006	0.020	0.028	0.05	1.259	0.536	0.593	0.479	0.43	245.33	4.100	15.630	21.520	0.06	0.813	0.392	0.304	0.321	0.42	0.126	0.130	0.080	0.115	0.86	2.02	1.480	1.136	6.572	1.51
	MI		1.32	0.82	0.17			0.02	3.08	1.43			0.43	1.11	0.81			0.02	3.81	1.38			0.48	0.78	1.05			1.03	0.62	1.43			0.73	0.77	5.79	
12.	*Abelmoschus esculentus*	0.009	0.008	0.005	0.015	1.06	0.328	0.048	0.003	0.004	0.06	1.377	0.507	0.313	0.475	0.31	92.49	48.732	9.021	11.189	0.25	0.725	0.395	0.247	0.210	0.39	0.144	0.151	0.133	0.259	1.26	2.95	1.287	1.502	1.954	0.54
	MI		0.95	0.62	2.82			0.14	0.07	1.32			0.37	0.62	1.52			0.53	0.19	1.24			0.54	0.63	0.85			1.05	0.89	1.94			0.44	1.17	1.30	
13.	*Mentha piperata*	0.006	0.008	0.002	0.013	1.29	0.382	0.084	0.035	0.046	0.14	2.258	1.057	1.256	0.058	0.35	83.51	11.978	10.794	11.007	0.13	1.251	0.740	0.552	0.292	0.42	0.020	0.168	0.139	0.102	6.81	2.23	3.670	2.372	2.014	1.20
	MI		1.38	0.27	5.79			0.22	0.41	1.33			0.47	1.19	0.05			0.14	0.90	1.02			0.59	0.75	0.53			8.39	0.83	0.73			1.64	0.65	0.85	
14.	*Raphanus sativum*	0.010	0.011	0.014	0.015	1.30	0.314	0.037	0.005	0.033	0.08	0.972	0.361	0.210	0.467	0.36	348.48	10.613	9.198	49.175	0.07	0.369	0.320	0.338	0.346	0.91	0.175	0.162	0.300	0.325	1.50	2.15	2.745	1.680	2.545	1.08
	MI		1.09	1.28	1.02			0.12	0.14	6.21			0.37	0.58	2.22			0.03	0.87	5.35			0.87	1.06	1.03			0.93	1.85	1.09			1.28	0.61	1.52	
15.	*Spinacia oleracea*	0.006	0.013	0.010	0.014	2.05	1.032	0.147	0.065	0.062	0.09	1.763	1.210	1.132	0.606	0.56	1263.55	28.097	21.798	117.999	0.04	1.779	0.405	0.322	0.279	0.19	0.203	0.127	0.113	0.150	0.64	4.76	3.606	3.594	4.515	0.82
	MI		2.17	0.77	1.38			0.14	0.44	0.95			0.69	0.94	0.54			0.02	0.78	5.41			0.23	0.80	0.87			0.62	0.89	1.32			0.76	1.00	1.26	
16.	*Lycopersicum esculentum*	0.010	0.018	0.013	0.011	1.40	0.651	0.319	0.015	0.073	0.21	2.769	2.308	0.800	1.226	0.52	246.32	131.225	23.205	26.163	0.24	1.896	0.944	0.323	0.570	0.32	0.335	0.256	0.105	0.217	0.57	9.82	8.992	4.378	2.650	0.54
	MI		1.78	0.74	0.82			0.49	0.05	4.77			0.83	0.35	1.53			0.53	0.18	1.13			0.50	0.34	1.76			0.76	0.41	2.06			0.92	0.49	0.61	
17.	*Cyamopsis soralioides*	0.003	0.012	0.008	0.004	2.77	0.010	0.077	0.015	0.017	3.59	0.429	1.905	0.851	0.664	2.66	10.24	38.658	6.173	28.808	2.40	0.380	0.516	0.446	0.322	1.13	0.256	0.071	0.088	0.131	0.38	1.72	2.288	1.660	2.100	1.17
	MI		4.11	0.67	0.52			7.55	0.20	1.15			4.44	0.45	0.78			3.77	0.16	4.67			1.36	0.86	0.72			0.28	1.24	1.49			1.33	0.73	1.27	
18.	*Lagenaria vulgaris*	0.009	0.005	0.006	0.104	4.27	0.393	0.096	0.017	0.038	0.13	1.444	0.933	0.659	0.217	0.42	380.10	18.922	10.705	13.652	0.04	0.944	0.705	0.540	0.333	0.56	0.141	0.094	0.100	1.420	3.82	4.64	2.658	2.062	7.721	0.89
	MI		0.61	1.15	16.55			0.24	0.18	2.26			0.65	0.71	0.33			0.05	0.57	1.28			0.75	0.77	0.62			0.67	1.06	14.21			0.57	0.78	3.74	
	Mean	0.010	0.014	0.010	0.014	1.65	0.400	0.135	0.029	0.052	0.36	1.47	1.126	0.608	0.566	0.62	295.32	38.665	12.115	27.989	0.27	0.902	0.701	0.452	0.495	0.71	0.173	0.178	0.147	0.236	1.54	5.75	3.874	2.503	4.022	0.91
			1.89	0.83	2.12			0.74	0.54	2.22			0.93	0.61	1.17			0.44	0.65	2.55			0.89	0.72	1.37			1.51	1.07	2.05			0.97	0.73	1.88	

accumulation in leaves (4.77) and the poor content (2.27) in stems. This indicated higher rate of mobility of metals from soil to roots in a particular plant, moderate from stems to leaves, and low from roots to stems. Thus, the present results were well-corroborated with the observations of Hunter *et al.*, (1987a, 1987b, 1987c).

Moreover, the vegetable crop plants such as *M. charantia* and *C. soralioides* were found to be hypo-accumulative and hyper-accumulative, respectively, in nature. Presence of heavy metals such as Cd, Pb and Zn was detected in lowest concentration in *M. charantia*, while *C. soralioides* was found to accumulate Co, Cu and Fe in high content. Therefore, *C. soralioides* could be used to decontaminate heavy metals from polluted soils in view of its ability to accumulate various heavy metals several folds higher than their available level within the soil. Therefore, it is recommended that such verities of vegetable crop plants could be effectively used to decontaminate heavy metal polluted soil due to its capability to establish and proliferate in soil podsol (Nivethitha *et al.*, 2002).

MOBILITY OF HEAVY METALS

Mobility Index (MI) showed biomobility and transport of heavy metals through different levels: Level 1 (Soil-Roots), Level 2 (Roots-Stems) and Level 3 (Stems-Leaves) in vegetable crop plants, which becomes functional to understand the transport mechanism of heavy metals in plant components, such as roots, stems and leaves. Present findings revealed that Level 1 (Soil-Roots) registered high mobility rate of Ni and Zn in *C. sativum* being 1.90 and 2.53, respectively, Fe (3.77) and Cu (4.44) in *C. soralioides*, Cd in *C. sativum* (6.63), Co in *C. soralioides* (7.55) and Pb in *M. piperata* being 8.39. In case of Level 2 (Roots-Stems), greater mobility rate of Zn was achieved in *A. esculentus* (1.17); Cu in *M. piperata* (1.19), Ni in *L. acutangula* (1.34), Cd in *B. oleracea var. botrytis* (2.61), Co in *C. indica* (3.34), Fe in *L. acutangula* (3.81) and low mobility rate of Pb was encountered in *B. oleracea var. botrytis* being 4.90. Thus higher mobility gradient of heavy metals among various levels can be expressed as Co > Fe > Zn > Cu > Ni > Pb > Cd (Table 1).

Present study also showed that some metals exhibited low mobility rate from one part to other part in particular vegetable crop plant. Low mobility of metals was encountered in Level 1 (Soil-Roots): low mobility of Co and Fe in *C. indica* and *L. acutangula* (0.002), respectively, Zn in *S. melongena* (0.21), Cu in *C. indica* (0.22), Ni in *S. oleracea* (0.23), Pb in *C. soralioides* (0.28) and low transfer of Cd was recorded in *M charantia* (0.33). In case of Level 2 (Roots-Stems), low mobility rate of Co was achieved in *L. esculentum* (0.05), Fe in *S. melongena* (0.07), Cu in *A. sativum* (0.09), Cd (0.13) and Zn (0.18) in *M. charantia*, Pb in *C. sativum* (0.23) and low mobility of Ni was registered in *A. sativum* (0.24). Moreover, level 3 (Stems-Leaves) showed low mobility of Cu in *M. piperata* (0.05), Pb in *A. graveolens* (0.14), Cd in *L. acutangula* (0.17), Ni (0.25), Co (0.32) and Fe (0.32) in *A. graveolens* and Zn in *L. esculentum* (0.61). Thus, lower mobility rate gradient of heavy metals through different plant components can be expressed as Co > Fe > Zn > Cu > Ni > Pb > Cd (Table 1).

Rate of mobility was found higher in Cd (1.61), followed by Pb (1.54), Fe (1.21), Zn (1.19), Co (1.17) and lowest in Ni (0.99) and Cu (0.90). Mobility of metals at different levels varied among various plant parts. Mobility factor was ranged from 0.44 to 1.89 in Level 1 (Soil-Roots), 0.54 to 1.07 in Level 2 (Roots-Stems) and 1.17 to 2.55 in Level 3 (Stems-Leaves) (Table 1). Thus mobility gradient of heavy metals in plant components could be drawn as Cd > Pb > Fe > Zn > Co > Ni > Cu. Similarly, metal transport mechanism was found significant in terms of mobility of a particular metal content from source to receiving level. High mobility was observed at different levels, which is established by the fact that very low content of heavy metals are transported from roots to stems (Level 2) being only 0.73. Gradual increase in transport of metal content was observed in Level 1

(Soil-Roots) with 1.05, while highest content of metals are transported through Level 3 (Stems- Leaves) being 1.90. This might be due to the fact that Cd is more readily available than other metals in surface soil horizons, which corroborated the findings of Hunter *et al*. (1987a, 1987b, 1987c).

Thus concentration of heavy metals was found moderate in roots could be due to increased mobility of heavy metals from soil to roots indicated the tendency of roots to accumulate good amount of metals from soil and transfer a little to above ground biomass. These results are in conformation with the findings of Jarvis *et al*. (1976) and Leita *et al*. (1993), who noticed moderate accumulation of heavy metals in root system. It reveals that sometimes roots act as barriers to transfer the toxic metals through soil-plant system (Jones and Clement, 1972). Jarvis and Robson (1982) reported that most of the accumulated Cu was retained within roots even when plants showed Cu deficiency symptoms.

CONCLUSION

1. Higher accumulation factor of heavy metals in various plant components particularly in roots, stems and leaves was found in the order Cd > Co > Pb > Ni > Cu > Zn > Fe.

2. Vegetable crop plants like *C. soralioides*, *B. oleracea var. botrytis*, *C. annum*, *A. graveolens* and *M. piperata* were found to be hyper-accumulative, whereas, *C. indica*, *A. esculentus* and *L. acutangula* were hypo-accumulative.

3. *C. soralioides* could be used to decontaminate the heavy metal polluted soils.

4. Greater mobility rate was observed in vegetable crop plants such as *C. sativum*, *C. soralioides*, *M. piperata* and *C. indica*, while poor mobility in *S. melongena*, *S. oleracea* and *L. esculentum*.

5. Mobility of heavy metals such as Cd, Co, Cu, Fe, Ni, Pb and Zn from soil to leaves suggested that all these metals were highly mobile from soil to plant components.

6. Comparing transfer potential of metals among various plant components, these metals markedly exceeded in Level 3 (Stems-Leaves), followed by a gradual decline in Level 1 (Soil-Roots) and Level 2 (Roots-Stems).

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COMPARITIVE BENEFITS OF BEEKEEPING ENTERPRISE IN CHITWAN, NEPAL

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ABSTRACT

Based on the survey cunducted in 2004, beekeepers in Chitwan had small and fragmented land holdings with lower rate of return from subsistence crop farming. They are keeping *Apis mellifera* L.in Langstroth hive in Terai and *A. cerana* Fab. in improved, traditional-log and wall hives in hills, for honey production purpose. The honey productivity in Terai was 3.54 folds higher (28.7 vs 8.1 kg/yr/hive) than in hills with highest average annual income in Bharatpur area followed by East and West Chitwan. Moreover, the income of the beekeepers in Chitwan from honey production was 3.62 folds higher than crop farming (NRs 83,996.88 vs NRs 23,214.22 /house hold/year). It clearly showed that beekeeping with *A. mellifera* in the Terai is potential enterprise for higher income compared to crop production.

Key words: annual income, apiculture, crop production, honey productivity, land holding.

INTRODUCTION

Bee Keeping Section (2004) reported 1,27,501 honeybee colonies including 1,01,684 traditional (log and wall hives) and 25,200 improved (*A. cerana* 17,744 and *A. mellifera* 7,456) hives kept in Nepal. The annual honey production is estimated 529.3 mt and it is one of the exporting, high value cash earning commodities in Nepal. Honey export in the year 2003 was equivalent to Rs 4,41,985 and was 4439.2 folds higher than that of 2002 (Bee Keeping Section, 2003). However, the role of bees as crop pollinators has been largely ignored and a vast potential, in using bees to augment national income through increased crop production has been forgotten. Honey production and crop pollination have to be exploited for the agriculture development and poverty reduction in Nepal. The Asiatic honeybee, *A. cerana* is adopting by the hill caste community and *A. mellifera* in Terai of Chitwan (DADO, 2004; DADO, 2005). The total estimated honeybee colony in Chitwan is 7500 (*A. mellifera* 5500 and *A. cerana* 2000) (Neupane, 2002). Chitwan seems to be the potential district enriched with apicultural raw materials, labor, and market. However, increasing use of agrochemicals specially the pesticide use on crop protection is a emerzing threat. Nectar and pollen as raw materials are available from both forest and cultivated areas. Development of road infrastructure provides easy bee migration in all the seasons (DADO, 2004; DADO, 2005). More over, the services, institutional development, honey productivity and market development are not satisfactory. Beekeepers in Chitwan are in hurdele from different managerial, technical, ecological, behavioral and socio-economical problems and policy issues hindering the beekeeping industry. Beekeepers in Chitwan are mostly the medium class economic category, growing different crops and majority engazed in other occupation too. Thus, it was necessary to compare the income from beekeeping to crop production and study the market situation of honey in Chitwan. The objective of the study was to compare the income from beekeeping and crop production, to investigate the situation of honey market and make subsequent recommendation for the beekeepers in Chitwan.

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MATERIALS AND METHODS

SURVEY SITE, TIME AND DURATION

The survey was conducted in Chitwan district (Inner Terai and the peripheral Mahabharata hills) at central Nepal. The survey sites of *A. cerana* beekeepers were Chandibhanjyang, Shaktikhor, Korak and Siddhi VDCs. Similarly, survey of *A. mellifera* colonies was carried out in the Terai areas: East Chitwan (Pithuwa, Jutepani, Shaktikhor, Chainpur and Padampur VDCs and Ratnanagar Municipality), west Chitwan (Dibyanagar, Sukranagar and Parbatipur VDCs) and Bharatpur municipality during September-October 2004. Thse were the emerzing beekeeping pockets of Chitwan valley where number of beeflora are avilable and thousands of bee colonies in migrated during the honey flow season.

BEEKEEPERS' INTERVIEW

A questionnaire was developed, pre-tested, revised and the final version of which was duplicated and used for collecting necessary information from the beekeepers (65 households randomly selected out of the list prepared by Nepal Beekeepers Associatiopn) to see the income of beekeepers (from crop cultivation and honey production) and honey market situation in Chitwan. The information collected from the survey was verified with available literature.

DATA PROCESSING

Collected data were tabulated using MS-EXCEL software and necessary tables, graphs figures were prepared and means were calculated to draw the results regarding the size of land holdings, croped areas, food sufficiency, crop productivity, apiary sizes, labour use and house hold incomes from crop cultivation and honey production.

RESULTS

A survey of 65 beekeepers (36 in hills and 29 in Terai) was accomplished in 2004 to compare the gross income from crop cultivation and beekeeping and investigate the marketing situation of honey in hills and Terai of Chitwan.

STATUS OF CROP PRODUCTION

Land holding

The hill and Terai respondents had an average land holding of 0.70 ha (irrigated 0.12 ha) and 0.57 ha (irrigated 0.34 ha), respectively (Table 1). The beekeepers in West Chitwan had the highest land holding of 0.67 ha (irrigated 0.42 ha), followed by Bharatpur 0.57 ha (irrigated 0.24 ha) and the least 0.53 ha (irrigated 0.38 ha) in East Chitwan.

Crop cultivated

Crops cultivated in Terai were diversified than in hills. Most of the respondents (82.8%) in Terai and nearly half of the respondents (44.4%) in hills had lowlands. They grew rice, *Oryza sativa* L in their lowland in rainy season. In the upland maize, *Zea mays* L. (91.7%, N=33 in hills and 72.4%, N=21 in Terai) and finger millet, *Eleusine coracana* Gaertn (77.7%, N=28 in hills) were the major crops grew during the rainy season. While, mustard, *Brassica campestris* L. var *dichotoma* (Roxb.) Kitam. in Terai (58.6%, N=17) and buckwheat, *Fagopyrum esculentum* Moench (36.1%, N=13) and mustard, *B. campestris* (33.3%, N=12) in hills were the major crops grew during winter. The respondents also grew sesame, *Sesamum orientale* L. (17.2%, N=5); buckwheat, *F. esculentum* (17.2%, N=5) and nizer, *Guizotia abyssinica* (L.) Cass. to some extent in Terai. Other minor crops included vegetable; wheat, *Triticum aestivum* L.; lentil, *Lens esculenta* Moench; blackgram, *Phaseolus mungo* L.; potato, *Solanum tuberosum* L.; cowpea, *Vigna unguiculata* (L.) Walp; sunflowers, *Helianthus annuus* L.; litchi, *Litchi chinensis* Sonner; mandarin orange, *Citrus reticulata* Balanco and greengram, *Phaseolus aureus* Roech (Table 2).

Table 1. Land holding of the beekeepers in Chitwan, 2004

Geographical area	Land holding (ha/household)		
	Upland	Lowland	Total
Hills	0.58	0.12	0.70
West Chitwan	0.25	0.42	0.67
East Chitwan	0.15	0.38	0.53
Bharatpur	0.33	0.24	0.57
Terai average	0.23	0.34	0.57
District average	0.41	0.33	0.74

Table 2. Crops grown by the beekeepers in Chitwan, 2004

Crops	Respondent (%)					
	Hills	Terai				Grand Total
		West	East	Bht*	Total	
Rice, *Oryza sativa* L.	44.4 (16)	100 (8)	92.3(12)	50.0 (4)	82.8 (24)	61.5 (40)
Mustard, *Brassica campestris* L. var *dichotoma* (Roxb.) Kitam.	33.3 (12)	100 (8)	46.2 (6)	37.5 (3)	58.6 (17)	44.6 (29)
Maize, *Zea mays* L.	91.7 (33)	75.0 (6)	92.3 (12)	37.5 (3)	72.4 (21)	83.0 (54)
Sesame, *Sesamum orientale* L.	-	37.5 (3)	-	25.0 (2)	17.2 (5)	7.7 (5)
Buckwheat, *Fagopyrum esculentum* Moench	36.1 (13)	62.5 (5)	-	-	17.2 (5)	27.7 (18)
Vegetables	11.1 (4)	-	7.7 (1)	37.5 (3)	13.8 (4)	12.3 (8)
Wheat, *Triticum aestivum* L.	5.5 (2)	-	-	12.5 (1)	3.4 (1)	4.6 (3)
Lentil, *Lens esculenta* Moench.	-	-	7.7 (1)	-	3.4 (1)	1.5 (1)
Blackgram, *Phaseolus mungo* L.	2.8 (1)	-	-	-	-	1.5 (1)
Potato, *Solanum tuberosum* L.	-	-	-	25.0 (2)	6.8 (2)	3.1 (2)
Finger millet, *Eleusine coracana* Gaertn	77.7 (28)	-	-	-	-	43.0 (28)
Cowpea, *Vigna unguiculata* (L.) Walp.	5.5 (2)	-	-	-	-	3.1 (2)
Greengram, *Phaseolus aureus* Roech	5.5 (3)	-	-	-	-	4.6 (3)
Nizer, *Guizotia abyssinica* (L.) Cass.	5.5 (2)	25.0 (2)	-	37.5 (3)	17.2 (5)	10.8 (7)
Sunflowers, *Helianthus annuus* L.	-	-	25.0 (3)	-	103 (3)	4.6 (3)
Litchi, *Litchi chinensis* Sonner	2.8 (1)	37.5 (3)	16.7 (2)	37.5 (3)	27.6 (8)	13.8 (9)
Mandarin orange, *Citrus reticulata* Balanco	19.4 (7)	-	-	-	-	10.8 (7)

Figures in parentheses show the respondent numbers.
* Bharatpur

Income and food sufficiency

Per capita income from crop cultivation in hills (Rs 16122.20/household) was lower by 49.6% than in Terai (Rs 32,018.00/household). It was comparatively higher in East Chitwan (NRs 34691.63) than in West Chitwan (NRs 31321.14) and Bharatpur (NRs 28370.50 /hh/year) in Terai (Table 3). Food from their farm production was only

Table 3. Beekeeper's land holdings, annual gross income from the crops and food sufficiency in Chitwan, 2004

Geographical area	Land hold. (ha/hh)	Income from crop (NRs)	Food suffi. (months/yr)	Way to meet the deficiency	
				Source	Respondents (%)
Hills	0.70	16122.20	6.6	Wage labor,	41.7 (15)
				Shop keeping	5.6 (2)
West Chitwan	0.67	31321.14	9.9	Apiculture	25.0 (2)
East Chitwan	0.53	34691.63	9.3	Grocery	37.5 (3)
				Apiculture	37.5 (3)
				Metal-workshop	37.5 (3)
Bharatpur	0.57	28370.50	5.1	Civil service	37.5 (3)
				House renting	12.5 (1)
Terai average	0.57	32018.10	8.3	-	-
District mean	0.41	23214.20	7.36	-	-

Figures in parentheses show the respondent numbers

sufficient for 6.6 months in the hills and for 8.3 months in the Terai. It was highest in West Chitwan (9.9 months) followed by East Chitwan (9.3 months) and Bharatpur (5.1 months). The hill beekeepers fulfilled their additional requirements from wage labor while in the Terai, they derived their income sources from apiculture (37.5%, N=3), grocery (37.5%, N=3), metal workshop (37.5%, N=3), civil services, etc.

STATUS OF BEEKEEPING

Purpose of beekeeping

The purpose of beekeeping in Chitwan was mainly for income generation from honey production and selling. However, 27.8% hill and 86.0% Terai beekeepers also realized the role of honeybee on crop pollination and thereby crop diversification (Table 4). All beekeepers in Terai also produced wax from *A. mellifera* combs while it was insignificant in the hills.

Table 4. Main purpose of beekeeping in Chitwan, 2004

Particular	Respondent (%) Hills	Terai	Total
Honey production	100.0(36)	100.0(29)	100.0(65)
Wax production	8.3(3)	100.0(29)	49.2(32)
Pollination awareness	27.8(10)	86.2(25)	53.8(35)

Figures in parenthesis show the respondent number

Among the respondent beekeepers, 27.8% (N=10) in hill and 86.0 % (N=25) in Terai were aware about the role of honeybees on pollination. The beekeepers in hills reported that the yield of mustard, B. campestris; citrus, C. reticulata; and buckwheat, F. esculentum rose by 10.0-25.0% from honeybee pollination. However, the Terai beekeepers realized the crop yield of cross-pollinated crops i.e. mustard, B. campestris; buckwheat, F. esculentum and litchi, L. chinensis rose up to 40.0% (Table 5).

Table 5. Crop productivity realized from honeybee pollination in Chitwan, 2004

Production rose	Respondent (%)					Grand Total
	Hills	Terai				
		West	East	Bharatpur	Total	
< 14 %	25.0 (9)	-	-	12.5 (1)	3.4 (1)	15.4 (10)
14-25%	2.8 (1)	75.0 (6)	53.8 (7)	50.0 (4)	58.6 (17)	27.7 (18)
25-35%	-	-	23.1 (3)	25.0 (2)	17.2 (5)	7.7 (5)
>35%	-	-	15.1 (2)	-	6.8 (2)	15.4 (2)
Mean	14.1 %	20.6 %	30.4 %	22.1 %	25.4 %	19.1 %

Figures in parentheses show the respondent numbers

Species of honeybees

Two domesticated honeybees: *A. mellifera* in Langstroth hive in Terai and *A. cerana* in 3 different hives (41.1% in improved, 31.2% in traditional log and 27.6% in wall hives) mainly in hills, with an mean colony size of 4.4 per household (N=36) in hills and 50.0 per household (N=29) in Terai were adopted by the beekeepers in Chitwan (Table 6, Fig. 1). The mean colony number of *A. mellifera* was highest in Bharatpur (87.5 colonies/household) followed by East Chitwan (43.6 colonies/household) and West Chitwan (22.6 colonies/household), respectively.

Table 6. Honeybee species kept by the beekeepers in Chitwan, 2004

Particulars	Location	*A. cerana*		*A. millifera*		Total	
		Colony	%	Colony	%	Colony	%
Colony number	Hills	170	99.4	1	0.6	171	10.6
	Terai	-	-	1448	100	1448	89.4
	Total	170	10.5	1449	89.5	1619	100
Hive types	Hills: Improved	70	41.2	1	100	71	4.4
	Log	53	31.2	-	-	53	3.3
	Wall	47	27.6	-	-	47	2.9
	Terai: Improved	-	-	1448	100	1448	89.4
	Total	170	100	1449	100	1619	100
Average colony/hh	Hills	4.4 (36)	-	1(1)	-	4.4 (36)	-
	Terai	-	-	50.0 (29)	-	50.0 (29)	-
	East Chitwan	-	-	43.6 (13)	-	43.6 (13)	-
	Bharatpur	-	-	87.5 (8)	-	87.5 (8)	-
	West Chitwan	-	-	22.6 (8)	-	22.6 (8)	-

Figures in parentheses show the respondent numbers

Colony handling

The range of the bee colonies per household ranges 4-250. The colony holding of A. cerana was found 4.4 /household, ranging from 4-12. The human resource involved to manage these colonies was 1.6/household and the range was 1-3. However, human resource engaged in keeping with A. mellifera in Terai ranged from 1-9 persons (Average 2.9/household). It was lower in West Chitwan (1.9 person/household) than in Bharatpur area (3 person/household) and in East Chitwan (3.5 person/household). Moreover, the per capita holding of A. mellifera colonies in Terai was significantly higher (50.0 colonies per household), among the respondents. Where, it was extremely higher (88.4 colonies/household) in Bharatpur followed by East Chitwan (43.3 colony/household) and least in West Chitwan (23.3 colonies/household) (Table 7).

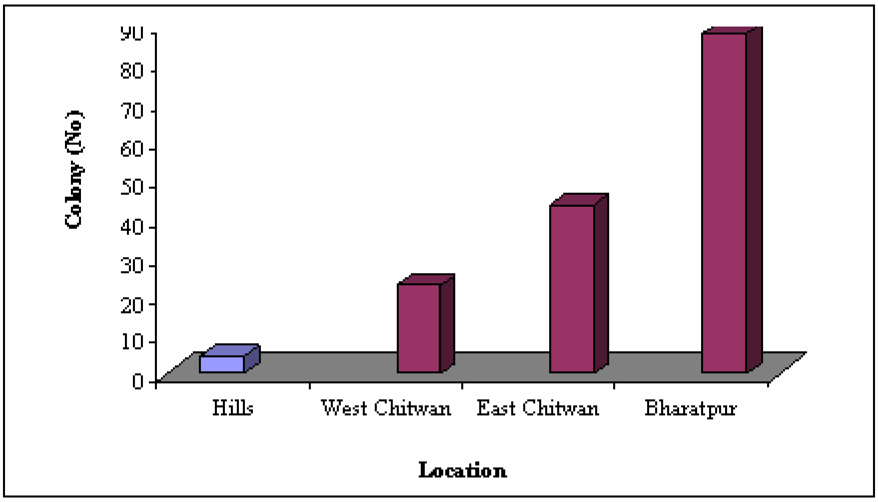

Figure 1. Mean number of colonies kept by beekeepers in Chitwan, 2004.

Table 7. Man power involved in beekeeping in Chitwan, 2004

Location	Honeybee colonies (No.)			Labour involved (No./household)		
	Range /household	Mean /household	Total	Range /household	Mean /household	Total
Hills	4-12	4.4	170 (36)	1-3	1.6	57
Terai	10-250	50.0	1456 (29)	1-9	2.9	85
West Chitwan	10-65	22,6	185 (8)	1-4	1.9	15
East Chitwan	10-95	436	563 (13)	1-7	3.5	46
Bharatpur	10-250	87.5	708 (8)	1-9	3.0	24
District total	4-250	25.0	1626 (65)	1-9	2.2	142

Figures in parentheses show the respondent numbers.

Honey production

The productivity of *A. mellifera* was 254.3% higher (28.7 kg vs 8.1 kg/colony/yr) than *A. cerana* (improved hive 8.6 kg, log hive 7.7 kg and wall hive 7.4 kg/yr) (Table 8). The beekeepers harvested honey 2-7 (mean 3.2) times from *A. cerana* in autumn and spring in the hills and 3-7 times (mean 4.8) from *A. mellifera* in the Terai in winter and spring. East Chitwan farmers had the highest honey harvesting frequencies (5.3 times/year) with the highest productivity of 34.8 kg per colony per year followed by (Bharatpur 4.6 times with 25.1 kg /colony /year) and West Chitwan (4.2 times with 22.2 kg /colony /year) (Table 8).

Table 8. Honey yield and harvesting frequency in Chitwan, 2004

Geographical location	Yield (kg/hive/yr.)	Harvesting frequency (No./year)	
		Range	Mean
Hills	8.1	2 - 7	3.2
Terai	28.7	3 - 7	4.8
West Chitwan	22.6	3 - 7	4.6
East Chitwan	34.8	3 - 7	5.3
Bharatpur	25.1	3 - 6	4.2
District mean	26.5	2 - 7	3.9

Honey price

Honey price was found decreasing annually by 4.7% in Terai and by 3.9% in hills and was ranging from Rs 100-150/kg in 2004. The average price of honey in the hills was 9.2% lower (Rs 104.7 vs 115.4/kg) than in Terai, and was highest in Bharatpur (Rs 132.5 vs 108.9 and 109.9) than in East and West Chitwan (Table 9, Fig. 2).

Table 9. Market price of honey during 2000-2005 in Chitwan, 2004

Year	Hills	Terai			
		West	East	Bharatpur	Total
2000	130.0	140.0	150.0	160.0	150.0
2001	130.0	135.0	135.0	150.0	140.0
2002	120.0	135.0	140.0	145.0	140.0
2003	120.0	128.0	126.0	136.0	130.0
2004	110.0	109.9	108.9	132.5	115.4
2005	104.7	109.9	108.9	132.5	115.4

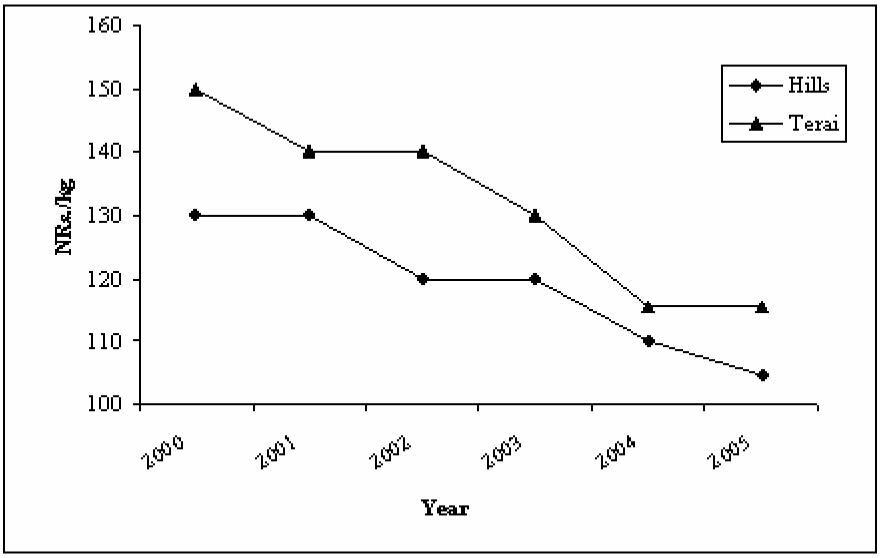

Figure 2. Honey price in Chitwan during 2000/20005

Honey marketing

The hill beekeepers in Chitwan sold *A. cerana* honeycombs or hand squeezed honey in Terai. The small and medium beekeepers (72.4%) in Terai supplied honey to the local market after wire/muslin cloth filtering. Some beekeepers also sold raw honey to the bigger farmers and or to Nepal Bee Keepers Association. Big farmers (27.6%) were involved in home processing, packing and marketing of honey or sold it to bee association, and thus, had access to market with all sorts of consumers i.e. with in district, inter-district and even at the international level. Honey marketing channel in Chitwan is shown in Fig. 3.

A total of 17.2% of *A. mellifera* honey sold was seal packed and rest (82.8%) was sold after wire/cloth filtered (Table 10).

Table 10. Types of honey marketed by beekeepers in Chitwan, 2004

		Respondents (%)			
Location	Farmer	Raw/comb	Filtered	Processed	Total
Hills	Small	100 (36)	-	-	100 (36)
Terai	Small	20.0 (2)	80.0 (8)	-	100 (10)
	Medium	72.7 (8)	27.3 (3)	-	100 (11)
	Big	9.1 (1)	18.2 (2)	62.5 (5)	100 (8)
	Sub total	37.9 (11)	44.8 (13)	17.2 (5)	100 (29)
	Total	72.3 (47)	20.0 (13)	7.7 (5)	100 (65)

Figures in parentheses show the respondent numbers

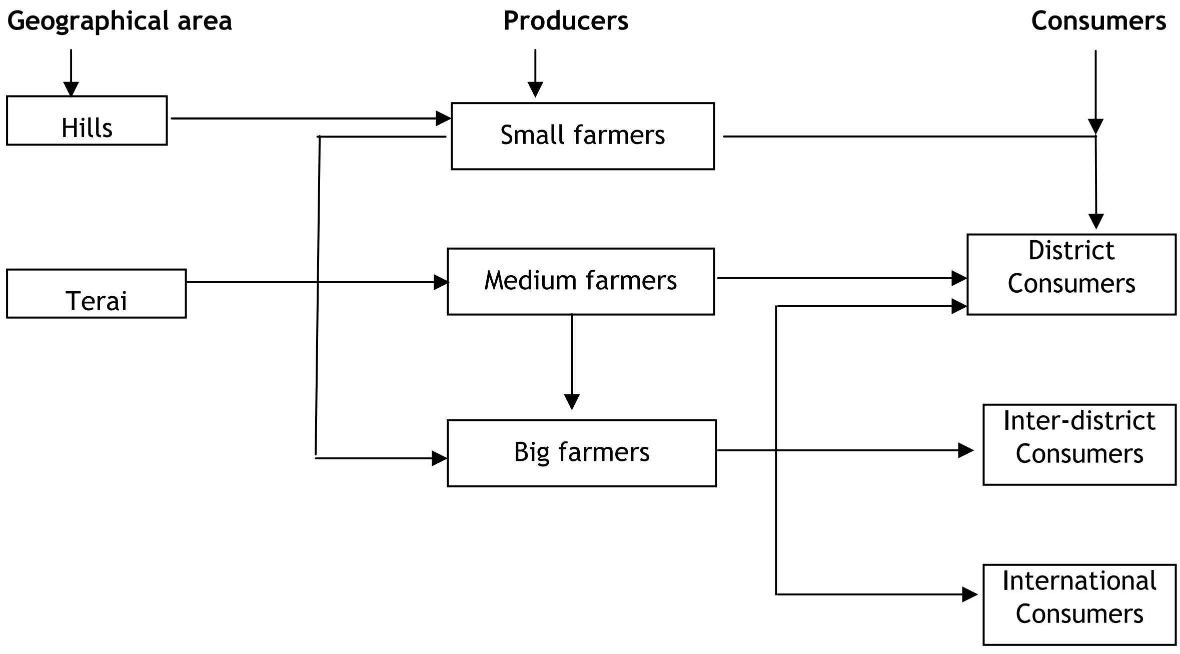

Figure 3. Marketing channel of honey in Chitwan, 2004.

Income from honey marketing

The average annual gross income from beekeeping was Rs 3794.4 /household (Rs. 862.36 /colony/year) in hills and Rs 1,84,474.3 (Rs 3,689.49/colony/year) in Terai. The range of the annual income from *A. cerana* beekeeping in hills was Rs 1,200-7,200 per household per year, which was several folds less than that of *A. mellifera* beekeepers in Terai (Rs 12,000-11,50,000) (Table 11). The average annual income of *A. mellifera* beekeeping in Bharatpur area was Rs 3,29,893 and was 475% higher than that of West Chitwan and 90.2% higher than East Chitwan because of high number of the colonies kept by the beekeepers in Bharatpur.

Table 11. Honey production and household gross income in Chitwan, 2004

Site/hive type	Colony number /hh		Productivity (kg/hive/yr)		Honey price (Rs)		Income (Rs/year)	
	Range/hh	Total	Range	Mean	Range	Mean	Range	Mean
Hills	4-12	4.40(36)	2-15	8.1	100-150	104.7	1200-7200	3794.4
Improved	2-12	4.12 (17)	2-14	8.6	100-150			
Log hive	1-6	3.41(17)	5-15	7.7	100-150			
Wall hive	1-5	2.80(15)	3-15	7.4	100-150			
Terai	10-250	53.66(29)	10-60	28.7	100-150	115.4	12000-115000	184474.3
West	10-65	23.13 (8)	10-35	22.2	100-130	109.0	12000-149500	57047.5
East	10-95	43.31(13)	10-60	34.8	100-120	108.9	13800-627000	173401.9
Bharatpur	10-250	88.50(8)	10-40	25.1	115-150	132.5	15000-1150000	329893.8
District total	4-250	25.01(65)	2-60	26.5	100-150	114.3	1200-1150000	83996.8

Figures in parentheses show the respondent numbers.

Comparitive income from beekeeping with crop production

The mean per capita gross agricultural income of the beekeepers in Chitwan was NRs 107211.10 per household per annnum. It was several folds higher in Terai than in hills (NRs 216492.40 vs NRs 19916.60). The per capita income was highest in Bharatpur (NRS 358264.30) followed by East Chitwan (NRs 208073.50) and West Chitwan (NRs 88357.60 /hh/year). The per capita income was higher by 261.83 % from apiculture than crop cultivation (NRs 83996.88 vs NRs 23214.22 /hh/year). Out of the total income, 78.35% was from beekeeping and rest from crop production. Income from apiculture was highest in Bharatpur (92.08%), followed by East Chitwan (83.33) and West Chitwan (64.56%). However, in hills the per capita income from apiculture was lower (19.05%) than crop production (80.95%). It was because of the adoption of lower number of colonies by the beekeepers in hills and the productivity and production of honey were in smaller quantities. The beekeepers in hills are dependent to crop cultivation and other alternatives income generating activities although it was also found marginal (Nrs 16122.20/hh). It was highest in East Chitwan (Nrs 34691.63/hh) followed by West Chitwan

(N31321.14/hh) and in Bharatpur (Nrs 28370.50/hh) (Table 12). Thus, the total income from agriculture in hills was several folds smaller than in Terai.

Table 12. Contribution of beekeeping in the household income in Chitwan, 2004

Location	Income (NRs)			Apicultural contribution (%)
	Crop production	Honey production	Total	
Hills (36)	16122.20	3794.40	19916.60	19.05
West Chitwan (13)	31321.14	57047.5	88357.60	64.56
East Chitwan (8)	34691.63	173401.90	208093.50	83.33
Bharatpur (8)	28370.50	329893.80	358264.30	92.08
Terai mean (29)	32018.10	184474.30	216492.4	85.21
District mean (65)	23214.20	83996.88	107211.10	78.35

Figures in parentheses show the respondent numbers

Suggestions given from beekeepers

A diagnostic laboratory for problem identification and provision of bee treatment, technical help and follow up support, breed selection, queen rearing and bee research program has been felt necessary in beekeeping for its commercialization in Chitwan. Beekeepers from the hills and Terai have suggested in many ways for the promotion of beekeeping in Chitwan. Modification of traditional log and wall hives, training on hive making, swarm capture and hiving, absconding control, better methods of honey harvesting and wax processing trainings are suggested by the *A. cerana* keepers. They also suggested for the development of low cost honey extractor. *A. cerana* race selection for better productivity and domestication has been felt necessary. However, the commercial *A. mellifera* keepers in Terai suggested for the advance level crop pollination and problem solving training and demanded a secured honey market and declaration of beekeeping policy and guideline from GoN. They demanded a diagnostic laboratory and provision of bee treatment follow up support and technical help from the government side. They are aware on the conflict arbitration on bee migration between beekeepers and bee crop growers and demanded interaction between the crop growers and beekeepers. Traffic problem on bee migration should be solved and GoN should attempt to control bee poisoning through legislative way.

DISCUSSION

Beekeepers adopted *A. mellifera* in Terai in improved hives and *A. cerana* in improved (41.1%), traditional log (31.2%) and wall hives (27.6%) in hills. Devkota (2003) stated that the Chepang and the hill caste communities were adapting *A. cerana* in traditional hives in hi1ls. DADO (2004; 2005) stated that *A. mellifera* multiplied during nineties and distributed through both farmers to farmers (59%) and from DADO to farmers (41.0%) in nineties in Terai. The average colonies in the hills were 4.4 and in Terai 50.0 per household. Labor engaged to manage these colonies were 1.6 in hills and 2.9 in Terai, which is in agreemenet with Neupane (2002). He estimated 5,500 *A. mellifera* and 2,000 *A. cerana* bee colonies in Chitwan in the year 2002. Beekeeping in Chitwan was mainly for income generation from honey selling as pointed by Bee Keeping Section (2003). However, considerable number of respondents (27.8% in hills and 86.0% in Terai) realized the role of honeybees in crop pollination. Reddy (1995) estimated that crop production increased by 30 to 3000 percent through bee pollination. Devkota (2000) also agreed on the result that pollination could significantly improve both yield and seed quality of bee pollinated crops. Similarly, many crops benefited from bee pollination (Free, 1993, Pokhrel, 2001).

The hill and Terai respondents had an average landholding of 0.70 ha (irrigated 0.12 ha) and 0.57 ha (irrigated 0.34 ha), respectively which is smaller than national average of 0.727 ha/hh (Agri-Business Promotion and Statistics Division, 2005). Mean annual income from crop cultivation in hills (Rs 16,122.20/hh) was lower by 49.6% than in Terai (Rs 32,018.00/hh) and food sufficiency was only for 6.6 months in hills and 8.3 months in Terai. The per capita GDP is lower in hills and higher in Terai than the national average of Rs 20821 (Agri-Business Promotion and Statistics Division, 2005).

The productivity of *A. mellifera* was 254.3% higher (28.7 kg vs 8.1 kg/colony/yr) than *A. cerana* (improved hive 8.6 kg, log hive 7.7 kg and wall hive 7.4 kg/yr). The results was similar to the previous study (Devkota, 2000). The beekeepers harvested honey 2-7 (mean 3.2) times from *A. cerana* during autumn and spring in the hills and 3-7 times (mean 4.8) from *A. mellifera* in Terai during winter and spring. Where, East Chitwan farmers had highest honey harvesting frequency (5.3 times/year) with the highest productivity (34.8 kg/colony/year) followed by Bharatpur (4.6 frequency with 25.1 kg/colony/year) and West Chitwan (4.2 frequency with 22.2 kg/colony/year), respectively. The production, productivity and harvesting frequencies were highly correlated with flora availability, management practices adopted and the colony number kept by the beekeepers.

Honey price (wholesale) was found decreasing annually by 4.7% in Terai and by 3.9% in hills, which ranged from Rs 100-150/kg in the year 2004. The mean honey price decreased from Rs.125 to 111 per kg in the past five years before 2003 in Chitwan (DADO, 2004). It was 9.2% lower (Rs 104.7 vs 115.4/kg) in hills than in Terai and was highest in Bharatpur (Rs 132.5 vs 108.9 and 109.9) than in East and West Chitwan. The reason was increased volume of honey production and limited domestic market availability with limitation on honey export due to unavailability of residue monitoring facility in the country (Pokhrel, 2001). The mean per capita income of the beekeepers from beekeeping in Chitwan was NRs 107211.10 which was several folds higher in Terai than in hills (NRs 216492.40 vs NRs 19916.60).

The per capita income of the beekeepers was higher by 261.83 % from apiculture than crop cultivation (NRs 83996.88 vs NRs 23214.22 /hh/year) although, it was lower (19.05% vs 80.95%) in hills because of the lower number of colonies kept by the beekeepers and lower honey production and productivity. In such cases, beekeeping can play a major role in poverty reduction and food security enhancement in Terai of Nepal. However, it needs special apicultural package of practices for the promotion of beekeeping in hills.

CONCLUSION AND RECOMMENDATION

The study realized that the hills needed a special package of practices for crop production that supported promotion of *A. cerana* beekeeping, which include educational activities, technical supports and extension of low cost technology to increase the productivity of *A. cerana* colonies.. In the Terai, *A. mellifera* was found promosing in terms of honey production, harvesting frequency, per capita colony holding and annual income, where commercialization of beekeeping with *A. mellifera* can earn higher than crop production. Hence, the demand of honey in both the domestic and external market is growing and to meet the demand an advanced apicultural research and extension mechanism including crop pollination and beekeeping trainings, a secured market for honey and formulation and implementation of clear beekeeping policy and guidelines by the government are recommended.

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OBSOLETE PESTICIDES: THEIR ENVIRONMENTAL AND HUMAN HEALTH HAZARDS

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ABSTRACT

UN FAO estimates that half a million tonnes of obsolete pesticides are in storage world-wide. In Nepal there are 74.5 metric tonnes of obsolete pesticides stored in warehouses in many places of the country. Many stocks are located near farm fields, human settlements, schools or water sources. Lack of health related studies and very limited studies on environmental contamination by obsolete pesticides led to undertake this study, which focuses on health and environmental impacts of obsolete pesticides stored in a warehouse at Amlekhgunj, Bara district, Nepal. The present study found an interrelation between the pesticide residue level in soil samples of a nearby school-ground and the health impacts seen on the students of the same school.

The government and concerned agencies should take out the initiatives to quick and safe disposal of obsolete pesticides and also take care that no new stock will be accumulated in the future.

Key words: Obsolete pesticides, soil contamination, health effects.

INTRODUCTION

Traditionally, farming in Nepal was organic in nature and was therefore, ecologically sound and sustainable for human beings and other living organisms. Until the 1950s, Nepali farmers were unaware of agro-chemicals. They were dependent upon their rich traditional wisdom to control pests. The use of agrochemicals such as fertilizers and pesticides started with the growth of population and transfer of traditional farming to modern agriculture with the establishment of the department of Agriculture Development (DOA) in the early 1960s.

There is discrepancy among published literatures and data as to the exact date of pesticides' first entry into Nepal. One report states that chemical pesticides were first introduced in 1955 when paris green, gamaxene and nicotine sulphates were imported from the United States for malaria control, and that DDT was first introduced in 1956 (WWF, 1995). Another report states that the first appearance of DDT in Nepal came in 1952 when 800 houses were sprayed in an effort to protect people from malaria (Kandel and Mainali, 1993). Regardless of the exact date, persistent pesticides were first introduced into Nepal in the form of DDT, which was used for malaria eradication. Department of Agriculture (DOA) initiated the use of chemical pesticides in agricultural sector to protect the crops from plants' disease and pest attack only after the second half of 1960s. Use of pesticides has definitely helped to improve health condition of people as well as to increase agricultural productivity, but it has also created several long-lasting side effects on human health and environment.

Pesticide exposure can have chronic and acute impacts on human health. Long term low dose exposure to pesticide causes immune suppression, hormonal disruption, diminished intelligence, reproductive abnormalities and cancer (Gupta, 2004).

Soil and groundwater pollution are the main environmental effects of pesticides. However, there are evidences that many species of insects, mammals and birds (Manandhar 2006)

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have been affected.

Pesticides in soils become toxic to arthropods, earthworms, fungi, bacteria, and protozoa which are vital to ecosystems, because they dominate both the structure and function of natural system (Pimentel et.al 1992).

OBSOLETE PESTICIDES

Another problem which occurs due to pesticide is the conversion of pesticides into the obsolete form, which may even show more harmful effects than the former.. When the pesticides are not used within the prescribed time of their efficacy, they become obsolete. "Obsolete pesticides" are defined as those pesticides that can no longer be used for their intended purpose or wanted to be used and therefore must be disposed off. They are decomposed into other chemical components, which are sometimes even more toxic than the original pesticides. Most pesticides expire two years after production, meaning they cannot be used unless they are tested and proved stable.

In Nepal, there is a stockpile 74.5 MT of the obsolete pesticides, majority of which belong to banned POPs pesticides, the "Dirty Dozen" under Stockholm Convention and are stored in 24 locations/warehouses across the country for more than 30-40 years. In Nepal such a huge amount of obsolete pesticides was due to the inappropriate donations from the donor agencies/countries and over-purchasing in the past. The condition of the stocks is highly variable. Some include products that are still viable and could be reformulated and repackaged for use (although the cost might be prohibitive). Other stocks consist of unprotected and unidentifiable mounds of mixed products, corroding containers and contaminating soils (MOEST 2006). Many stocks are located near farm fields, human settlements, schools or water sources, as the pesticides were stored close to where they were to be used. Many stocks are abandoned, unmanaged, have no labels, and have no clear “owner” to be responsible (Manandhar 2006). In most cases, such stocks would be classified as hazardous waste under international law and controlled by the Basel Convention if subject to transboundary movements.

STATEMENT OF PROBLEM

Of the 74.5 MT of obsolete pesticides stored in different ware house/stores in Nepal, Amlekhgunj is the major warehouse containing 50.90 MT of pesticides packed in 200 liter steel drums and 60 liter HDPC (MOEST 2006). These consists of POPs, pesticides 28.10 MT, organomercury 7.40 MT, organ chlorine 7.3 MT, organophosphate 1.20 MT , fungicides 2.50 MT, rodenticides 1.0 MT, fumigants 2.0 MT herbicides 1.40 MT. Due to huge amount of unsafe storage and leakage of obsolete pesticide in the past, there is great probability of environmental contamination as well as human health problems (mostly the school children near the warehouse). According to the report of Pro Public (2005), five composite samples from the school ground adjacent to Amlekhgunj warehouse HCH, DDD, DDE, DDT, Dieldrins, Chlorpyrifos were detected; also mercury was present in 4 samples. So there is high chance that the school children, teachers and staffs might have been affected by the soil and air contamination and needs proper assessment and verification.

OBJECTIVE OF THE STUDY

The objective of this study was to know the level of soil contamination by the leakage of obsolete pesticides around the warehouse and its health impacts on the school children of Shree Nepal Secondary School, Amlekhgunj, Bara District.

MATERIALS AND METHODS

Amlekhgunj Warehouse and Shree Nepal Madhayamik Vidhayalya were selected as the study area, which lie in the Ward No.1 of Amlekhgunj VDC, Bara District, Nepal. It is about 50 km North of Birgunj on the way to Kathmandu along the Mahendra Highway.

Shree Nepal Madhayamik Vidhayalya is a government owned secondary school, which lies adjacent to the warehouse, where 50.9 MT obsolete pesticides are stored. The west wall of the warehouse and the school playground are adjacent to each other. This is the biggest school in the area having around 1000 students.

Seven composite soil samples were collected from the school ground at every meter (1, 2, 3 and 4m in the south and 0, 1, 2 m in the north) from the wall of the warehouse. The soil samples were taken to Pollution Monitoring Laboratory (PML), New Delhi, India, where the analysis of 26 different types of pesticide residues (16 organochlorines, 10 organophosphates and one heavy metal Hg) in the soil was done. PML is known to follow the internationally used methodology prescribed by United States Environment Protection Agency (USEPA) for organochlorine and organophosphorus pesticides detection.

The semi-structured questionnaires survey was done to collect the information on the health hazards of the students, teachers and the villagers.

RESULTS AND DISCUSSION

HEALTH IMPACTS

The study showed that the majority of the school children were from poor family background and most of the parents/guardians were daily wage workers, who were not able to bear huge cost for any catastrophes. As the school children, aged between 3 to 15 years, were in their tender ages, they were among the most vulnerable ones to the contaminants of obsolete pesticides.

The main entrance of the school was directly attached to the warehouse and due to the closeness with the warehouse the staffs and students were feeling very strong smell of pesticides, especially during the time of high temperatures and rainy season. Due to constant exposure they had become used to to such level of smell and could not even feel the strong smell, which the new visitors could feel in the very first exposure.

Moreover, the smell was strong during daytime and very strong during the noon, probably due to the high temperatures of those hours. The exposed ones had reported the cases of irritation, dizziness and decreasing working efficiency and less concentration at work or study. Nearly half of the children did not attend regular classes to avoid constant exposures, but appeared only in the examinations. It had thus great impact on the quality of education.

On the other hand the parents did not have better alternatives other than to send their children to this school. Study showed that 95% of pupil of the school claimed the problem to be due to the storage of obsolete pesticides in the adjoining warehouse. Along with the available scanty health data, the behavior of students and their level of study efficiency was compared with such qualities/ parameters of the students from other school of the same grades and it was found that the students of Shree Nepal Madhayamik Vidhayalya showed symptoms of some sort of pesticide contamination. The following health risks (Table 1) were obtained among the students of the school.

Table 1. Different health effects observed in the students (in percentage)

Health effects	Result (%)
Headache	90
Vomiting	10
Heart complaint	4
Foul smell	100
Unconsciousness	10
Drowsiness	72
Irritation	50
Eye problem	33
Skin problem	24
Loss of concentration	75

SOIL

The soil showed the evidences of high contamination in the school ground adjacent to the warehouse. Among 16 organochlorines and 10 organophosphates pesticides, all 26 could not be detected in the soil samples; the detected pesticides including a heavy metal Hg are presented in Table 2. Higher concentration of pesticides and heavy metals were detected in the soil samples from the north side of warehouse.

Table 2. Pesticides and heavy metal concentrations (mg/kg) in soil samples from the school playground at Amlekhgunj (2008): Present study

S. No	Pesticide	Class	North			South			
			0m	1m	2m	1m	2m	3m	4m
1	α- HCH	Oc	0.0013	0.0009	**0.3617**	0.0007	ND	ND	ND
2	β -HCH	Oc	0.0014	ND	**1.2566**	0.0018	ND	ND	ND
3	γ-HCH		0.0412	0.0135	**0.7684**	ND	0.0080	0.0252	ND
4	Heptachlor	Oc	0.0029	0.0016	**0.3925**	ND	0.0036	0.0048	0.0034
5	Aldrin	Oc	ND	ND	**0.3613**	ND	ND	ND	ND
6	phosphamidon	Op	ND	ND	**1.0728**	ND	ND	ND	0.0094
7	α -endosulfan	Oc	0.0158	0.0044	**0.7537**	0.0011	ND	ND	ND
8	cis chlordane	Oc	ND	ND	ND	0.0502	0.0440	0.0565	ND
9	trans chlordane	Oc	0.0137	0.0020	**0.3885**	ND	ND	ND	ND
10	DDE	Oc	0.0300	0.0175	**0.3378**	0.0013	0.0119	0.0145	0.0139
11	Dieldrin	Oc	0.0407	0.0111	**1.0076**	ND	ND	ND	0.0016
12	DDD	Oc	0.0328	0.0161	**0.2460**	ND	0.0155	0.0125	0.0128
	Heavy Metal								
13	Mercury	Heavy Metal	3.4600	1.8700	**1.6090**	ND	ND	3.4250	2.4110

Note: Oc – Organochlorine. Op – Organophosphorus; ND - not detected

Among 16 Organochorines analysed, DDE (most persistent metabolite of DDT) was detected in all seven samples. δ-HCH, DDT, and ß-endosulfan, were not detected in any sample. Among 10 Organophosphorus pesticides, only phosphamidon was detected in two samples. Mercury was detected in five of the seven soil samples.

Very few studies were conducted in the past on the pesticide residues in the contaminated soil. A similar study done by Pro-Public in the year 2005 (MOEST 2007) showed significant level of pesticides contamination in the same site by taking only 5 composite soil samples. The Pro-Public, an NGO, did not study the relation between the health impacts and soil contamination at that time. However, the result of the present study when compared with the findings of the Pro-Public, an increase in some pesticides residues i.e α-endosulphan and mercury in the soil but in the meantime a decrease of DDD could be found. The residues of some pesticides i.e.▫-HCH had disappeared, whereas the new ones like heptachlor, cis and trans chlordane appeared in the soil.

Table 3. Pesticides and heavy metal concentrations (mg/kg) in soil samples from the school playground at Amlekhgunj (2005): Pro-Public study

S.No	Pesticides	0 m	1m	2m	3m	4m
1.	α- HCH	n.d.	n.d.	n.d.	n.d.	n.d.
2.	ß –HCH	n.d.	n.d.	0.002	n.d.	n.d.
3	γ- HCH	0.0920	0.0964	0.1065	0.0833	0.0792
4.	δ- HCH	0.0091	0.0091	0.0020	n.d.	n.d.
5.	Heptachlor	n.d.	n.d.	n.d.	n.d.	n.d.
6.	Chlordane	n.d.	n.d.	n.d.	n.d.	n.d.
7.	DDD	0.2112	0.0138	0.0189	0.0692	0.2614
8.	DDE	0.0529	0.0260	0.0423	0.0262	0.0773
9.	DDT	06397	.012749	0.0858	0.9475	9.4621
10.	Dieldrin	0.0040	0.0040	0.00402	0.0029	0.0030
11.	Aldrin	n.d.	n.d.	n.d.	n.d.	0.0147
12.	α- endosulphan	0.00088	n.d.	n.d.	n.d.	n.d.
13.	ß- endosulphan	n.d.	n.d.	n.d.	n.d.	n.d.
14.	Endosulphan sulphate	n.d.	n.d.	n.d.	n.d.	n.d.
15.	Methoxychlor	n.d.	n.d.	n.d.	n.d.	n.d.
16.	Chlorpyrifos	0.0021	.0091	0.0050	0.0047	0.0061

(Source: MOEST 2007)

CONCLUSION

Pesticide residues, some of which even belong to POPs category, in the soil near the warehouse were found having adverse impacts on the human health and environment of the study area. The constant presence of such pesticides over a long time or even increasing level of some obsolete pesticides in the soil confirmed that the pesticides had persistence nature and their concentrations in the soil was increasing with time along with the potential of increasing health hazards. Among the students, 95% related their health problems to the soil contaminants of pesticides in the adjoining warehouse. If obsolete pesticides stored in Amlehkganj Warehouse, will not be disposed off safely in time, unavoidable accidents may aggravate the problem in the future. Since the pesticides have the property of bioaccumulation and biomagnifications, they will derive long lasting impacts on the environment and human health; especially the students need to be protected in time. Students spending 180 days in the school come in contact with such pesticides in soil or air for 1080 hours in a year and this is enormously high occupational exposure to any contaminant. An exposure of this degree at the growing and learning stage of the school children is actually a loss to the Nation. The complaints of the students indicated that there might be a significant level of these pesticides in their tissues, which needs to be verified by the future investigations. Moreover, similar research is also needed to be done in air samples to reach at the core of conclusions. Government needs to pay special attention towards the safer disposal of obsolete pesticides to protect the environment and public health and to ensure clean and healthy environment, which is the basic right of the citizen and the state is responsible to guarantee it.

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ASSESSMENT OF RICE AND MAIZE BASED CROPPING SYSTEMS FOR RURAL LIVELIHOOD IMPROVEMENT IN NEPAL

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ABSTRACT

This paper explores the assessment of rice and maize base cropping system in agro-ecological regions for sustainable rural livelihood development in Nepal. Analysis of 1994-2007 data showed rice-dominated cropping systems in the Plain region, as opposed to maize-dominated cropping systems in the Mountain and the Hill regions. The production increase was achieved mainly through increases in area. The growth in the yield of crops was very minimal in all three regions. During the last fifteen years, the cropping pattern changed slightly from Maize-Wheat to Maize-Paddy in the Mountain region, but no significant change was observed in the other two regions. The current rate of fertilizer application is lower than the recommended rate. Improved access to and availability of agricultural inputs is key to improve the production and yield of major food crops to achieve sustainable rural livelihood in the country.

Key words: Agro-ecological-region, cropping system, farm income, rural livelihood, sustainable livelihood

INTRODUCTION

In different literature the definition of cropping systems may vary , however, in general cropping systems refers to the pattern of crops taken up for a given piece of land, or sequence in which the crops are cultivated on piece of land over a fixed period and their interaction with farm resources and other farm enterprises. According to Department of Agriculture, Government of Kerala, India, the cropping system is the cropping pattern used on a farm and its interactions with farm resources, other farm enterprises, and available technology which determine their makeup. However, cropping pattern is the yearly sequence and spatial arrangement of crops and fallow on a given area. Rice, maize and wheat are the major crops of Nepal. Farming systems and crop production in Nepal vary across the agro-ecological regions. Rice-based cropping systems, with wheat or maize as a secondary crop, are predominant in the Plain (Terai) and middle hills, whereas in the high mountains maize, millet, barley and buckwheat are cultivated. Tea, cardamom, ginger and coffee are the important cash crops of the middle hills. Likewise, wide ranges of temperate fruits in the high mountains; citrus in the middle hills; tropical/subtropical fruits are also grown in the Plain (Terai) and middle hill valleys. Vegetable-growing in kitchen gardens is practiced at all elevations (FAO, 1996). Although these major food crops are highly important for maintaining food security and supporting livelihood, the yield performance of these crops is much less than satisfactory. The yield of major food crops in Nepal in recent years has also been lower than other South Asian countries (see Table 1).

Nepal's agricultural production is characterized by diversity in farming systems influenced by differences in agro-ecological topography. Farming systems and crops vary widely depending upon altitude and climatic conditions. The agricultural sector contributed 40.22% to the Gross Domestic Product in 1995/96 (CBS, 1996). A large majority of households depend upon agriculture and allied activities such as livestock-rearing and forest product collection. As the agriculture sector is the key sector of the economy, determining economic growth and employment, the standard of living of the majority of the population depends on its development. Despite investment in irrigation and agricultural development projects, agriculture production is still largely determined by favourable weather conditions (EIU, 1997).

Table 1. Paddy, maize and wheat yield and fertilizer application in south Asian countries (IFA/IFDC/PPI/IPI/FAO, 2002 and FAOSTAT, 2005).

Country	Yield* (t/ha)			Fertilizer use** (kg/ha)		
	Paddy	Maize	Wheat	Paddy	Maize	Wheat
Bangladesh	3.85	5.21	1.78	97	48	63
India	3.18	2.00	2.63	101	49	135
Nepal	2.69	2.05	2.12	71	42	77
Pakistan	3.18	3.04	2.62	59	68	138
Sri Lanka	3.73	1.54	-	143	84	-

*Three years' average from 2005 to 2007, ** whole fertilizers in the year of 2002

Agriculture occupies an important place in the economy and politics of many countries of the Asian and Pacific region. In 1992, for example, its contribution to the GDP among the developing countries of the Asian and Pacific region was generally upwards of 25%, rising to 62% in Nepal (ADB, 1992); and it provides employment to a significant proportion of the total labor force in many countries. In Japan, South Korea, and Taiwan, while agriculture's contribution to the GDP is under 10% (only about 4% in Taiwan), many city dwellers maintain their roots in the countryside, where parents or other close relatives still live on ancestral land. And while the economy of the latter countries is tied to industrial development, governments are struggling to find strategies to maintain a balance between industrial development and agricultural stability. Their buoyant economies notwithstanding, they are concerned about issues of food and agricultural security as they import increasingly larger quantities of food and other agricultural products. They are also concerned about the possible environmental and psychological effect of the gradual disappearance of vegetation (OECD, 1988).

The Nepalese economy is primarily agriculture based. The agriculture sector accounts for 33% of GDP and over 65% of the economically active population depends on it. Poverty is much more severe in rural areas (42%) than urban areas (10%) and is particularly severe in the mountain agro-ecological region (CBS, 2007). About 80% of the rural population aged over 15 is engaged in agriculture. The level of income in Nepal is lower than other south Asian countries (see Table 2).

Table 2. Development indicators in South Asia (World Bank, 2004)

Indicator	Unit	Nepal	Bangladesh	India	Pakistan	Sri Lanka
GDP per capita	US $	241	396	493	518	899
Poverty	% of total population	31	50	29	33	25
AGDP	% of total GDP	33	23	23	23	20

The country is divided into three agro-ecological regions namely Mountain in the north, Hill in the middle, and Plain in the south. According to Pariyar (2005), the Mountain region is characterised by higher elevation (> 2500 M), lower temperatures and lower rainfall. Likewise, the Hill region is characterized by moderate elevation (500-2500 M), a sub-tropical to warm temperate climate, and higher annual rainfall. On the other hand, lower elevation (< 500 M), sub-tropical to tropical climate and medium rainfall characterize the Plain region.

A doubling (102%) of fertilizer consumption recorded in south Asia was due primarily to rapid growth in Bangladesh (150%), India (110%),and Nepal (200%); Pakistan (74%) came a little behind. More modest rates of growth were recorded in Sri Lanka (20%) and Afghanistan (11%). In Myanmar, on the other hand, a 45% reduction in fertilizer consumption took place. The reduction here and the limited growth in Afghanistan could be attributed to the prevailing disturbed political situation. Sri Lanka's smaller growth may also reflect the fact that the level of fertilizer use there (136 kg/ha) is already high for the crops grown (Table 3).

Compared to 1965, when fertilizer use accounted for 0-6% of the total agricultural production in Bangladesh, India, Nepal, and Pakistan, and 43% in Sri Lanka, fertilizer dependence had grown to 24-52% in 1990. This might reach 39-54% by the year 2000. Thus, by that time, about one-third to half of the total agricultural production needed in south Asia will have to be obtained by using fertilizers (Ahmed, 2008).

METHODOLOGY

The data required in this study has been compiled from various secondary sources published by Government and non-Government agencies of Nepal. Area, production and yield data of major food (Paddy, Maize, and Wheat) and vegetable crops were used to find out the production value and agricultural land use changes in different agro-ecological regions from 1995 to 2004. Likewise, real price data was calculated by using a GDP deflator taking 1995 as the base year. Whereas, the production value was derived from annual crop price data (standard local currency in Rupees), which was available in FAOSTAT (2005). Analysis of these data made it easy to assess the contribution of agricultural crops to sustainable economic development in agro-ecological regions of Nepal.

RESULTS AND DISCUSSION

MOUNTAIN AGRO-ECOLOGICAL REGION

Real Production Value

Table 3 presents the real production value trends and the annual economic contribution of major food and vegetable crops in the Mountain agro-ecological region from 1995 to 2004. It clearly indicated that the contribution of paddy and vegetable crops was remarkable in 2004 improving by 174% and 153% over 1995, respectively. This implies that policy supporting higher yield and better farm gate prices for vegetable crops is appropriate to increase farmers' income in Mountain region. The percentage changes per annum show distinct variation in gross production value in most of the years. This might be due to the higher dependency of agricultural crops on nature.

Agricultural Land Use Changes and Price

Table 4 shows that maize was found to have the highest share of agricultural land use area, covering 39% of the total area in 1995. It was followed by wheat (29%), paddy (27%) and vegetables (4%). Similarly, in 2004 maize accounted for the highest share (44%) followed by paddy (28%), wheat (24%) and vegetables (4%). It should be noted that the percentage shares of maize and paddy area to the total area covered were higher in 2004 than in 1995, while in the case of wheat, the situation was reversed meaning that the percentage share of wheat of the total area was lower in 2004 than 1995. Hence, the dominance of crops scenario was changed in 2004 (Maize-Paddy) as compared to 1995 (Maize-Wheat). This implies that the cultivation of paddy is gradually increasing in the Mountain region. On the other hand, the yield of major food and vegetable crops was almost stagnant during this period. The yield of paddy, maize, wheat and vegetables increased by only 14%, 11%, 16% and 17%, respectively from 1995 to 2004.

Table 3. Real production value of major food and vegetable crops in the mountain agro-ecological region (NRs. in million) (FAOSTAT, 2005; MOAC, 2005)

Year	Paddy		Maize		Wheat		Vegetable		Total Value	Annual Change (%)
	Value	% Share*	Value	% Share*	Value	% Share*	Value	% Share*		
1994	404	23	669	38	337	19	353	20	1764	0
1995	482	25	761	39	352	18	359	18	1953	30
1996	522	29	564	31	382	21	354	19	1822	16
1997	572	27	584	28	404	19	537	26	2096	12
1998	459	25	560	30	360	19	475	26	1853	-8
1999	558	25	747	33	433	19	531	23	2269	27
2000	580	24	872	36	477	19	518	21	2446	3
2001	619	23	923	34	491	18	665	25	2699	11
2002	691	26	977	37	476	18	525	20	2668	16
2003	698	26	996	36	471	17	564	21	2730	4

*out of total production in the particular year

Table 4. Agricultural land use changes and real price of major food and vegetable crops in 1995 and 2004 (MOAC, 2005; MOF, 2004)

Crops	1995			2004			Change % (1995-2004)	
	Agri Land Use(000 ha)	Yield (t/ha)	Price* (Rs./ton)	Agri Land Use (000 ha)	Yield (t/ha)	Price* (Rs./ton)	Agri Land Use	Price
Paddy	41 (27)	1.8	5540	56 (28)	2.0	6144	37	11
Maize	60 (39)	1.6	7080	89 (44)	1.7	6463	47	-9
Wheat	45 (29)	1.3	5880	49 (24)	1.5	6424	11	9
Vegetable	7 (4)	8.1	6412	9 (4)	9.5	6822	28	6
Total	153 (100)	-	6228	203 (100)	-	6463	33	4

* Calculated by using Agricultural GDP Deflator as base year 1995. Figures in parentheses express the crop area in percentage of total agricultural land area.

HILL AGRO-ECOLOGICAL REGION

Real Production Value

Table 5 revealed that maize made the largest contribution to the total production value followed by paddy in the Hill agro-ecological region. It is, however, worth noting that, over the years, the percentage share of total production value of vegetables kept increasing as compared to other crops. Moreover, while the production value from other crops increased by nearly two times, there was an almost threefold increase in production value (income) from vegetables during the 1995 to 2004 period of analysis. It clearly established that the increased importance of vegetable farming in the Hills of Nepal was a result of the increased consumption and favourable price structure for vegetables. Hence, it can be concluded that despite comparatively less harvested area than other major food crops, vegetables contributed markedly to the gross crop income value, which ultimately will help boost the economic conditions of Hill farmers. On the other hand, production value decreased in some particular years (see Table 5) was due to the unfavourable climatic condition and upsurge in insurgency (Pakyuryal *et al.*, 2005).

Table 5. Real production value of major food and vegetable crops in the hill agro-ecological region (NRs. in Million) (FAOSTAT, 2005; MOAC, 2005)

Year	Paddy		Maize		Wheat		Vegetable		Total Value	Annual Change (%)
	Value	% Share*	Value	% Share*	Value	% Share*	Value	% Share*		
1994	4078	27	6257	42	1936	13	2744	18	15015	0
1995	5166	28	8074	41	2173	12	3476	19	18215	32
1996	5292	32	6074	32	2429	15	3475	21	16374	-3
1997	5960	32	6513	29	2440	13	4735	26	18549	16
1998	4826	30	7190	33	2280	14	3578	22	15908	-2
1999	5760	31	9084	34	2533	14	3888	21	18494	22
2000	5212	27	9317	34	2705	14	4829	25	19307	3
2001	5874	27	10050	31	2688	12	6312	29	21697	17
2002	6088	29	10802	34	2794	13	4877	23	20796	0
2003	6143	29	11190	34	2866	14	4956	24	21020	4

*out of total production in the particular year

Agricultural Land Use Changes and Real Price

LRMP (1986) reported that of all the agro-ecological regions, the Hills had the highest area covered by maize, which contributed 70% to total national production. Table 6 shows that

Table 6. Agricultural land use changes and real price of major food and vegetable crops in 1995 and 2004 (MOAC, 2005; MOF, 2004)

Crops	1994			2003			Change % (1994-2003)	
	Agri Land Use(000 ha)	Yield (t/ha)	Price* (Rs./ton)	Agri Land Use (000 ha)	Yield (t/ha)	Price* (Rs./ton)	Agri Land Use	Price
Paddy	338 (29)	2.2	5540	383 (30)	2.6	6144	13	11
Maize	543 (47)	1.6	7080	578 (45)	1.9	6463	7	-9
Wheat	230 (20)	1.4	5880	242 (19)	1.9	6424	5	9
Vegetable	50 (4)	8.6	6412	68 (5)	10.6	6822	37	6
Total	1161 (100)	-	6228	1271 (100)	-	6463	10	4

* Calculated by using Agricultural GDP Deflator as base year 1995. Figures in parentheses express the crop area in percentage of total agricultural land area.

maize was found to have the highest share of the total area of major food and vegetable in 1995. It was followed by paddy (29%), wheat (20%) and vegetables (4%). Similarly, in 2004 maize accounted for the highest share (45%) followed by paddy (30%), wheat (19%) and vegetables (5%). It was observed that the percentage shared by maize, paddy and wheat area of the total area covered was changed in 2004 as compared to that in 1995, while the dominant crops scenario was the same (Maize-Paddy) during that period in the region. In 2004, the yield of paddy, maize, wheat and vegetable crops increased by 20%, 16%, 29% and 24% over 1995, respectively.

3) PLAIN AGRO-ECOLOGICAL REGION

(i) Real Production Value

Paddy, which is one of the major crops of Nepal, is the main crop grown in the Plain region. Table 7 showed that the gross production value substantially increased from 1995 to 2004, It is notable that an emphatic growth in the production value was observed in paddy followed by wheat and vegetable crops between 1995 and 2004. This clearly indicates that despite comparatively less harvested area than maize and wheat crops, vegetables had a considerable contribution to the gross crop income value in the Plain region.

Table 7. Real production value of major food and vegetable crops in the plain agro-ecological region (NRs. in Million) (FAOSTAT, 2005; MOAC, 2005)

Year	Paddy		Maize		Wheat		Vegetable		Total Value	Annual Change (%)
	Value	% Share*	Value	% Share*	Value	% Share*	Value	% Share*		
1994	11617	27	2293	42	3264	13	4671	18	21845	0
1995	16888	28	2721	41	3918	12	5372	19	28900	32
1996	17974	32	1958	32	4409	15	5263	21	29605	-3
1997	18621	32	1970	29	3889	13	7350	26	31830	16
1998	14629	30	1863	33	4220	14	6169	22	26881	-2
1999	19280	31	2084	34	4860	14	6968	21	33192	22
2000	17802	27	2066	34	4802	14	7051	25	31721	3
2001	19863	27	2185	31	5204	12	9543	29	36795	17
2002	18595	29	2074	34	5382	13	6911	23	32962	0
2003	20535	29	2226	34	5574	14	7375	24	35709	4

*out of total production in the particular year

Agricultural Land Use Changes and Real Price

Table 8 shows that the percentage share of paddy area of the total area covered were slightly higher in 2004 than 1995, while, in the case of wheat and maize the situation was reversed. However, the dominant crops scenario (Paddy-Wheat) was the same in the 1995 and 2004. Unlike other agro-ecological regions, the yield of paddy, wheat and vegetable crops increased distinctly by 41%, 46%, and 30%, respectively, while maize yield increased only by 7% from 1995 to 2003.

Table 8. Agricultural land use changes and real price of major food and vegetable crops in 1995 and 2004 (MOAC, 2005; MOF, 2004)

Crops	1994			2003			Change % (1994-2003)	
	Agri Land Use(000 ha)	Yield (t/ha)	Price* (Rs./ton)	Agri Land Use (000 ha)	Yield (t/ha)	Price* (Rs./ton)	Agri Land Use	Price
Paddy	989 (62)	2.1	5540	1121 (64)	3.0	6144	13	11
Maize	169 (11)	1.9	7080	168 (10)	2.1	6463	0	-9
Wheat	350 (22)	1.6	5880	374 (21)	2.3	6424	7	9
Vegetable	84 (5)	8.7	6412	96 (5)	11.3	6822	14	6
Total	1592 (100)	-	6228	1759 (100)	-	6463	11	4

* Calculated by using Agricultural GDP Deflator as base year 1995. Figures in parentheses express the crop area in percentage of total agricultural land area.

CONCLUSIONS

The results indicate that from 1994 to 2003, the proportionate increase in area was the highest in the Mountain region followed by Hill and Plain, while proportionate increases in yield, production and production value were highest in the Plain region followed by the Hill and the Mountain regions for both major food and vegetable crops. Vegetable expansion in the three agro-ecological regions was mainly due to the high vegetable consumption by an increased population and also to the effects of the 20-year Agriculture Prospective Plan.

The Plain and Hill regions are envisaged as more appropriate for the cultivation of major food and vegetable crops than the Mountain region. Maize dominated cropping systems were found in the Mountain and Hill regions, whereas, paddy dominated the cropping system in the Plain region. During the 1995 to 2004 period, cropping patterns were changed slightly in the Mountain region from Maize-Wheat to Maize-Paddy, while they did not significantly change in other regions during the past decade. Despite smaller harvested area, the contribution of vegetables to gross production value was remarkable in all three regions. This implies that vegetable crops are one of the most important and potential sources of farm income. The importance of vegetables is particularly high in the hill and mountain regions, as the yield of major food crops is significantly lower in these regions. Improved access to and availability of agricultural inputs is key to improving the production and yield of major food and vegetable crops to provide sustainable economic development in the country.

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VULNERABILITY OF MOUNTAIN COMMUNITIES TO CLIMATE CHANGE AND ADAPTATION STRATEGIES

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ABSTRACT

Climate Change, one of the most important global environmental challenges facing humanity, has implications on food production, natural eco-systems, fresh water supply and health in Nepal. It is contributing mostly to the rise in air temperature leading to rapid melting of glaciers and increment of glacier lakes. Exploitation of natural resources associated with growing population has led to increasing pollution, declining water quality, land degradation, etc. Extreme climate events including flooding, heavy rainfall, droughts, heat wave and cold stream etc. are also the consequences of climate change in Nepal.

Moreover, Nepal is largely dependent on climate-sensitive sectors, such as rain-fed agriculture; its fragile mountain ecosystems and dramatic topography make the country prone to flooding. Due to such events, agricultural productivity is declining with increasing problem of food security in mountainous regions. In recent years, the signs of such changes are being observed and may become more prominent over next couple of decades. Many rural communities are struggling through different adaptation measures as an attempt to reduce the risk of climate change vulnerability.

INTRODUCTION

CLIMATE CHANGE

Global climate change has attracted much scientific and public attention in recent years, as a result of fears that human's economic activities are leading to an uncontrolled increase in Greenhouse Gas (GHG) emission and concentration in the Earth's atmosphere leading to a global rise in the Earth's temperature due to the radioactive properties of these gases. Global warming is expected to continue, with increase projected to be in the range of 1.4 to 5.8ºC by 2100 in comparison to 1990 (IPCC 2003). There is increasing observational evidence that regional changes in climate have contributed to various changes in physical and biological systems in many parts of the world (IPCC 2003). These include the shrinkage of glaciers, changes in rainfall frequency and intensity, shifts in the growing season, early flowering of trees and emergence of insects, and shifts in the distribution ranges of plants and animals in response to changes in climatic conditions.

In context of Nepal, the global emission of greenhouse gases is negligible at per capita CO_2 emission of 0.13 tonnes. But, Nepal still faces the consequences of global warming because of the geographical and climatic conditions, high dependence on natural resources and lack of resources to cope with the changing climate. The average temperature in Nepal is rising by 0.5 degrees Celsius per decade. However, such minimal change in air temperature can also lead to rapid melting of glaciers and Glacier Lakes (Dhakal, 2003). WWF Nepal Program (2005) study indicated that the Khumbu Glacier, a popular climbing route to the summit of Mt Everest, has retreated over 5kms.

The Himalayas in Nepal are geologically young and fragile and are vulnerable to even insignificant changes in the climatic system. However, in both developing and developed

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countries, the impact of climate change can be much greater for indigenous communities living in the more remote and ecologically fragile zones and relying directly on their immediate environments for subsistence and livelihood (UNFCCC, 2004).

Agricultural productivity can be affected by climate change in two ways: first, directly, due to changes in temperature, precipitation and/or CO_2 levels and second, indirectly, through changes in soil, distribution and frequency of infestation by pests, insects, diseases or weeds.

VULNERABILITY AND ADAPTATION CONTEXT IN NEPAL

Due to late Monsoon and decrease in rainfall, farmers of Abukhaireni VDC in Tanahun district of Nepal were forced to slash and burn the nearby forest and cultivate in the land to cope up with the potential food shortages as they depended only on the rain-fed land (Regmi, 2005).

The Tsho Rolpa risk-reduction project in Nepal is an example of adaptation measures being implemented to address the creeping threat of glacial lake outburst flooding as a result of rising temperatures. This is one of the most significant examples of collaborative anticipatory planning by the government, donors, and experts in Glacial Lake Outburst Flood (GLOF) mitigation.

Successful adaptation reduces vulnerability to an extent that depends greatly on adaptive capacity: the ability of an affected system, region, or community to cope with the impacts and risks of climate change. Enhancement of adaptive capacity can reduce vulnerability and promote sustainable development across many dimensions (IPCC 2003).

OBJECTIVES OF THE STUDY

The objective of this research was to assess the vulnerability of indigenous mountain communities to climate change as well as to understand the adaptation strategies taken to mitigate climate-induced change on agriculture.

METHODOLOGY

THE STUDY AREA

The study area lies in the Eastern Development Region of Nepal in Solukhumbu district and within the Buffer Zone of the Sagarmatha National Park. Situated between latitudes 27° 42' 42.87" to 27° 47' 03" N and longitudes 86° 41' 44.66" to 86° 44' 46.61" E, the study area is a part of Chaurikharka VDC. It covers five major settlements: namely, Jorsalle and Benkar (Ward no.1), Phakding (Ward no. 4), Chhermading (Ward no. 9) and Ghat (Ward No. 5) of Chaurikharka VDC. These settlements lie within the major trekking route of the Everest region.

DATA COLLECTION

Primary data from the study site were collected through structured interview, interview with key informants, and field observation. To ensure well-distributed representation, the selection of samples from the study area was done by a simple random sampling and on the basis of their economic categories: namely, rich, middle class and poor via wealth ranking assessment. Stratified random sampling was applied to select the household in the study villages. PRA method was applied to gather information on perception and awareness of climate change, vulnerability induced by climate change and adaptation measures of local mountain communities to minimize such impacts. Focused Group Discussion (FGD) was applied to understand the perceptions, attitudes and practices. Socio-Economic Vulnerability Assessment of each settlement was also calculated. In this study, six factors i.e. number of household, occupation, literacy status; assets, food sufficiency and public awareness to natural disaster were used as indicators for socio-economic vulnerability assessment of each settlement. The total score of each village indicated the Vulnerability Indices (VI) which were then classified into three categories using "Three Categorized Ranking Method" (TCR) assigning scores of 1 to 3, 1 being the least vulnerable (Shrestha *et al.*, 2003 in Shrestha, 2005). Socio-economic vulnerability of a settlement was calculated by combining these six VI and Ranking of each VI are as given below.

1. Higher household number in a settlement is associated with higher vulnerability.
2. People with diversified occupation are considered less vulnerable and people involved only in agriculture are considered highly vulnerable.
3. Lower level of literacy is associated with higher vulnerability.
4. People having higher property investment are considered more vulnerable.
5. Higher food deficiency is associated with higher vulnerability.
6. Lower level of awareness to natural disaster and climate change and its adaptation and mitigation options are associated with higher vulnerability.

(*Source: WWF Nepal 2008*)

Secondary data were collected from previous works and also the hazard maps, natural disaster profiling and analysis, land-use maps, meteorological data and topographical maps were reviewed.

RESULTS AND DISCUSSION

SOCIO-DEMOGRAPHY

The study area was found to be dominated by Sherpa (74%) with scattered population of Rai (12%), Magar (9%) and Chhetri (5%). The proportion of male and female respondent was 62% and 38%, respectively, with the family size ranging from 2 to 4, while Benkar had the highest members per household, i.e. 8. Among the studied villages, highest literacy (86%) was found in Jorsalle, whereas Ghat had the lowest literacy (75%).

LIVELIHOOD

More than 74% of respondents were found to have owned some form of agricultural land which were categorized into kitchen garden, upland bari and lowland bari, while the average landholding was found to be highest in Chermading (18.5 ropanies) followed by Phakding with 14.11 ropanies and Ghat with 10.69 ropanies.

Agriculture was the major occupational choice in Ghat and Chermmading with 37% of the respondents depending on it for their livelihood. The major agricultural crops grown were potato, leafy vegetables, wheat, cabbage, buckwheat, carrot, beans (white). Regarding the agricultural production sufficiency, 56% had enough food production for 9-12 months, and the rest were suffering from food deficiency. Nearly 69% of the households were found to cultivate crops like potatoes, leafy vegetables, cabbage, cauliflower, carrots, radish and beans for the purpose of selling.

Among the respondents, 27% stated an increment in agricultural productivity due to better rainfall timing, better farming through crop rotation, new seeds and use of organic fertilizers and training interventions. Meanwhile, the decline in agricultural produce was mainly due to pest infestation, old seeds, loss of soil nutrients, decreasing man power to work on the fields and increasing dependency on tourism.

Livestock rearing was another common income source. More than 76% of the respondents owned livestock such as cow, ox, wild boar, whereas zopke, yak, and horse, used for transport, brought twice the income compared to the human porter.

RAINFALL AND TEMPERATURE

The mean annual rainfall of about 2100 mm and mean monsoon rainfall of about 1750 mm were measured at Chaurikharka Station, estimating the year 1971 with the highest annual rainfall (2934.7 mm) as well as monsoon season becoming the most devastating season. As observed in the recent years, the devastations with the frequent stream flows included the washing away of the bridges near Tengboche Monastry in 2007, Thado Koshi Khola and Phakding in 2008.

Studies on temperature trends in Nepal have identified increasing trend in annual mean and annual maximum temperature in high altitude more than that of at lower altitude (Shrestha *et al*., 1999; Baidya *et al*., 2008). It clearly shows amplification of global warming in high elevation compared to low land. In addition, one of the principal concerns expressed by local respondents was the increasing danger and difficulty now experienced in carrying out traditional subsistence activities (collecting dry leaves) from the forest for manure due to the high intensity of rainfall.

Nepal's agriculture is very much dependent on the rainfall, and any significant change in air temperature can result in change in climatic conditions, like rainfall and weather conditions, resulting in shift in agriculture pattern.

CLIMATE CHANGE IMPACT

Agriculture

Potatoes harvesting was found shifted in Ghat (from Mid March to Mid January) and Phakding (from Mid March to Mid December), while leafy vegetables were shifted by 15 days in July, August and September, respectively. Though the agriculture yield has been improved in the study area, respondents stated a shift in growing time of vegetables.

Similarly, the change in flowering and fruiting patterns were also noticed in recent years. Some farmers of these settlements were happy with their potato and peach harvests as well as with increased sweetness of fruits. On the contrary, it was miserable for others, who had not only decreased size of potatoes, but also the potato seedling were smaller due to seed decaying and extreme rainfall. Additionally, decreased apple harvest was found to be due to reduced fruiting, early growing, dying and drying of apple plants, which had brought into a huge loss to the economy of the farmers. The problem was also due to the loss of agricultural produces by insect pests, like black flies, red flies, white flies, khumle with wings, and caterpillars, which were unknown to them few years back.

The occurrence of new species of trees i.e. Uttis (*Alnus Nepalenses),* vegetables as pumpkin and fruits including watermelon were also observed at Phakding and this is yet to be decided whether it is due to climate change or varieties improved for high altitudes. Similarly, farmers at Ghat stated the successful harvest of ginger for the first time.

Awareness

All respondents of Jorsalle, 86% of Benkar and only 50% of Chermmading, Ghat and Phakding were aware of climate change phenomenon. Similarly, the knowledge of GLOF was also high in Ghat, Benkar, and Phakding, but 57% of the respondents at Jorsalle and 17% at Chermmading did not know about such phenomenon.

Socio-Economic Vulnerability

With the estimation of six factors i.e. number of household, occupation, literacy status, assets, food sufficiency and public awareness to natural disaster, the socio-economic vulnerability was assessed which identified Ghat village as the most vulnerable among five settlements, because of its weak adaptive capacity including highest (75%) illiteracy, almost 100 % of village respondents had agricultural land ownership, indicating high dependency on agriculture to sustain their livelihood.(Table 1).

Table 1. Socio-economic vulnerability assessment of the five settlements

SETTLEMENTS	VI 1	VI 2	VI 3	VI 4	VI 5	VI 6	VI COMBINED	VULNERABILITY
JORSALLE	2	1	1	1	1	1	1.17	L
BENKAR	2	2	3	1	2	3	2.17	M
PHAKDING	3	1	2	3	1	2	2.00	M
CHERMMADING	1	2	2	3	1	2	1.83	L
GHAT	2	3	3	3	2	2	2.50	H

VI 1 – No. Of HHs, VI 2- Occupation, VI 3- Education, VI 4-Property Value, VI 5- Food Sufficiency, VI 6-Awareness;

VULNERABILITY: L = Low, M = Medium, H = High

Similarly, according to ICIMOD (2007), the hazard assessment maps and classification of the Imja and Dudh Koshi valleys identifies the village of Ghat, Chutawa, Chhermading, Phakding and Benkar in 'Moderate Hazard' category, where there is the possibility of overtopping by the GLOF. In addition, the damage will in all likelihood lead to a chain reaction on the upper terraces in Ghat village.

The landslide hazard zonation map of Chaurikharka VDC prepared by WWF Nepal (2008) reveals that 49% of the villages lie in high hazard zone while 51% in the moderate hazard zone. The villages in high hazard zone include Jorsalle, Benkar and Phakding while the village of Chermading and Ghat was observed to be in moderate hazard zone.

During the 1985 Dig Tsho GLOF both houses and cultivated land of Ghat, Chermading, Phakding and Benkar were overtopped (ICIMOD 2007) while the respondents at Ghat (88%) and Chermading (67%) state the maximum loss of property i.e. land, house and livestock. While it is predicted that the severity of impact of Imja Tsho GLOF will be even greater than the Dig Tsho GLOF due to the very fast retreating rate of Imja Glacier at 74meters per year for the past decade (ICIMOD 2007).

Similarly, with more than 74% of the respondents of Chermading, Phakding and Ghat with the highest average landholding, the impending natural disaster could result in property loss or physical capital, one of the key assets for adaptation to climate change. Meanwhile, considering the high socio-economic vulnerability of Ghat and moderate vulnerability of Benkar and Phakding, limits the ability of these communities to adapt to any disasters as a result of changing climatic condition.

Adaptation

Adoption of different practices by the respondent farmers in the major settlements was observed to cope with impacts of climate change. The planning of their agriculture was mostly based on weather calendar and particularly precipitation as well as adopting agro-forestry to adapt to the reduction of forest resources for fodder and firewood.

In order to tackle change in cropping, harvesting, heavy rainfall or snowfall, respondent farmers were found adopting indigenous strategies. Some of such strategies included covering vegetables with bamboo nets (*chitra*), cultivating before rainy season and after snowfall, digging deep to protect from snowfall, dry leaves spread over crops (millet, carrot and cabbage), support sticks to prevent crops from falling down due to heavy rainfall. The wide spread use of indigenous plant material such as '*titepati*' to combat pests that normally attacked food crops, was also found among small scale farmers which had also been used as manure mixing with dry leaves and ash.

In addition, the religious belief and faith was observed to be prominent in the region. Moreover, they were also found adopting a mixture of modern practices to protect the agricultural field. The protection of the agri-land from river overflow or in case of extreme floods was done by planting Pine and Juniper trees. Stone dykes were also constructed for fixing soil-surface nutrients, which otherwise would be washed away by runoff.

CONCLUSION AND RECOMMENDATIONS

Climate change, one of global inequity and an observed warming trend over the last few decades, is already having discernible and generally adverse impacts on the key resources. Potential intensification of monsoons combined with enhancement of GLOF risks also contribute to enhanced risk of flooding and landslides which can have serious impact on mountain agriculture and rural livelihoods. Based on socio-economic vulnerability, the village of Ghat was identified as a 'High Vulnerable Catagory' amongst the settlements because of their weak adaptive capacity to cope with the potential climate change impacts.

Subsistence production, predominantly agriculture has traditionally been the main livelihood strategy for most of the indigenous Sherpa communities. Though agriculture has its increasing yield, noticeable shifts in growing and harvesting of major crops were identified. The change in flowering and fruiting patterns was also noticed. In addition, the emergence of new species of trees i.e. Uttis (*Alnus Nepalenses)*, vegetables like pumpkin and fruit including watermelon at Phakding might be the consequences of climate change.

To mitigate the challenges of climate change at the local/community level, risk reduction will be the entry point. Vulnerability analysis could be the key while building resilience to future climate change and climatic variability. The importance of and difficulties in building trust of communities, and using intermediaries such as NGOs for interventions can help minimize the impact of climate change on agriculture in the region. Mainstreaming adaptation into development activities will be essential, but requires time and patience, additional funding, knowledge and technology.

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EFFECTS OF AGRICULTURE ON CLIMATE CHANGE: A CROSS COUNTRY STUDY OF FACTORS AFFECTING CARBON EMISSIONS

Krishna Prasad Pant (PhD)[1]

ABSTRACT

Agriculture affects atmosphere by releasing green house gases and get affected in turn, from climate change. This paper reviews the literature on both the aspects and test empirically that what affects emissions of carbon dioxide to the atmosphere. Data on carbon emissions, energy consumption and agriculture related national level variables are obtained for 120 countries from the World Bank's Green Data Book. Multiple linear regression analysis revealed that agricultural land, irrigation, forest area, biomass energy, and energy use efficiency negatively affect the Carbon dioxide emission. But, fertilizer use and per capita energy use affect it positively. The analysis confirms that the people in rich countries are more responsible for carbon emission than the people in poor countries. It recommends for cross subsidization for low external input agriculture, particularly for organic farming in poor countries.

Key words: agriculture, carbon emissions, climate change, energy consumption, GHGs

BACKGROUND

Climate change is realized as the greatest threat to the living beings on the earth affecting widely from tropical to arctic regions and from sea to land and atmosphere. Though the climate on the earth is changing naturally in its slow pace, the increased rate of climate change due to anthropogenic factors is of grave concern. The climate change is mainly attributed to industrial revolution and large amount consumption of fossil fuels. Agriculture that comprises crop and livestock also emits green house gases aggravating the problem. In addition, the climate change affects agriculture adversely, and the agricultural practices need to be modified to reduce the problem of climate change. The paper empirically analyses the factors affecting emission of the main green house gas, carbon dioxide, using cross-country data on emissions and agricultural variables like agriculture land, fertilizers and irrigation.

The discussion starts with issues of climate change and its relations to the agriculture sector. The second section deals with the methodology followed and the third section presents the test of hypothesis by comparing mean differences. The fourth section delineates the factors affecting the carbon dioxide emission and finally the fifth section concludes with some recommendations.

ISSUES OF CLIMATE CHANGE

The climate change is attributed to the change in the composition of the global atmosphere that increases mean temperature that affects the ecology in the earth and ocean. The change in the composition of the atmosphere is caused directly and indirectly by various human activities in addition to natural climate variability over time. The energy from the sun

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reaching the earth is balanced by the energy that the earth emits back to space. The cloud of greenhouse gases (GHGs) like water vapour, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) trap some of the solar energy that the earth releases to space (Robertson *et al.*, 2000). Such GHGs have effects like a greenhouse on the earth's atmosphere and the temperature of the earth increases.

Since 1750, the atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased by approximately 31 percent, 151 percent and 17 percent respectively. Current rates of increase per year are 0.5 percent for carbon dioxide, 0.6 percent for methane and 0.3 percent for nitrous oxide (IPCC, 2001). Human activities increase the GHG levels in the atmosphere by introducing new sources or removing natural sinks[1] such as forests. A balance between sources and sinks determines the levels of greenhouse gases in the atmosphere.

Aiming at stabilizing GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, members of United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992 produced international environmental treaty named United Nations Framework Convention on Climate Change (UNFCCC)[2]. The treaty has set no limits on GHG emissions for individual nations and contained no enforcement provisions. Kyoto Protocol[3] under the treaty sets mandatory emission limits for industrialized countries as specified under Annex one countries[4] of the Protocol. Developing countries like Nepal are not expected to implement their commitments under the Convention unless developed countries supply enough funding and technology. For such countries, reduction in GHG emission has lower priority than economic and social development and poverty alleviation program. As the developing countries have less capacity to adapt than do their wealthier neighbors, they lose more from the effects of global warming on agriculture than do industrial countries. We can use green sector opportunities of the country to trap GHGs if enough funding and technology are provided by the industrial countries. The opportunity in forestry sub-sector is better known whereas that of agriculture sub-sector is still illusive.

The challenges of how to respond to climate change and ensure sustainable development are currently high on the political agenda among the world's leading nations (Olsen, 2007). Gleneagles meeting (2005) of Group of Eight countries confessed the seriousness of the issue and linked challenges in tackling climate change, promoting clean energy and achieving sustainable development (Blair *et al.*, 2005). The UN Climate Conference (2007) in Bali agreed to pursue negotiations toward a new international agreement by 2009 to succeed the Kyoto Protocol. The new negotiations can set the stage for meaningful international abatement

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[1] Sources are processes or activities that release greenhouse gases; sinks are processes, activities or mechanisms that remove greenhouse gases.

[2] The FCCC was opened for signature on May 9, 1992. It entered into force on March 21, 1994. The stated objective is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a low enough level to prevent dangerous anthropogenic interference with the climate system.

[3] The Kyoto Protocol came into effect on February 16, 2005.

[4] Signatories to the UNFCCC are split into three groups: Annex I, Annex II and developing countries. Industrialized countries are under Annex I and agree to reduce their emissions (particularly CO2) to target levels below their 1990 emissions levels. If they cannot do so, they must buy emission credits or invest in conservation. Annex II countries have to provide financial resources for the developing countries and consist of the OECD members. Developing countries have no immediate restrictions.

measures in the post-Kyoto period (Cline, 2008). However, knowledge is not enough to develop practical and efficient measures to address the problem of climate change.

There is a need to further strengthen the knowledge base on the emerging challenge of climate change and adaptation. To date, most work on climate change has been on knowledge development with a major focus on the water resource sector, including water-induced disaster management. Work in other key sectors, such as human health, forestry and biodiversity and agriculture, is only just starting (World Bank, 2007a). Nepal's greenhouse gas emissions are extremely small in global terms. The Initial National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) showed that its total greenhouse gas emission in 1994/95 was equivalent to 39,306 giga grams of carbon dioxide. Land use change and the forestry sector were the main sources of CO_2. The energy sector is the second largest emitter of greenhouse gases (MoPE, 2004), whereas the contribution of agriculture sector is very low.

While Nepal's contribution to GHG emissions is small, it will face a significant challenge in responding to the effects and impacts of climate variability, climate change, and extreme weather events. There was an average increase in the mean annual temperature of earth surface by 0.06°C per year between 1977 and 1994 (World Bank, 2007a). Such rapid increase in the temperature may have affected agricultural production in the country, we have not yet conducted a specific research on this regards. Such study is, however, beyond the scope of this paper. It is not counter intuitive to think that with predicted increases in temperatures and changes in rainfall patterns, there will be significant negative impacts on ecosystems and people's livelihoods. Specifically, there will be negative impacts on public health, forestry and biodiversity, agriculture and water resources (MoPE, 2004). As the agriculture is concerned with the food security and livelihood of the majority of the people in developing countries and under developed countries, this sector deserves immediate attention for making it environment friendly.

INTER-LINKAGES BETWEEN AGRICULTURE AND CLIMATE CHANGE

Agriculture emits GHGs and can trap them as well. The major gases emitted by agriculture are carbon dioxide, methane and nitrous oxide. The amount of sources and sinks of these gases depends on land use and management of soils, crops, manures, livestock and energy. In agriculture, the majority of on-farm carbon dioxide emissions come from fuel combustion for heating farm buildings and machinery, intensive tillage regimes, and summer fallow when soil organic matter is decomposing. Similarly, the primary on-farm sources of methane emissions include enteric fermentation from ruminant livestock like cattle, sheep and goats, anaerobic respiration of organisms in riparian areas, and manure storage systems like stockpiled solid or liquid storage (Takle and Hofstrand, 2008). Likewise, the primary on-farm sources of nitrous oxide emissions involve soil nitrogen management like wet soils containing nitrogen-fixing plants like alfalfa or pulses and application of manure and nitrogenous fertilizers.

On one hand, the agriculture aggravates the problem of climate change by emitting different GHGs and also gets affected from the climate change. On the other hand, it offers an opportunity for sequestering such gases from the atmosphere mitigating, though partly, the problem of climate change.

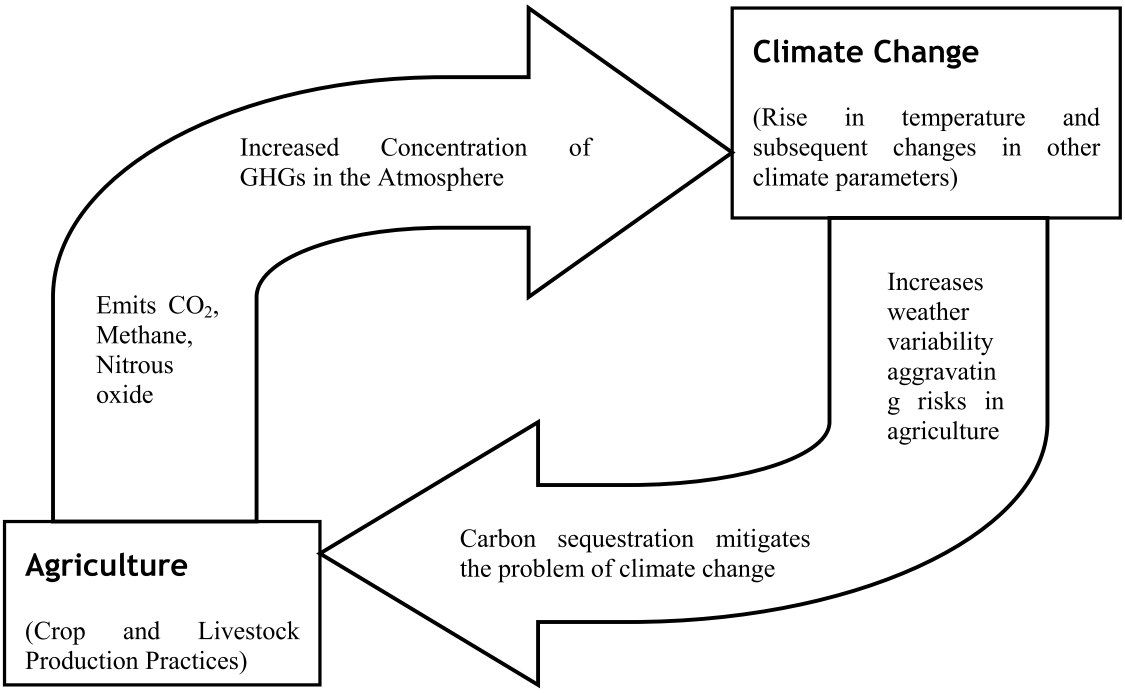

Figure 1: Inter-linkages between agriculture and climate change

Green House Gas Emissions from Agriculture

Agricultural greenhouse gas emissions come from soil and manure management, enteric fermentation and fossil fuels consumption. Agricultural soil management accounts for about 60 percent of the total emissions of nitrous oxide from the agricultural sector. The large increase in the use of nitrogenous fertilizer for the production of high nitrogen consuming crops has increased the emissions of nitrous oxide. Efficient use of nitrogenous fertilizer can reduce nitrous oxide emissions (Takle and Hofstrand, 2008). Ruminant animals are the major emitters of methane. Enteric fermentation in digestive process of animals produces methane. Feed quality and feed intake influence the level of methane emissions. Similarly, manure management also affects methane emissions. Methane is produced by the anaerobic decomposition of manure. Dairy cattle and swine contribute about 85 percent of the methane emissions (Takle and Hofstrand, 2008). When rice is grown with no oxygen, the soil organic matter decomposes under anaerobic conditions and produces methane that escapes into the atmosphere. Carbon dioxide from fossil fuel consumption is another source of GHG. The use of fossil fuels in agricultural production also emits green house gases from agriculture.

Effects of Climate Change on Agriculture

Agriculture is likely to get affected positively and negatively by the climate change. Negative effects are feared to be larger than the positive effects. Some studies have been conducted for evaluating the potential effects of climate change on agriculture in global level (Kane *et al.*, 1992; Rosenzweig and Parry, 1994; Darwin *et al.*, 1995), regional level (Adams *et al.*, 1990;, Adams *et al.*, 1993; Mendelsohn *et al.*, 1994) and farm level (Kaiser *et al.*, 1993; Easterling *et al.*, 1993). Some others are conducted in the effects of climate change on crop yields (Andresen and Dale, 1989; Dixon *et al.*, 1994; Kaufmann and Snell, 1997; Wu, 1996). Increased temperature during growing season can reduce yields, because crops speed through their physiological development producing less grain. Faster plant growth and modifications of water and nutrient budgets in the farm (Long, 1991) will render existing farming technology unsuitable. Change in crop physiology will make traditional practices inappropriate.

The higher temperature also increases the process of evapo-transpiration and decreases soil moisture availability. Because global warming is likely to increase rainfall, the net impact of higher temperature on water availability is a race between higher evapo-transpiration and higher precipitation. As the precipitation is not regular, the race will be won by higher evapo-transpiration (Cline, 2008). Rainfed agriculture, mostly practiced by the poor, is likely to get affected adversely by the climate change.

Higher concentration of CO_2 and carbon fertilization (increased availability of the carbon to the crops) increase plant photosynthesis and thus crop yields (Rosenzweig and Hillel, 1998; Kimball, 1983). Enhanced photosynthesis can increase the yield of C3 crops such as wheat, rice and soybean, but not of the C4 crops such as sugarcane and maize (Cline, 2008). Moreover, increase in the temperature and changes in precipitation pattern have potential to affect crop yields (Reilly *et al.*, 2001). But this can either be positive or negative. Chang (2002) estimates crop-yield response models and finds negative effects associated with some climate changes. Physical effects of temperature rise on crop yield are feared more damaging in tropical and subtropical countries than in the temperate countries.

Initial National Communication of Nepal to the UNFCCC notes that there will be growing negative impacts on ecosystems and people's livelihoods with predicted increases in temperatures and changes in rainfall patterns in the future (MoPE 2004). Nepal's agricultural sector is highly dependent on weather, particularly on rainfall. Given the low productivity increase of the last few years compared to population growth, climate change is likely to have serious consequences for the agriculture. Most of the population is directly dependent on a few crops for food such as rice, maize and wheat. The predicted decrease in precipitation from November to April would adversely affect the winter and spring crops, threatening food security. Higher temperatures, increased evapo-transpiration and decreased winter precipitation may bring about more droughts in Nepal (Alam and Regmi, 2004). Increased water evaporation and evapo-transpiration may also mean that crops will require more water through irrigation.

The major effects of climate change can be summarized as increase in temperature, weather variability, evapo-tranpiration and uncertainty of precipitation. This will affect both crop and livestock production technologies particularly choice of variety/breed, sowing time, disease/pest management and water management.

Mitigation of Climate Change by Agriculture

We are searching for effective approaches to improve energy efficiency and minimize GHG emissions from agriculture sector. Improved livestock farming can reduce GHG emissions through improved livestock feeding and manure management. Carbon sequestration in crops, pastures and trees and trapping carbon is soil can reduce atmospheric carbon. Similarly, substituting fossil fuels with renewable energy in crop and livestock production can reduce GHG emissions. Thus, the agriculture can reduce atmospheric greenhouse gases.

Soil organic carbon (SOC) pool is the largest among terrestrial pools and the restoration of SOC pool in arable lands represents a potential sink for atmospheric CO_2 (Jarecki *et al.*, 2005). Restorative management of SOC includes using organic manures, adopting legume-based crop rotations and converting plough till to conservation till system. When land is ploughed, soil carbon gets oxidized and become atmospheric carbon dioxide (Takle and Hofstrand, 2008). Minimum till farming practices provide a great potential for the future sequestration of atmospheric carbon and building soil organic matter while also minimizing soil erosion and reducing production costs. However, the carbon trapped in the soil is reversible and it gets released to the atmosphere after some years.

Restoration of SOC in arable lands represents a potential sink for atmospheric CO_2 (Lal and Kimble, 1997). Strategies for SOC restoration by adoption of recommended management practices include conversion from conventional tillage to reduced tillage, increasing cropping intensity by eliminating summer fallows, using highly diverse crop rotation, introducing forage legumes and grass mixtures in the rotation cycle, increasing crop production and increasing carbon input into the soil (Lal *et al.*, 1998; Lal, 1999; Desjardins *et al.*, 2001; Hao *et al.*, 2002). The potential to sequester carbon varies considerably between crop type, crop rotation and the amount of fertilizer necessary for crop growth.

Sequestration of the carbon in biomasses like woodlot through improved forest management practices and trapping the carbon in agricultural soils are two major sinks for the carbon. Growing trees sequester large amounts of carbon dioxide from the atmosphere through photosynthesis. The soil is a great storehouse of carbon in the form of organic matter. There are several opportunities like sequestering carbon in agricultural soils by reducing tillage, reducing nitrous oxide emissions through more efficient use of nitrogenous fertilizer, developing viable technologies for creating such fertilizers, capturing methane emissions from anaerobic manure handling facilities (such as biogas) and substituting renewable fuels for fossil fuels (Takle and Hofstrand, 2008). Soil management practices like crop rotations, tillage and fertilizer management affect the level of carbon dioxide in the soil (Martens and Frankenberger, 1992; Nyamangara *et al.*, 1999; Martens, 2000b). Crop characteristics like species, productivity, canopy structure, root physiology and root function and pattern affect soil organic carbon (Chan and Heenan, 1996). Change in farming practices to the emission reducing ones can offer great potential to reduce the problem of climate change.

Crop residue management can have a substantial influence on SOC concentration (Follett, 2001; Franzluebbers, 2002; Hulugalle and Cooper, 1994; Unger, 1997; Kushwaha *et al.*, 2001). Maize residue has high carbon to nitrogen (C:N) ratio, and high SOC concentrations (Martens, 2000a). There is not a direct relationship between legumes and SOC concentration. The low quantity of residues from soybean does not promote SOC concentration (Martens, 2000a; Martens, 2000b). Enhanced crop rotation for several years increases SOC concentration (West and Post, 2002). After 30 years of crop rotations, annual SOC gains ranged from 60 to 220 kg per ha per year for fields in Canada (Campbell *et al.*, 2000). Nutrient management through fertilization and manure application generally increases SOC concentration (Haynes and Naidu, 1998; Schjonning *et al.*, 2002; Munkholm *et al.*, 2002; Hao *et al.*, 2002). Manure application increases SOC concentration (Martens and Frankenberger, 1992; Haynes and Naidu, 1998; Nyamangara *et al.*,1999; Aoyama *et al.*, 2000). Long-term manure applications and incorporation of crop residues in the soil increase SOC (Whalen and Chang, 2002). Burning crop residues is clearly a climate unfriendly practice.

Reduced and no-till systems have higher SOC concentrations compared with conventional tillage practices (Salinas Garcia *et al.*, 1997). Conservation tillage reduces biomass mineralization, decreases oxygen availability and increases SOC concentration (Martens, 2000b). Soil erosion resulting from soil mismanagement results in loss of SOC (Lal, 2003b). Management practices such as reduced tillage and increased carbon inputs through residue management and manuring improve soil structure, reduce erosion and carbon loss through mineralization and CO_2 emissions (Hao *et al.*, 2002; Lal, 2003a; Lal, 2003b). Bronick and Lal (2005) suggest that the combination of conservation tillage, increasing carbon inputs and increasing the complexity of the agricultural system combining different crops and animals improves carbon aggregation and SOC concentration. Improved management practices such as reduced tillage, manure application, mulching, composting, summer and winter fallowing, crop rotations and agro-forestry (Lal *et al.*, 1999; Bruce *et al.*, 1998) as well as changes in land use, including the conversion of degraded croplands to grasslands or pasture, increase the rate of CO_2 uptake from the atmosphere.

The paper addresses the first part of the problem, the green house gas emissions from agriculture, by assessing the factors affecting emission of per capita CO_2 from different countries on the earth.

METHODOLOGY

For empirical testing, some pertinent hypotheses are proposed first and data sources are analyzed for the purpose. Then the analytical frameworks are discussed briefly before going to the results and discussions.

HYPOTHESES

Following nine general hypotheses (Table 1) are tested empirically using the test of mean differences and multiple linear regression models.

Table 1: Hypotheses tested

SN	Hypotheses	Method of testing
1	A person in a rich country emits more carbon dioxide to the atmosphere than a person in a poor country.	Test of mean difference
2	Higher the proportion of land under agriculture less is the emission of carbon dioxide.	Multiple regression
3	Higher the proportion of the arable land irrigated higher is the emission of CO_2.	Multiple regression
4	Higher the dose of fertilizer application higher is the emission of CO_2.	Multiple regression
5	Higher the population pressure on agricultural land higher is the CO_2 emission.	Multiple regression
6	Larger is the proportion of forest area in the country the smaller will be the CO_2 emissions.	Multiple regression
7	Larger the contribution of biomass on the total energy consumption larger will be the amount of CO_2 emission.	Multiple regression
8	Higher is the per capita consumption of energy (deflated by the latitude of the country) higher will be the emission of CO_2.	Multiple regression
9	Higher the energy use efficiency in the country lower will be the emission of CO_2.	Multiple regression

DATA AND SOURCES

A country is taken as the unit of analysis. Country-wise data on carbon dioxide emissions and other important variables are taken for 120 countries from the World Bank (2007b). For rest of the countries in the world, data on one or the other variables included in the study are missing. The emissions include the carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.

ANALYTICAL FRAMEWORK

Statistical and econometric analyses are conducted to test the hypotheses. Summary statistics of study variables and explanatory variables are generated statistically. To test the mean difference of the CO_2 emissions in the poor and rich countries difference of variances was tested first using group variance comparison test. Based on the equality or inequality of the variances, the mean difference is tested using group mean comparison test.

The effects of explanatory variables to the emission of CO_2 (hypotheses 2 to 9) are tested with a linear multiple regression model.

$$C = b0 + b1L + b2I + b3F + b4Pb5Lf + b6Bb7E + b8Ee + u$$

C Carbon dioxide emissions per capita

L Agricultural land

I Irrigation

F Fertilizer use

P Population pressure on agricultural land

Lf Forest area

B Biomass energy

E Energy use per capita deflated by the latitude

Ee Energy use efficiency

b0, b1, etc. are parameters to be estimated

u random term

The functional form, the linear equation is used based on the logic of linear effects at the mean level, strength of the equation being estimated and the logical validity of the coefficients estimated.

CARBON DIOXIDE EMISSIONS IN RICH AND POOR COUNTRIES

Emission statistics from 120 countries show that average per capita emission of CO_2 is 5.23 tons per year ranging from a zero to 33.4 tons (Table 2). The minimum per capita emission is in the poorest quartile whereas the highest per capita emission is in the richest quartile (see Annex I). The per capita mean emission of CO_2 is less than one ton (0.67 ton) per year in poorest quartile and 2.58 tons in the second quartile countries. It is 6.00 tons in the third quartile countries whereas a person in the richest quartile country on an average emits over 11 tons of carbon dioxide per year.

Table 2: Carbon Dioxide Emission of Countries by Income Quartile (tons per capita)

Gross National Income Quartile	N	Mean	SD	Minimum	p25	p50	p75	Maximum
1 Poorest countries	27	0.67	0.92	0.0	0.2	0.4	0.9	4.8
2	33	2.58	2.35	0.2	1.0	1.4	3.5	10.7
3	29	6.00	4.59	0.9	3.1	5.4	7.9	22.1
4 Richest countries	31	11.31	6.83	3.5	7.7	9.6	11.4	33.4
Total	120	5.23	5.90	0.0	0.9	3.5	7.95	33.4

Source: Compiled from World Bank, 2007b.

The zero order correlation between per capita gross national income and per capita carbon dioxide emission is 0.60, and it is highly significant (p = 0.000). It means richer country residents are more responsible for green house gas emissions and climate change than the poor country residents. This conclusion is further verified by the test of hypothesis of mean difference.

The test of mean differences with unequal variances is found to be highly significant and that leads to rejection of null hypothesis of equal per capita emission in rich and poor countries (Table 3). Out of the 120 countries under analysis countries under first two income quartiles are taken as rich and rest as the poor. Adopting an alternate hypothesis, it can safely be inferred that the people in richer countries emit more carbon dioxide than the people in the poor countries.

Table 3: Test of differences in per capita carbon emission between poor and rich countries

Group	N	Mean	Standard Error	Standard Deviation	Test of mean difference for unequal variance	Test of difference in variance
Rich countries	60	8.740	0.826	6.396	t= 8.08	F observed = 9.53 (p=0.000)
Poor countries	60	1.723	0.267	2.072	(p=0.000)	
Combined	120	5.232	0.539	5.901		

Source: Compiled from World Bank, 2007b.

FACTORS AFFECTING THE CARBON DIOXIDE EMISSIONS

The factors affecting the carbon dioxide emissions in different countries are assessed using linear multiple regression taking the emission data as the dependent variable regressed over agricultural, forestry and energy variables. Before going to the actual modeling of the empirical relations the summary statistics of the explanatory variables are discussed (Table

4). The agricultural land in the sample countries are taken as the percent of the total geographic areas. Nearly 42 percent of the totals geographical areas are under the agricultural uses, on an average. Nearly 21 percent of the crop area is irrigated. Average fertilizer consumption is 165 kg per ha with highest of 2,555 kg/ha in Iceland and the second highest of 2,418 kg/ha in Singapore. The lowest use of chemical fertilizer is recorded 0.4 kg per ha in Namibia and 0.5 kg/ha in Congo Republic and Angola. The fertilizer consumption in Nepal is reported to be 37.8 kg/ha of arable land.

Population pressure on agricultural land is another issue that deserves some discussions. The average population pressure is 3.24 persons per ha ranging from 0.05 persons/ha in Australia to 19.31 persons/ha in Oman. The population pressure on agriculture land in Nepal is 9.69 persons per ha that is higher than that in India (4.89 per ha) and China (7.66 per ha).

On an average 28 percent of the geographical areas are under the forest. The statistics report no forest area in Oman and very little area (0.1 percent) in Libya and Egypt. The highest area under forest is in Gabon (84.5 percent of geographic area) followed by Finland (73.9 percent). In Nepal 25 percent of the total geographic area is reported under the forest defined as natural or planted tree stands. However, our national data reports nearly 39 percent of the total geographic area under the forest jurisdiction.

Table 4: Summary statistics of explanatory variables

SN	Variable	Unit	N	Mean	Standard Deviation	Minimum	Maximum
1	Agricultural land	% of geographical area	118	41.84	20.92	1.00	85.00
2	Irrigation	% of crop land	116	20.51	23.71	0.10	99.90
3	Fertilizer use	kg/ha	120	165.24	334.78	4.00	2,555.00
4	Population pressure on agricultural land	person/ha of agricultural land	120	3.24	3.67	0.00	19.31
5	Forest area	% of geographical area	120	28.43	19.94	0.00	84.50
6	Biomass energy	% of energy use	115	21.86	27.29	0.00	92.50
7	Energy use per capita deflated by the latitude	kg of oil equivalent per capita divided by average latitude of the country	119	139.97	428.02	6.76	4,404.38
8	Energy use efficiency	GDP $ per kg of oil equivalent	117	5.02	2.36	0.80	10.90

Source: Compiled from World Bank, 2007b

Another difference among the countries is energy consumption. Nearly 22 percent of the average energy consumption comes from biomass. Some countries (Armenia, Azerbaijan, Israel, Jordan, Saudi Arabia, Syrian Arab Republic and United Arab emirates) use no biomass energy. However, Congo Democratic Republic (92.5 percent) and Tanzania (91.6 percent) depend heavily on the biomass for their energy supply. Nepal draws nearly 87 percent of total energy consumed from the biomass sources.

Energy use per capita is measured in terms of kilogram of oil equivalents (kgoe). Energy consumption depends on lifestyle and climatic conditions. To neutralize the effects of climatic conditions on energy consumption the per capita energy consumption is deflated by the average latitude of the country. Such deflated energy consumption per capita is 140 kg of oil equivalent per capita ranging from 6.76 kg (Bangladesh) and 4,404.00 kg (Singapore). It is 12 kg of oil equivalent in Nepal.

Another issue to discuss is that how efficiently the energy is being utilized. We measure the energy efficiency in an economy in terms of GDP produced per kg oil equivalent of energy consumption. Higher the GDP per unit of energy use the more energy-efficient is the economy. It would be ideal to use the disaggregated energy consumption for production only. But, such disaggregated data are not available. The average energy efficiency is US$ 5.02 per kg of oil equivalent. The least energy efficient country is Uzbekistan ($ 0.8 /kg of oil equivalent) followed by Tanzania ($1.3/kgoe), and Trinidad and Tobago ($1.3/kgoe). The most energy efficient countries are Colombia and Peru ($ 10.9/kgoe). Energy efficiency in Nepal is medium ($ 4.00/kgoe).

Based on the multiple linear regression analysis agricultural land, irrigation, forest area, biomass energy, and energy use efficiency negatively and significantly affected the CO_2 emission. Fertilizer use, and energy use per capita deflated by the latitude affected it positively and significantly. More specifically, the linear multiple regression using these explanatory variables shows that the countries with larger proportions of land under agriculture and forestry emit less CO_2 per capita as compared to those countries with smaller proportion of agricultural and forest areas (Table 5). One percent increase in agricultural land decreases per capita CO_2 emission by 0.048 metric tons. Similarly, one percent increase in area under forest decreases per capita CO_2 emissions by 0.049 metric tons. Agriculture and forest enterprises require less fossil fuel as compared to industrial sector; they are more climate friendly. Irrigation of crop land decreases the release of CO_2 to the atmosphere. Though the irrigation consumes some fuels, it reduces the flaring of CO_2 from the land. One percent (of the crop area) increase in irrigated land decreases per capita CO_2 emission by 0.085 metric tons. Dependency on biomass fuel reduces per capita emission of CO_2. One percent increase in the contribution of biomass on energy consumption in the country reduces per capita CO_2 emissions by 0.114 metric tons. Energy use efficiency (measured as gross domestic production per unit of energy use) also matters for CO_2 emissions. One United State Dollar increase in GDP per unit of energy (kg of oil equivalent) decreases per capita CO_2 emissions by 0.608 metric tons. This is because, higher the energy use efficiency lesser fuels to consume and low level of emissions. The equation estimated is statistically significant and explains 50 percent of the variation on the per capita CO_2 emissions.

Higher the energy use per capita higher is the CO_2 emission per capita. This is because of the release of CO_2 from the energy sources particularly that from fossil fuels. One kilogram increase in per ha use of the chemical fertilizers increases per capita emission of the CO_2 by six kilogram. This is because the production and transportation of the chemical fertilizers consume fossil fuels that release the carbon dioxide to the atmosphere. Increased use of chemical fertilizer also decreases the soil organic carbon by accelerating mineralization of SOC. Increase in the fertilizer consumption in agriculture increases the problem of global warming. This is the reason why low external input sustainable agriculture is being emphasized in many countries. As many farms in Nepal use very little fertilizers and many farms do not use them at all, this practice should be attributed as the climate friendly agriculture. Such farms deserves cross subsidization from carbon releasing activities within the country or from other countries that will compensate lower productivity of the low external input agriculture and promotes the climate friendly agricultural practices. Support for organic farming is one approach for harvesting such double dividends of climate protection and farmers wellbeing.

Table 5: Effects of agriculture on carbon dioxide emissions

	Explanatory variables	Coefficient	Standard Error	t	P>|t|	95% Confidence Interval	
1	Agricultural land	-0.048*	0.025	-1.940	0.055	-0.097	0.001
2	Irrigation	-0.085***	0.023	-3.740	0.000	-0.131	-0.040
3	Fertilizer use	0.006*	0.003	1.740	0.085	0.001	0.013
4	Population pressure on agricultural land	0.178	0.144	1.230	0.220	-0.108	0.463
5	Forest area	-0.049*	0.027	-1.800	0.074	-0.103	0.005
6	Biomass energy	-0.114***	0.018	-6.380	0.000	-0.149	-0.078
7	Energy use per capita deflated by the latitude	0.005**	0.003	1.980	0.050	0.000	0.011
8	Energy use efficiency	-0.608***	0.181	-3.350	0.001	-0.968	-0.248
9	Constant	13.772***	2.009	6.850	0.000	9.785	17.760
	Number of observation	106				R^2	0.501
	F(8, 97)	12.150				Adjusted R^2	0.459
	P > F	0.000				Root MSE	3.967

Note: n <120, due to some missing data.

CONCLUSIONS

Climate change affects crop and livestock production practices and yields. Negative effects are projected to be more prominent than the positive effects. Agriculture emits and traps green house gases. Farm practices can be modified to reduce emissions and to sequester the green house gases. The agricultural practices to reduce emissions should be pragmatic and cost-effective. The emissions reductions should be sector wide covering crop and livestock production, food processing enterprises, farm yard manure management, composting of crop residues, agro-forestry and pasture management.

Average per capita carbon dioxide emission of 120 countries is over five tons per year. The emission is directly related to per capita income. Richer country residents are more responsible for green house gas emissions and climate change than the poor country residents.

Linear multiple regression analysis shows that the countries with larger proportions of land under agriculture and forestry emit less carbon per capita as compared to those countries with smaller areas under agriculture and forest. As agriculture and forest enterprises require less fossil fuel, agriculture-dominating countries are more climate friendly than the others. Irrigation also decreases the release of carbon to the atmosphere. Thus, energy used for irrigation should not be blamed for carbon emission. Similarly, dependency on biomass fuel reduces per capita emission of carbon. Higher the energy use efficiency lower is the carbon emissions.

Higher the energy use per capita higher is the carbon emission. Energy intensive lifestyle can be attributed for climate change. Use of fertilizers is also contributive to the climate change. We need to emphasize low external input agriculture particularly organic farming. Such low or no fertilizer farming shall be subsidized to the tune of social benefits of emission reduction from such practices. People in high-income countries with higher carbon emission rate should buy organic products from less developed countries to promote such practices. The pricing of such organic vegetable should include the external benefits of reducing carbon dioxide emissions so that high-income people pay for their higher emission of the green house gases.

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Annex I: Summary Statistics of Per Capita Gross National Income (US $) by Income quartile

Quartile	1	2	3	4	
Country	Bangladesh, Benin, Congo Democratic Republic, Congo Republic, Cote d'Ivore, Ethiopia, Ghana, Haiti, India, Kenya, Kyrgyz Republic, Moldova, Mozambique, Nepal, Nicaragua, Nigeria, Pakistan, Senegal, Sudan, Tajikistan, Tanzania, Togo, Uzbekistan, Vietnam, Yemen Rep, Zambia and Zimbabwe	Albania, Algeria, Angola, Armenia, Azerbaijan, Belarus, Bolivia, Herzegovina, Cameroon, China, Colombia, Dominican Republic, Ecuador, Egypt, El Salvador, Georgia, Guatemala, Honduras, Indonesia, Iran, Jordan, Kazakhstan, Macedonia FYR, Morocco, Namibia, Paraguay, Peru, Philippines, Sri Lanka, Syrian Arab Republic, Thailand, Tunisia and Ukraine	Argentina, Botswana, Brazil, Bulgaria, Chile, Costa Rica, Croatia, Czech Republic, Estonia, Gabon, Hungary, Jamaica, Latvia, Lebanon, Libya, Lithuania, Malaysia, Mexico, Oman, Panama, Poland, Romania, Russian Federation, Serbia & Montenegro, South Africa, Trinidad and Tobago, Turkey, Uruguay and Venezuela	Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Korea Democratic Republic, Korea Republic, Kuwait, Netherlands, New Zealand, Norway, Portugal, Saudi Arabia, Singapore, Slovenia, Spain, Sweden, Switzerland, United Arab Emirates, United Kingdom and United States	Total
N	27	33	29	31	120
mean	531.85	2001.82	6007.93	32806.67	10410.5
sd	226.6	710.12	2242.87	12004.83	14530.97
min	120	1000	3220	12510	120
p25	350	1320	4470	23950	1040
p50	510	2290	5010	33860	2990
p75	690	2650	7210	39340	12510
max	950	2990	11220	60890	60890

Source: Compiled from The World Bank, 2007b

PERSPECTIVES OF ORGANIC AGRICULTURE AND POLICY CONCERNS IN NEPAL

Deepak Mani Pokhrel (PhD)[1] and Kishor Prasad Pant (MSc)[2]

ABSTRACT

Agriculture production worldwide has been intensified with a simultaneous expansion in pesticides, fertilizers and other agro-chemicals use to meet growing peoples' demands for food. Indiscriminate use of agrochemicals has however resulted in several problems such as pests' resistance to pesticides and resurgence due to elimination of natural enemies, toxic residues in food, water, air and soil, degrading soil environment and ecosystem, animal and human health hazards and ultimate economic losses. Realizing the facts, organic farming is becoming popular recently, and there have been growing concerns on its importance and promotion in number of countries irrespective of their stage of development. Consequently, farming system paradigms have now shifted from mere increased production and productivity to resource sustainability and eco-friendly production techniques in their emphasis.

Higher cost due to agro-chemicals and resulting environmental losses incurred in conventional agriculture on one side and higher advantages of ecological diversities available in the country on the other have proved that Nepal has high potentialities and comparative advantages of producing quality organic products. A high majority of mountain farmers in Nepal, excluding a few of the agricultural pockets where so-called commercial agriculture has already introduced, do not use any chemicals. Owing to globally increasing trend of demand for organic food, Nepal can benefit from such exports. The government based on some of its policy instruments is also committed to promoting organic farming in the country. However, the instruments are inadequate and not well integrated. Inadequate research, extension services and manpower especially on production and marketing information and input supply have hindered promotion of organic agriculture. Organic product legislation, standardization, certification and infrastructure in such development are also major issues of policy concerns.

Key words: organic-certification, organic-farming, organic-standard, policy, Nepal

BACKGROUND

The conventional agriculture focused merely on yield rise to meet growing food needs of increasing population, and paid little concerns to sustainable use of locally available both natural and human resources. This resulted in mere intensive use of agro-chemical inputs but a wide productivity gap between the best possible and the farm practice; agricultural lands continued to shrink, and farming system led to environmental degradation such as depletion of soil and soil fertility, decline in water availability and increase in different forms of pollution. At the same time, such practice upset both environmental resources and indigenous knowledge system rendering the agriculture system unsustainable (Scialabba, 2000). Realizing the facts, importance of organic farming is increasing, and the goal of agricultural development in many countries shifted from mere increased production and productivity to achieving sustainable and environment friendly production system.

Organic agriculture is one of several approaches to sustainable agriculture development practiced today, which is ecologically safe, economically viable and socially acceptable

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(Scialabba, 1999). As been widely accepted, it is a holistic production management system that emphasizes on the use of management practices accomplished by using agronomic, biological and mechanical methods in preference to off-farm inputs and as opposed to using synthetic materials to fulfill any specific function within the system. Of which, the soil is of central importance, and the primary goal is to optimize the health and productivity of interdependent communities of soil life, plants, animals and human being. Prohibiting the use of genetically modified organisms (GMOs), it avoids or largely excludes the use of chemical pesticides, herbicides, fertilizers, growth regulator, hormones and antibiotics. In several ways, the system can help to promote and enhance healthier agro-ecosystems including biodiversity, biological cycles and soil biological activity. In reality, organic farming is a consistent system approach based on the perception that tomorrow's ecology is more important than today's economy.

Table 1: Pesticides consumption in Nepal (PRMS, 2007)*

Kinds of pesticide	Quantity (a.i. in kg).		
	year 2004	year 2005	year 2006
a. Agricultural uses	**157936**	**148172**	**128728**
1. Insecticides	44962	65196	46553
1.1 Organochlorine (endosulfan)	*2473*	*3097*	*8215*
1.2 Organo-phospates (acephate, chlorpyriphos, quinalphos, dichlorovos, phorate)	*26912*	*25401*	*24683*
1.3 Carbamates	*191*	*1008*	*115*
1.4 Syn. pyrethroids (alpha-, cyper-, deltamethrin, fenvalerate.)	*3147*	*31050*	*2640*
1.5 Botanical products (azadiractin)	*17*	*4*	*4*
1.6 Mixed insecticide (chlorpyriphos+cyper/alphamethrin +chlorpyriphos, quinalphos+cypermethrin, etc.)	*1235*	*1147*	*2290*
1.7 Others (aluminiumphosphide, cartaphydrochloride, imidacloprid, propargite, ethofenprox, fenpropathrin, fipronil etc.)	*10988*	*3489*	*8606*
2. Herbicides (glyphosate, 2,4-d, butachlor, etc.)	6186	11230	5702
3. Fungicides	102004	67699	74369
4. Rodenticides	1523	1457	1808
5. Bio-pesticides (bt, npv, etc)	4.3	30.4	57.6
6. Acaricides (dicofol, propargite)	864	77	239
7. Bactericides	12.0	13.8	0
8. Others (metaldehydes, chloroflurazuron, etc.)	2380	2469	0
b. Public health uses (alphacypermethrin, lambda cyhalothrin)	**1406**	**3300**	**2557**
Grand total (a+b)	**159342**	**151472**	**131285**

* Pesticide consumed in any year= Pesticide imported in the year + Stock from the previous year

NATIONAL CONSUMPTION OF FERTILIZERS AND PESTICIDES

A substantially increasing rate of pesticides consumption in agricultural use would be expected over the past decades (PPD, 2007) despite a decreasing trend in the recent year (Table 1). However, average consumption is very low as compared to other countries (Palikhe, 2002). According to PPD (2007), annual consumption of pesticide in Nepal was 131.3 Mt of a.i. formulations (valued NRs. 131284500) in 2006. Organophosphates, carbamates, selective and pre-emergence herbicides (including atrazine and its urea substitutes) and systematic and dicarbamate-based fungicides are the major types of pesticides commonly used. Of the total pesticide consumption, about 40-50% is used in rice, 10-20% in vegetables and the rest in cash crops. An increase in consumption of pesticides in the country is also attributed to increasing area under seasonal and off-season vegetables.

Fertilizer is one of the prioritized inputs of agricultural production; the import of which in the country increased significantly after the implementation of Fertilizer Deregulation Policy 1997 and National Fertilizer Policy 2002. However, total consumption has been far below the level as envisaged by Agriculture perspective Plan (NPC, 1995).

Average fertilizer consumption in Nepal is 26 kg/ha as of 2002 (SAIC, 2004), which is very low as compared to other SAARC countries, where the consumption is 166kg/ha in Bangladesh, 197kg/ha in India, 136kg/ha in Pakistan and 277kg/ha in Sri Lanka (SAIC, 2004). But unbalanced use of fertilizers is widespread in the country specifically in areas where commercial production of crops has already started.

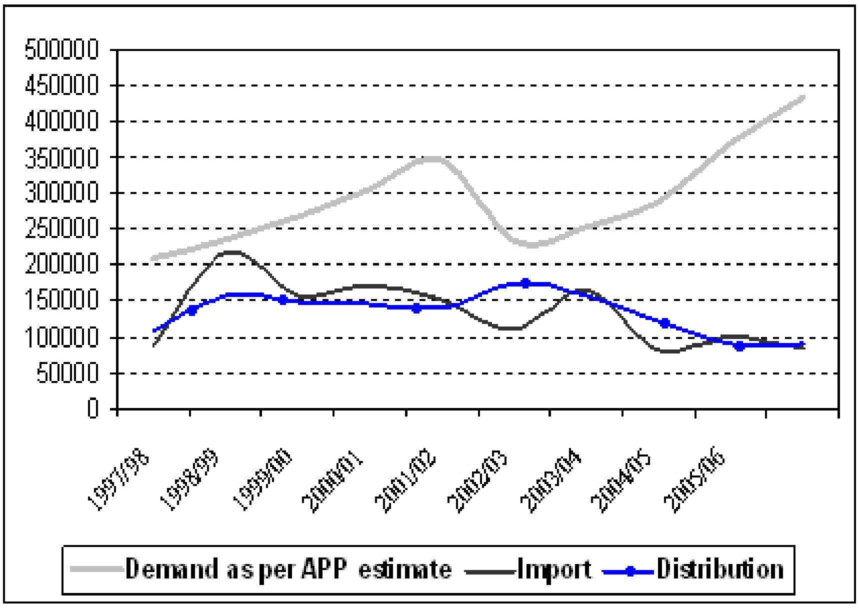

Figure1: Demand, import and distribution of fertilizer after fertilizer deregulation in Mt (MOAC, 2007).

IMPORTANCE OF ORGANIC AGRICULTURE

Agriculture is one of the major contributing sectors in Nepalese economy that shares 36% in the GDP at 1984/85 constant price (MOAC, 2007) and provides employments to two-third of the economically active population (MOAC, 2006). The government, through the past development plans, has made significant efforts to increase agricultural production and productivity. However, the efforts have not yielded results to desired levels due mainly to difficult topography, poor infrastructural development and high level of farm poverty (NPC, 2007).

Nepalese agriculture is predominately characterized by traditional knowledge based subsistence type with low productivity. The agricultural systems in the mountain comprise $2/3^{rd}$ of the nation's geographical area and largely integrate crops and livestock to traditional knowledge and locally available resources. With very low productivity, the systems are largely organic by default for maintaining soil fertility and production. Most of the farmers in the high mountain and majority of them in the middle mountain do not use chemical inputs in their farming. The use of agro-chemicals such as fertilizers and pesticides is becoming important only to the commercial agriculture pockets recently being developed in the accessible areas. With introduction of improved agronomic and composting practices, bio-fertilizers and bio-pesticides, there is greater possibility of converting the systems to organic types with little effort. Farmers in the terai are producing crops in combination of both indigenous and conventional knowledge system. Organic farming with low productivity is adopted in a few areas (Pant, 2006).

In Nepal, use of pesticides and fertilizers is wide spread in commercial production areas due to conventional agriculture based market and infrastructure development. Pesticides and fertilizers consumption is increasing at faster rate with intensification of farming business regardless of their detrimental effects on human and environmental health. Indiscriminate use of the agro-chemicals has, in consequence, initiated several problems such as pests' resistance to pesticides and resurgence due to elimination of their natural enemies, environmental pollution (water, air, and soil), toxic residues in food and feed materials, depletion of soil fertility, disruption of ecosystem, animal and human health hazards and other economic losses. This forces to think alternative strategies towards sustainable agriculture development and preserving natural eco-system.

PRESENT STATUS OF ORGANIC AGRICULTURE DEVELOPMENT

Though sounds as a new terminology, 'organic farming' is not a new concept in Nepalese context, where a very high percentage of agriculture farming is by default organic in nature. This is a good prospect of organic farming development in Nepal. Over a century, dominantly resource poor and subsistent farmers are practicing organic farming in traditional way. As a common phenomenon in Nepalese agriculture system, every farm family keeps a few pair of goats and chickens, a pair of bullock, one or two cows or buffaloes integrated with crop farming. Despite a prevailing argument that whether such farming can be called an organic or indigenous knowledge based, transforming the system to organic is not difficult in Nepal. Moreover, such a development would be conducive to poverty alleviation in the country.

So far establishment of commercial organic farming in Nepal was started in the early I990s. Though organic farming accounts for small segments in terms of both acreage and production, it is gaining momentum for its ecological importance and economical opportunities. Recently, there have been growing interests from both government and non-government sectors at different levels for its promotion, and farmers have been growing different organic crops individually or collectively. The common practices adopted by the organic growers are crop rotation, natural pest management and using bio-fertilizers and organic manures mainly farmyard manure, vermi-compost and green manure in soil fertility management. The major organic products grown in Nepal and available in the market are tea, coffee, large cardamom, ginger, fresh-vegetables, honey and herbal products. However, data related to area coverage, production, certification procedures and market situation of the commodities are extremely limited. As reported by International Federation of Organic Farming Movement (2006), the number of organic farms in Nepal is 1247, and the area under organic management is 1000 ha. If the area under traditional farming where farmers never used fertilizers and pesticides is considered, the area under organic farming should be much higher.

ORGANIC AGRICULTURE DEVELOPMENT INITIATIVES

Some initiatives have been taken by government (such as DOA, NAST, NARC, IAAS, Tea and Coffee Development Board, Kathmandu Metropolitan), non-government (I/NGOs such as SSMP, Winrock International, ECOCENTER, Nepal Permaculture Group, SECARD, HOPTA and AEC) and community-based organizations to promote organic farming in the country. Despite that level of organic technology generation and dissemination is not much significant. Extension services provided by government agencies are very limited, and are confined to awareness raising and training programs. Institutional supports promoting organic farming are also limited. Professional institutions are not functionally established to assist farmers in the production, post-production, product certification and marketing processes. NGOs and private service providers are catering the technological need of organic farmers to some extent. They have played a major role in supporting farmers' associations in their program areas in adopting organic methods of crop production and inspection, and product certification and marketing.

POLICIES AND STRATEGIES ON ORGANIC AGRICULTURE DEVELOPMENT

As the relationship between agriculture and environment has been recognized, some policy statements to reduce detrimental effects of agriculture on environment have been undertaken ever since the seventh plan. In this regard, the state has enacted Plant Protection Act 2048, Pesticides Act 2049 and Regulation 2050, Food Act 2023, Consumers' Right Act 2054 and Regulation 2056 and Environment Protection Act 2053 and Regulation 2054 and formulated National Standards of Organic Agriculture Production and Processing 2064 and some other relevant policies and strategies though fragmented and inadequate. The state is yet to formulate some effective policies including laws and regulations regarding production and trade of organic agricultural products.

Till date, the Agriculture Perspective Plan (1994/95--2017/18) has been considered as a guiding strategy towards agricultural development in the country (NPC, 1995; NPC, 1997) that aims at achieving increased agricultural economic growth through priorities on intensive use of limited inputs essentially non-organic. Moreover, the APP strategies are considered as guiding principles in the succeeding periodic plans, policies and strategies (NPC, 1998: NPC, 2003; MOAC, 2004; NPC, 2007), which are developed in line with the APP objectives. The plan is basically apathetic to organic development of agriculture since harnessing comparative advantages of available resources through organic agricultural products is not possible under existing system of indiscriminate markets for organic and inorganic products in the country.

The 10th Plan (NPC, 2003) and National Agricultural Policy (MOAC, 2004) have, for the first time, spelt out policy statements regarding promotion of organic farming in the country. The policy documents have adopted one of their objectives as to conserve, promote and utilize natural resources, environment and biodiversity, which vaguely infers to a kind of state emphasis laid on development of organic agriculture. The Agriculture Policy, 2004 has policy statements for encouraging organic farming, supporting organic products certification, minimizing adverse effects of agrochemicals in livestock products, land, water and other aspects of environment, improving production and usage of organic manure, enhancing local participation in food quality management and regulating use of pesticides and GMO. In addition, the then and succeeding periodic plans emphasize on promoting integrated plant nutrients and pest management (NPC, 2002: NPC, 2007). Three Years' Interim Plan (NPC, 2007) has a mention that farms' increasing dependence on pesticides and their improper and indiscriminate use on crops had adverse effects on environment and human health. And the plan, on a broad basis, has laid emphasis on developing and disseminating eco-friendly technologies, developing such technologies on indigenous knowledge and skills and protecting farmers' rights on such knowledge system. Agribusiness Promotion Policy 2006 has a policy statement for the development of special production zones including organic/pesticide free production area though a clear strategy towards implementing the policy is yet to be established.

Based on state policy, fertilizer constitutes a key component for achieving increased agricultural production through improving soil fertility, which is not the only remedy sufficient to replenish the crop removals from soil. Therefore, the preamble of the National Fertilizer Policy, 2002 has emphasized balanced use of fertilizers, adoption of Integrated Plant Nutrients system (IPNS) and promotion of organic and microbial fertilizer use in order to prevent degradation of soil fertility and other likely negative impacts of fertilizers on environment. Previously the policy had no provision for direct subsidy on fertilizers excepting that on transportation for some inaccessible areas. Recent amendment (2065) has introduced direct subsidy on price to enhance fertilizer consumption in the country. The state has been allocating huge amount of money each year for subsidy on fertilizer transport. A wide gap observed between the budgetary allocation and the expenditure indicates towards low productivity of scarcely available resources (Figure 2). Transfer of that to organic agriculture development especially in inaccessible areas would be much rational.

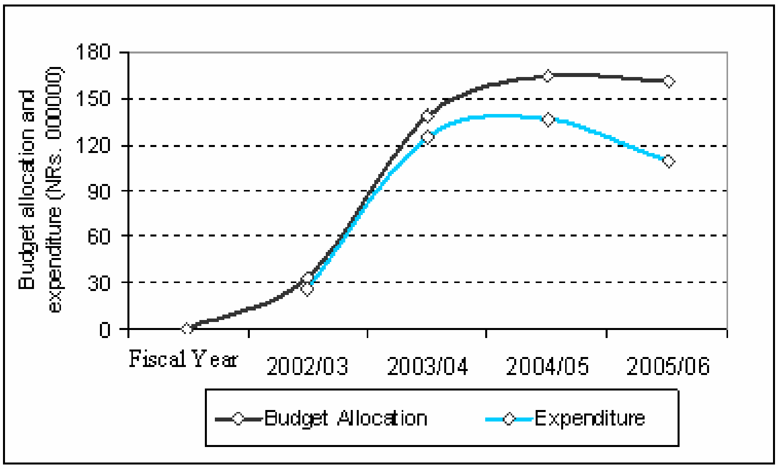

Figure 2: State provision of subsidies on fertilizer transportation (DOA, 2006)

PROGRAMS IN SUPPORT OF ORGANIC AGRICULTURE DEVELOPMENT

Realizing vital role of plant protection in sustainable agriculture, Agriculture Prospective Plan as well as succeeding periodic plans have endorsed Integrated Pest Management (IPM) as a new extension approach to solve pest and pesticide problems. The IPM program introduced farmers' field school as effective tools of extension teaching, which emerged as a pioneer approach to address farmers' problems through community participation (PPD, 2003). More than 15,000 farmers including 4,500 women have been trained through 600 FFS throughout the country (PPD, 2007). As a result, a reduction in pesticide consumption by 55% and an increment in crop production by 10% are reported (PPD, 2005).

Sustainable Soil Management Project (SSMP) is also launching several activities in favor of organic agriculture particularly in areas of soil fertility management and organic coffee production.

ORGANIC AGRICULTURE STANDARDS AND PRODUCT CERTIFICATION

The certification of organic products has not been gaining momentum in Nepal though it was introduced in 1996 (Vaidya, 2006). In the national level, the norms and standards required for production, inspection and certification of organic products have not yet been implemented except some initiatives taken by some private traders and NGOs. Some internationally recognized certifying agencies such as National Association of Sustainable Agriculture Australia (NASAA), the Institute for Marketecology (IMO, Switzerland), the Ethical and Environmental Certification Institute (ICEA, Italy), Ecocert France, OneCert America and Organic Certification Nepal show their local presence to work on organic product certification. With the implementation of National Standards of Organic Agriculture Production and Processing 2007 (2064) the organic certifiers operating in the country are to be accredited and regulated by National Accreditation Body, which is yet to be operated.

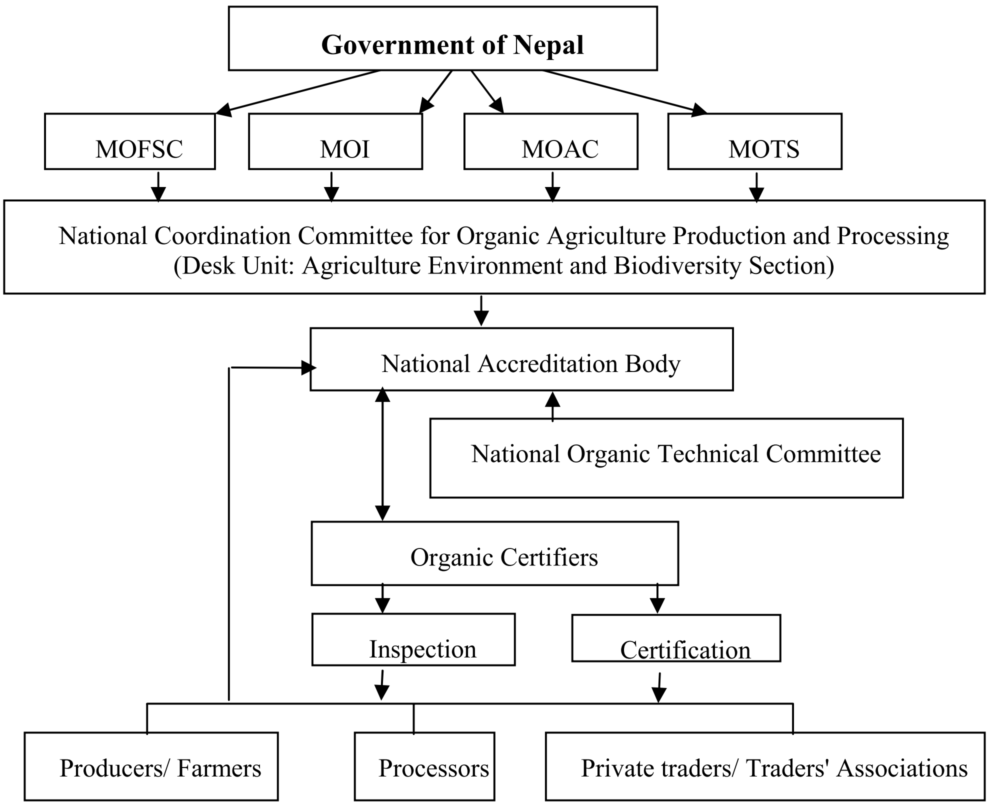

Figure 3: Structural arrangements for Organic certification

In compliance with IFOAM and CAC guidelines, the National Standards of Organic Agriculture Production and Processing 2007

- specifies land arrangement for organic production,

- prohibits agro-chemicals contamination in crop production and product transfer and storage, use of inorganic feeds, GMOs/LMOs and radioactive devices and burning of organic wastes,
- limits use of fertilizers, undecomposed and poultry manure and town-compost,
- emphasizes using local-variety, organic seed source and no chemical seed treatment technique,
- avoids torturous raring of animals, fetal implantation, cloning and hormonal use in animal production
- limits artificial insemination in livestock as well as fish production
- protects farmers for fair remuneration from their produces, and employees, children, consumers and tribal groups for their rights
- provides structural arrangements for organic certification and
- recognizes private sectors as key stakeholders in designing policies and organic certification.

MAJOR CHALLENGING ISSUES

There is no doubt that organic agriculture is more sustainable and low input based farming system. But, there are several challenging issues to be resolved both on theoretical and practical grounds for promoting organic farming in Nepal. In order to make national product competitive in the domestic and international market, the country has many problems and constraints to face. The major being setting up own norms and standards for individual products, developing product guarantee and certification mechanism and awareness building to state agencies, organic producers, traders, consumers and other stakeholders. Certification process itself is more complicated and costly that smallholder Nepalese farmers hardly can afford the costs. In addition, plant nutrients supplied by organic manure may be costlier than that from fertilizers (pant, 2006). The relative cost of organic production is generally higher and the prices available compared to non-organic products are relatively low, which is not fair to organic producers. Meeting harsh norms and standards through continuous supervision of the production, transfer and storage and laboratory tests of the products also add to the cost of organic farming. Moreover, food safety, hygiene and sanitation are very important for organic products. It requires good agricultural practices, standard procedure and quality assurance system (services) through accredited institutions. In Nepal, such institutions are very limited in both government and private sectors. Quality assurance, reliable marketing information and other services and rules/regulations complying with those of importing countries are prerequisites to get access in international market. Since the country has least developed institutional framework and infrastructures required for organic agriculture, it is a challenging issue to bring the products at international market. Besides, extension personnel in the country have rarely received adequate training in organic farming, and professional institutions dealing with capacity building in organic farming are not functional yet. Risks involved in shifting to new farming methods, uncertainty of crop yields, inability to achieve economies of scale, limited market information, difficult market access and high costs of supervision and certification services are some other challenges in organic agriculture promotion. Additionally, subsidies on imported inputs and no price discrimination between organic and in-organic products are some of the lacuna to upset organic production and processing. Promotion of group certification as well as marketing mechanism would be an appropriate solution in response to the above mentioned problems and challenges that calls for deliberate contemplation by state policy makers and organic agriculture promoters.

PROSPECTS OF ORGANIC FARMING AND POLICY GAPS

Policy instruments associated with organic agriculture development in the country are much fragmented. Integrating them in organic production promotion and trading on such products is much crucial in achieving sustainable agriculture and higher economic growth. The state for dealing in the aforementioned challenges should have

- **a clear organic agriculture development policy** specifying the roles of government as well as various private sectors. It should have identification of the areas and commodities for organic promotion. State supports including subsidies would be justifiable to reach the organic farmers on the ground of environmental costs.

- **Implementation of organic standards and certification programs**. Since organic certification is more a 'process' than ‘product' certification, the role of certifying agencies is more crucial. In this context, Nepalese standard should be developed focused on the specialty of traditional agriculture practices.

- **Commodity specific and location specific organic production zones** should be demarcated which will encourage to the producers and ensure marketing mechanisms.

- **Residue analysis laboratories and price discrimination systems** should be initiated which ensures the trust on the part of the products and likely chances of their "rejection".

- **Institutional and legislative arrangement.** Establishment and operation of institutions such as National Accreditation Body maintaining and enforcing organic standards and organic certifiers as per the National Standards of Organic Agriculture Production and Processing are vital. Their activities and roles as well as production and marketing mechanism should be guided and regulated by enacting suitable laws. For quality assurance, the production, marketing, storage and transfer including processing of organic agricultural products should come into the purview of domestic laws. Establishment of such institution helps to comply with the international regulations on organic production and trade

- **An identification of the priority programs** to be implemented including research, development, coordination and capacity building. Viewing limited research on organic agriculture and few of that confined on soil fertility management studies only, adequate priority and resources should be allotted on quality assurance, verifying economic aspects of organic farming and scientific validation of indigenous knowledge and farming practices. Building capacity of extension service providers as well as that of producers and sellers through trainings is important. They should be made well aware of national organic standards, legislation and quality assurance system. Effective extension programs for educating consumers and producers about health, environment and social benefits of organic farming, promotion and documentation of indigenous knowledge and skill, cooperative development and group mobilization and provision of information regarding market opportunities (demand/supply), price premiums and consumers' preferences are also essential. For such implementation, an effective linkage and coordination among government and private participants is crucial. Explicit policies, norms and standards and clarity in enforcement of legislation would bring them into strong linkage.

CONCLUSION

Over a century, especially resources-poor and subsistent Nepalese farmers are dominantly practicing organic agriculture to which, due to increasing demands for organic produces, domestic as well as export markets are visible for their livelihood improvement. On such ground, the state, through its policies and periodic plans, has emphasized promotion of organic agriculture. However, the country is not committed to such endeavors since some important policies, laws and regulations regarding production and trade of organic agricultural products are yet to be formulated and agriculture development programs streamlined to such achievements.

Formulation of National Standards of Organic Agriculture Production and Processing (2064) has been an important step, which has left doors open to organic producers, promoters and certifiers to contribute to organic production and processing promotion. However, implementing the standards is itself a major challenge as setting standards, making people aware of them, meeting them at various stages and certification mechanisms for individual products are complicated and costly. Besides, policy instruments associated with organic agriculture development in the country are observed much fragmented and, sometimes, conflicting. For example, subsidies on imported inputs such as fertilizers and no discrimination of prices for organic and inorganic produces are not conducive to such promotion. Integrating policies in organic production promotion and trading is crucial and, for such achievement, a clear organic agriculture development policy, implementation of organic standards and certification programs, demarcated organic production zones, organic-inorganic price discrimination, necessary institutional arrangements and identification of priority activities are important.

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CLIMATE CHANGE AND ORGANIC AGRICULTURE

Ram Chandra Khanal[1]

ABSTRACT

This paper attempts to explore some research findings focusing on the climate change impact on (organic) agriculture and agriculture impact on climate change through a literature review. This review reveals that climate change and agriculture are closely linked and interdependent. Compared to conventional agriculture, organic agriculture is reported to be more efficient and effective both in reducing GHGs (CO_2, CH_4 and N_2O) emission mainly due to the less use of chemical fertilizers and fossil fuel. Organic agriculture also reported to be climate change resilience farming systems as it promotes the proper management of soil, water, biodiversity and local knowledge there by acting as a good options for adaptation to climate change. But, due to lack of proper research, the contribution of organic agriculture for climate change adaptation and mitigation is yet to be known in the Nepalese context. It is argued that organic agriculture positively contributes to offset negative impacts of climate change, but there is inadequate systematic data to substantiate this fact.

Key words: adaptation, climate change, greenhouse gases mitigation, organic agriculture,

INTRODUCTION

Climate change is a natural process but recent trends related to climate change are alarming mainly due to anthropogenic reasons. Climate change has already affected people, their livelihoods and ecosystems and presents a great development challenge for the global community in general and for the poor people in developing countries in particular.

The level of greenhouse gases (GHGs) - mainly carbon dioxide (CO_2), nitrous oxide (N_20) and methane (CH_4) - have been rapidly increasing after the industrial revolution. The increased level of GHGs has created a greenhouse effect which subsequently altered precipitation patterns and global temperatures around the world. Impacts have been witnessed in several areas due to change in precipitation and temperature. The impact areas include, including others, agriculture, forestry, water resources, biodiversity, desertification, human health, and ecosystems goods and services globally. Researches revealed that rate and extent of climate change effects have increased significantly over the years with the increasing climate variability and extreme events.

Clear impacts from climate change are being witnessed in agriculture. Impacts are both positive as well as negative. They are, however dependent on latitude, altitude and type of crop. There have been noticeable impacts on plant production, insect, disease and weed dynamics, soil properties and microbial compositions in farming systems. According to IPCC 2007a, a temperature change in tropical areas has in general had a negative impact on food production and it is estimated that food production within South Asia will decrease by about 30% by 2050.

Although causes and effect relations of climate change and agriculture are seen many forms and extent, assessment of those relations and effects of climate change on agriculture and the impact of (both conventional and organic) agriculture on climate change are not properly

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documented. Understanding of these nexus is vital not only to improve the agricultural sector productivity but it is also important to positively contribute to the environmental management regime at large.

In this backdrop, global communities are in a quest of identifying more efficient farming practices which reduce GHGs emissions (mitigation) as well act as resilient systems that able to adapt impacts of climate change (adaptation). Organic agriculture is being considered as one of the appropriate farming systems that could serve the twin objectives of climate change mitigation and adaptation.

Box 1: Major findings of IPCC 2007

Crop productivity is projected to increase slightly at mid to high latitudes for local mean temperature increases of up to 1-3°C depending on the crop, and then decrease beyond that in some regions.

At lower latitudes, especially seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1-2°C), which would increase risk of hunger.

Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1-3°C, but above this it is projected to decrease.

Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes.

It is projected that crop yields could increase up to 20% in East and Southeast Asia while they could decrease up to 30% in Central and South Asia by the mid-21st century. Taken together and considering the influence of rapid population growth and urbanization, the risk of hunger is projected to remain very high in several developing countries.

OBJECTIVES

This paper attempts to inquire climate change – (organic) agriculture nexus in order to integrate sustainable agriculture issues in agriculture and climate change policies by initiating policy dialogues. The specific objectives of this paper were to explore effect of climate change on agriculture and how organic agriculture could contribute in climate change mitigation and adaptation to climate change.

METHODS AND SCOPE

This paper is based on a desk review of available literature. Data related to climate change, agriculture and organic agriculture is very limited in Nepal and in other south Asian countries; hence information was accessed mainly through web search and it is presented primarily for raising awareness and policy discussions. Some personal observations and views were also captured.

AGRICULTURAL IMPACTS ON CLIMATE CHANGE

Agriculture is one of important contributors of GHG emissions at the global scale. Agricultural land use in the 1990s was responsible for approximately 15% of all GHG emissions (Organic Consumer Association, 2008). Another report produced by OECD (2001) stated that agriculture contributes to over 20% of global anthropogenic greenhouse gas emissions (Food and Agriculture Organization, 2008).

According to the World Bank (2008), agriculture contributes about half of the global emissions of two of the most potent non-carbon dioxide greenhouse gases: nitrous oxide and methane (World Bank, 2008). Livestock manure, nitrogenous fertilizers and irrigated paddy are said to be responsible for producing most agricultural nitrous oxide and methane emissions. These non-carbon GHGs have more powerful greenhouse effects and have greater longevity than carbon dioxide. The different sources of GHGs and the role of the agricultural sector are presented in figures 1 and 2 (Research Institute of Organic Agriculture, 2008).

Agricultural intensification mainly in developed countries after World War II has consumed heavy amounts of fossil fuels and other inputs, contributing significantly to GHG emissions. The doubling of GHG production during the last 35 years was associated with a 6.9 fold increase in nitrogen fertilization, a 3.5 fold increase in phosphorus fertilization and a 1.7 fold increase in irrigated land (food and Agriculture Organization, 2008). The increase of chemical fertilizers contributed substantial amount of GHGs emissions.

Nitrous oxide emissions not only contribute to the greenhouse effect but also to the depletion of stratospheric ozone. Almost 90% of the global atmospheric N_2O is formed during the microbial transformation of nitrate (NO_2^-) and ammonia (NH_4^+) in soils and water. Globally, agriculture contributes 65-80% of total N_2O, mainly from nitrogenous fertilizers on cultivated soils, cattle and feedlots. N_2O emissions from soils are due to the unproductive loss of mobile N. Any nitrogen input (mineral and organic fertilizers, biologically fixed N, crop residues) and the mineralization of nitrogen compounds in soils, contribute to the emission of N_2O. Especially in agricultural soils, elevated N_2O production depends on the nitrogen fertilization level

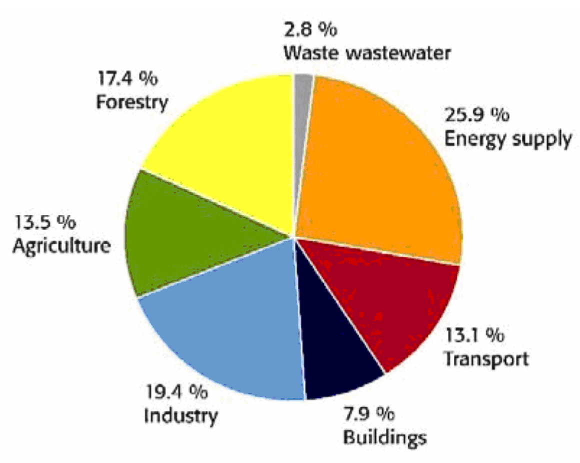

Figure 1. Green House Gas emissions

Agriculture is believed to account for roughly two-thirds of the total man-made methane (CH_4) emissions; mainly from paddy rice fields, burning of biomass and ruminants (enteric fermentation and animal waste treatment). Aerobic agricultural soils, however, are considered sinks for atmospheric CH_4.

Nepal's contribution to GHGs emissions is about 0.025% of the global total. (MoPE, 2004). The 1994/5 National Greenhouse Gas Inventory Study of Nepal revealed the gas emission as below

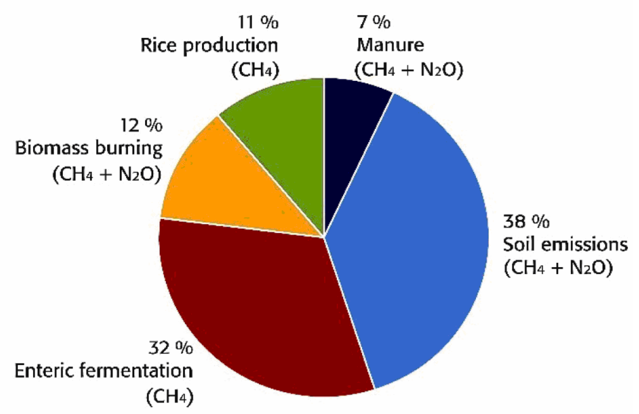

Figure 2: Main sources of GHGs from agriculture -2005

Table 1: Nepal's National Greenhouse Gas Inventory in 1994/95 (Gg) (MoEST, 2008)

Greenhouse Gas (Source and Sink Categories)	CO_2 Emission	CO_2 Removal	CH_4 Emission	N_2O Emission
1. Energy	1465		71	1
2. Industrial Processes	165			
3. Agriculture			867	29
4. Land Use Change & Forestry	22895	-14778		
5. Wastes			10	1
Total emission and removal	*24525*	*-14778*	*948*	*31*
Net emission	9747		948	31

Table 2: General impacts on biophysical and socio-economic areas

Biophysical impacts	Socio-economic impact
Physiological effects on crop, pasture, forest and livestock (quantity and quality)	Decline in yield and production
Change in land, soil and water resources	Reduced marginal GDP from agriculture
Increased weed and pest challenges	Fluctuation in world market price
Shifts in spatial and temporal distribution of impacts	Changes in geographical distribution of trade regimes
Sea level rise and changes to ocean salinity;	Increased number of people at risk of hunger and food security
Sea temperature rise causing fish to inhabit in different ranges.	Migration and civil unrest

CLIMATE CHANGE AND ITS IMPACTS ON AGRICULTURE

According to the nature of impact of climate change on agriculture, Food and Agriculture Organization (2007) ha

s divided into two groups i.e.Biophysical and socio-economic (Table 2).

IMPACTS ON PLANT PRODUCTION

The impacts presented in Table 2 are generally negative. However, while looking critically on plant production, the climate change has both positive and negative impacts. Rises in temperature, for example, would help to grow crops in high altitude areas and towards the poles. In these areas, increases in temperature extend the length of the potential growing season, allowing earlier planting, early harvesting and opening the possibility of completing two crop cycles in the same season. The warmer conditions support the process of natural decomposition of organic matter and contribution the nutrient uptake mechanisms. The process of nitrogen fixation, associated with greater root development, is also predicted to increase in warmer conditions and with higher CO_2, if soil moisture is not limiting.

Increases in temperature, at the same time, might affect lower altitude areas (in Nepal, the *Terai* and foothills) where temperatures are already high. Higher temperatures affect both the physical and chemical properties in the soil. Increased temperatures may accelerate the rate of releasing CO_2 resulting in less than optimal conditions of net growth. When temperatures exceed the optimal level for biological processes, crops often respond negatively with a steep drop in net growth and yield. Heat stress might affect the whole physiological development, maturation and finally yield of cultivated crops.

Higher temperatures provide a conducive-environment for the majority of insect pests. Longer growing seasons, higher night temperatures, and warmer winters help insect pests undergo multiple life-cycles and increase the chances of affecting plant production.

Change in climate affects the pattern and extent of rainfall and evapotranspiration processes which affect soil moisture storage, run-off, and water absorption by the plant. Both lack of and access to water might affect the different stages of plant production. Moisture stress during flowering, pollination, and grain-filling stage is harmful to most crops. Increased evaporation from soil and accelerated transpiration in the plants themselves will cause moisture stress.

Researches have shown that increased concentration of CO_2 in the atmosphere increases the likelihood of higher absorption of CO_2 inside the plant through stomata during photosynthesis which provides carbohydrates for plant growth. Crop species vary in their response to CO_2 according to their physiological class i.e. C_3 versus C_4 plants.

CLIMATE CHANGE, FOOD AND PEOPLE'S LIVELIHOODS

The developing world already contends with chronic poverty and food crisis. Climate change presents yet another significant challenge to be met. The estimate for Africa is that 25-42% of species habitats could be lost, affecting both food and non-food crops. Habitat change is already underway in some areas, leading to species range shifts and changes in plant biodiversity which includes indigenous foods and plant-based medicines. In developing countries, 11% of arable land could be highly affected by climate change. There will be a reduction of cereal production in 65 countries and retardation of about 16% of agricultural GDP (FAO, 2007). IPCC (2007a) has predicted a decrease of 30% in food production in South Asia. The major findings of IPCC are presented in Box 1.

Climate change will have serious impacts on world economic output, human life and the environment throughout the world. The most vulnerable – the poorest countries and populations – will, however, suffer earliest and most, even though they have contributed least to the causes of climate change (HM Treasury, 2009). Poor people who depend on agriculture are the most vulnerable to climate change. Increasing crop failures and livestock deaths are already imposing high economic losses and undermining food security. More frequent droughts and increasing water scarcity may devastate large parts of the tropics and undermine irrigation and drinking water in entire communities of already poor and vulnerable people (World Bank, 2009. The increased frequency and extent of floods, droughts and land cutting has rendered the agriculture sector more vulnerable and reduced the productivity of land and of the potential for plant production. The case is much more severe in countries like Nepal where people have inadequate knowledge, weak governance systems and fewer resources to respond.

ORGANIC AGRICULTURE AND GHGS EMISSIONS

Organic agriculture not only enables agriculture-influenced ecosystems to better adjust to the effects of climate change but also offers potential to reduce the emissions of agricultural greenhouse gases.

Mitigation is a process of reducing Green House Gases (GHGs) which are responsible for change in climate and climatic variability. The main GHGs include methane, nitrous oxide and carbon dioxide.

Organic agriculture not only enables ecosystems to better adjust to the effects of climate change but also offers potential to reduce the emissions of agricultural greenhouse gases. In organic agriculture, soil fertility is maintained mainly through farm internal inputs (organic manures, legume production, wide crop rotations etc.); energy-demanding synthetic fertilizers and plant protection agents are rejected; and there is less or no use of fossil fuel. The carbon sink idea of the Kyoto Protocol (Article 3.4) may therefore partly be accomplished efficiently by organic agriculture (Food and Agriculture Organization, 2008). In order to reduce GHG emissions from the agriculture sector, suggestions by IPCC (2007a) included improving crop and grazing land management to increase soil carbon storage; improving nitrogen fertilizer application techniques to reduce N; and dedicated energy crops to replace fossil fuel use (IPCC, 2007b).

Research reveals that consumption of fossil fuels in organic agriculture is about half that of conventional agriculture. In organic agriculture, almost 70% of CO_2 emissions were due to fuel consumption and the production of machinery, while in conventional systems 75% of the CO_2 emissions are ascribed to N-fertilizers, feedstuff and fuels (Food and Agriculture Organization, 2008).

The main factors responsible for lower emission of CO_2 from organic agriculture are maintenance and increase of soil fertility by the use of farmyard manure, the omission of synthetic fertilizers and synthetic pesticides; and the lower use of energy-intensive animal feeds.

Sustainable agricultural strategies comprising recycling of organic matter, tightening internal nutrient cycles, and low- or no-tillage practices may rebuild organic matter levels and reduce losses from the system. A report estimated that a 20% increase in soil organic matter as a result of organic agriculture would result in a decrease of about 9 tonnes of carbon emission per hectare (Food and Agriculture Organization, 2008).

The avoidance of synthetically-produced mineral nitrogen in organic agriculture confines productivity within natural limits (i.e. N-fixation) or the limits defined by the annual nutrient balance of the farm, including imported fodder and organic fertilizers. Organic agriculture, therefore, is likely to emit less N_2O because of:

- a systemically lower N-input;
- less N from organic manure due to lower livestock densities;
- a higher C/N ratio in applied organic manure and less available mineral nitrogen in the soil as a source for denitrification;
- the permanent plant cover in organic systems which results in a more efficient uptake of mobile nitrogen in soils, thus reducing the potential risk for N_2O emissions.

However, some researches have shown that organic agriculture is more likely to produce and release nitrous oxide in the environment due to the use of much more organic manure from livestock.

Very little information is available in relation to organic agriculture and methane. The emission of methane by ruminants is probably not affected by organic production. The higher proportion and lower productivity of ruminants in organic agriculture may, however, lead to slightly higher emissions of CH_4.

In general, research shows significant reductions of GHGs especially CO_2 and N_2O from organic agriculture. However, importantly for countries such as Nepal, there is no information or research data related to subsistence farming systems and different types of conventional as well as organic agriculture to compare among different farming systems.

CLIMATE CHANGE ADAPTATION AND ORGANIC AGRICULTURE

IPCC (2001) defines adaptation to climate change specifically as "adjustment in natural or human systems in response to actual or expected climatic *stimuli* or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation."

It is reported that organic agriculture could be a resilience systems for adaptation to climate change. Organic agriculture helps to increase resilience of farming systems through better management of soil and water, promoting biodiversity and strengthening community knowledge systems. Organic agriculture provides better results in many aspects of environmental issues compared to conventional agriculture (Food an Agriculture Organization, 2008).

SOIL AND WATER RESOURCES MANAGEMENT

Soil and soil management are the foundation of organic production. Organic growing systems are soil-based which care for the soil and surrounding ecosystems and provide support for a diversity of species, while encouraging nutrient cycling and mitigating soil and nutrient losses. Organic farming returns microbial plant or animal material to the soil to increase or at least maintain its fertility and biological activity. It also manages the water resources judiciously. Hence, healthy soil and proper use of water resources would help for effective adaptation process.

ORGANIC AGRICULTURE AND BIODIVERSITY

Organic agriculture utilizes various combinations of plant and animal species in time and space. Some organic systems are more diverse than others. Crop rotations (i.e. diversity in time) are a requirement of organic standards. Crop rotations are the most basic and common form of diversity on organic farms. Organic farmers rotate crops and livestock from one part of the farm to another rather than growing the same product over and over in the same space. This practice provides multiple benefits for soil quality, helps to break pest and disease life cycles and maximizes efficient use of soil nutrients and water. Some farmers also use multiple sowing dates, thereby lessening the chance that the whole crop will be at a critical stage during an extreme weather event (Food and Agriculture Organization, 2008).

Organic standards also require farmers to use organic seeds and encourage genetic diversity in both crops and livestock. Organic farmers are expected to save their seeds year after year, making them self-sufficient and self-reliant. It is thus vital in developing countries particularly in the regions where farmers cannot afford to buy their own seed. Farmers select seeds from successful plants and in so doing develop local landraces that are highly adaptable to local ecosystems.

The combination of these activities increases farms' resemblance to natural ecosystems, thereby enhancing resilience. Agricultural biodiversity in time and space increases resilience in a myriad of ways: complementary use of soil nutrients and water, increased total productivity through appropriate polyculture mixtures, decreased risk from one crop failure, pest protection, the creation of microclimates suitable for beneficial insects and strengthening the genetic traits of local landraces.

COMMUNITY KNOWLEDGE SYSTEMS

Organic agriculture is based on ecological processes; knowledge of the agro-ecosystem is thus a pre-requisite to any organic farm. Farmers with a traditional knowledge base are potentially better able to develop ecological processes to respond to the effects of climate change.

Community knowledge represents a process of learning as much as a single body of information. Traditional knowledge is not just a system for the present, but a source of institutional memory about what practices have worked best over time. Such knowledge has been described as a "reservoir of adaptations," a whole set of practices that may be used again if the need arises (Food and Agriculture Organization, 2008).

Organic agriculture promotes improved soil quality and efficient water use, agro-ecosystems and strong community knowledge processes which in turn help to improve farm resilience against the adverse impacts of climate change and strengthen farms' adaptive capacity.

ECOSYSTEMS GOODS AND SERVICES

Organic agriculture provides a basis for maintaining environmental goods and services at the farm and landscape level. According to Food and Agriculture Organization (2008), organic agriculture provides the following environmental goods and services.

Table 3: organic agriculture and environmental goods and services

Areas	Environmental goods and services
Soil	Organic matter content is usually higher in organically-managed soils, indicating higher fertility and stability of organic soils as well as moisture retention capacity, which reduce the risk of erosion and desertification.
	Organically-farmed soils have significantly higher biological activity and a higher total mass of micro-organisms, making for more rapid nutrients recycling and improved soil structure. While the proportion of soluble nutrient fractions is lower on organically managed soils, there is no decrease in organic yields since higher biological activity and higher mycorrhizal root colonization counteract nutrient deficiency.
Water	Organic agriculture poses no risk of ground and surface water pollution through synthetic pesticides.
Air	Organic agriculture enables ecosystems to better adjust to the effects of climate change and has a major potential for reducing agricultural greenhouse gas emissions.
	Organic agricultural strategies, by recycling organic matter and tightening internal nutrient cycles, contribute to carbon sequestration.
Energy	Organic agriculture performs better than conventional agriculture on a per hectare scale, both with respect to direct energy consumption (fuel and oil) and indirect consumption (synthetic fertilizers and pesticides).
	Efficiency of energy use of organic farms is high.
Bio-diversity	Agriculture genetic resources, including also insects and micro-organisms, have all been shown to increase when land is farmed organically.
	Wild flora and fauna within and around organic farms are more diverse and abundant than in conventional or integrated agriculture.
Ecological services	Organic agriculture offers vast food resources and shelter for beneficial arthropods and birds, thus contributing to natural pest control.
	Organic agriculture contributes to the conservation and survival of pollinators, thanks to the banning of synthetic chemical pesticides and herbicides and the enhanced ecosystem diversity

Organic agriculture promotes ecological resilience, improved biodiversity, healthy management of farms and the surrounding environment, and builds on community knowledge and strength. Hence, organic agriculture has been proved to be effective for enhanced adaptive capacity of farmers adversely affected by climate change.

IMPLICATIONS AT NATIONAL LEVEL IN NEPAL

Despite the alarming impacts-both potential and realized of climate change on agriculture, there is hardly any information available related to climate change, agriculture and organic agriculture in Nepal. Organic agriculture is beginning to gain attention both in the Government and in the non-government sector these days. The Ministry of Agriculture and Cooperatives (MoAC) through its district level offices has started working in organic agriculture but the efforts are still not adequate. The ministry has already finalized the organic agriculture standard for certification for Nepal.

The Government of Nepal through the Ministry of Environment Science and Technology (MoEST) is going to prepare a National Adaptation Programme of Action (NAPA) for Nepal. Though it is not yet clear how the government is going to prepare the NAPA, the involvement of MoAC and other non-governmental organizations in the process of NAPA formulation is vital for the integration of organic agriculture and adaptation related issues.

CONCLUSION

Although there is very little information available related to organic agriculture and its associations with climate change mitigation and adaptation in Nepal, this review of international literature reveals that organic agriculture could support both GHGs emissions reduction as well as the development of resilient farming systems for adaptation. It is imperative to bring this issue to the forefront of discussions by government and non-government sectors to assess the potential contribution of organic agriculture to the climate change mitigation and adaptation process. Involvement of appropriate partners is crucial while preparing national and regional climate change related plans and policies including the NAPA for Nepal.

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PESTICIDE APPLICATION AND FOOD SAFETY ISSUE IN NEPAL

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ABSTRACT:

It has been increasing pest population including weeds, invasive species, insects and insect vectors and plant diseases, which lead to increase pesticides on crop production. Some of the pesticides also contribute to global warming and the depletion of the ozone layer. Pesticides are the potential health hazards which have drawn attention to everyone. The current practice adopted in pesticides control in Nepal appears not enough in line with food safety. This has created a promising threat in food safety and human health. In turn, global warming is also likely to increase pesticide use and degrade food safety situation. Necessary measures should be adopted to curb upcoming alarming situation in food safety.

Key words: food safety, global warming, pesticides, Nepal

INTRODUCTION

Food is synthesis of soil, sunlight and rain (Miller 2004). Current estimate of warming in climate indicates an increase in global mean of annual temperature by 1 C by 2025 and 3 C by the end of next century. Such increases in temperature have a number of implications in temperature-dependent pests (Palikhe 2007). Climate and weather can substantially help the development and distribution of insect pests. Pests and diseases are predicated to spread much further to take advantage of global warming (Cammel 1991). The assessment on investigation of the relationship between pesticide use and warm climate for crops revealed that pesticide requires relatively higher amount than before (Reynolds 1997). Pesticide use is projected to increase for most crops and there is increased need for pesticide application on corm is generally in the range of 10-20%, on potatoes 5015% and soybean and cotton 2-5% (Brussel 2006). Flowering pattern, breeding behavior and the timing of migration will be changing. The distribution of plants, insects, animals and even soil bacteria will be shifting rapidly for every 1 C increase in temperature (Lohani 2007).

Global warming which is a gradual rising of Earth's temperature, is different from disaster lime earthquakes, volcanoes eruptions etc representing a scale of threat greater than anything humans have faced in recent history (Bailey 2008). Global warming allows pest migration or population expansion that may adversely affect agricultural productivity, profitability and possibly even viability and safety of food products (Ghimire 2007). Use of pesticide in agriculture has created four fold problems through tropic levels: health related problems, environmental problems, yield loss due to non-target pesticide application resulting in pesticide induced pests resurgence and finally financial burden to the farmer.

There is no comprehensive study has been made so far to know the relationship between use of pesticides and global warming in Nepalese context. Therefore, this study aims to know the current practices regarding the pesticide usage and ultimately aware people about the increasing use of pesticides due to global warming.

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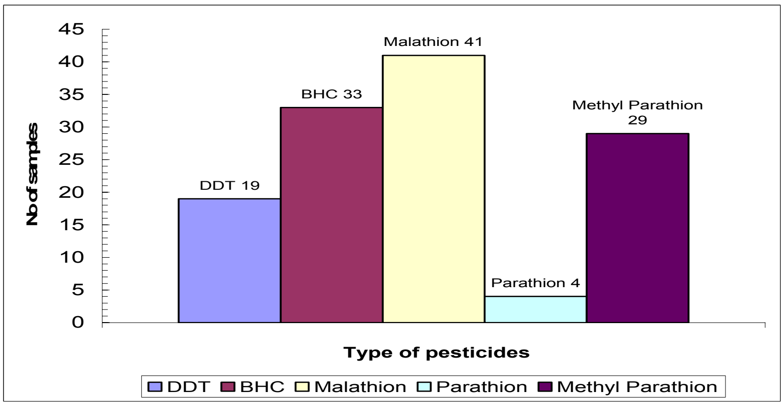
STATUS OF PESTICIDES APPLICATION

Nepal imports pesticides from six different countries with local production in scant quantity. Fifty-five certified importers are involved in marketing of seventy-three registered common pesticides in three hundred and forty two trade names. The total number of pesticides registered in the country is seventy-three. Among the total registered pesticides, insecticides are major and a total of thirty-nine different insecticides are registered followed by fungicides which is eighteen. Fourteen types of pesticides are banned for normal use by Government of Nepal (Koirala 2009). The study carried out in Department of Food Technology and Quality Control during 1995-2007 for the analysis of 1034 food products, 12.1 percent samples were found contaminated with pesticides (Koirala[a] 2008). Malathion and BHC were two major pesticides that contaminated in food products (Fig 1)

Figure 1: Pesticides in Food (Koirala, 2008)



STATE REGULATORY FRAMEWORK AND ORGANIZATIONS

Pesticide regulation has established guidelines on management of pesticides in Nepal. Pesticide management involves the regulatory control, proper handling, supply, transport, storage, application, use, waste management and disposal of obsolete pesticide in order to minimize adverse environmental effect and human exposure.

The Pesticide Act, 1991 and the pesticide Regulations, 1993 came into effect from 16 July 1994. It covers basic handling techniques of pesticides. The importers wishing to market and sell pesticides shall have to submit an application dealing with the use of pesticides, toxicity, the correct use of pesticides for agriculture safety and human health hazard. No pesticide can be imported into the country without seeking prior Government approval (Pesticide Act 1991).

Food Act, 1967 and Food Regulations 1970 have proposed Maximum Residue Limits (MRLs) for pesticides in food products. But the maximum residue limit has been fixed only for cereals, pulses and their products, processed water and infant food. No MRLs has been fixed for tea. Department of Food Technology & Quality Control (DFTQC) constantly monitors pesticide residue level in only in those food products where standard has been laid down (Koirala[a, b] 2007).

In order to investigate the level of pesticide in food, laboratory analysis is necessary. In Nepal, the existing pesticide testing facilities are limited to very few organizations. DFTQC , Nepal Agriculture Research Council (NARC) and the other two-accreditated private sector laboratory carry out the analysis (Koirala[a] 2008).

The pesticides to be imported, distributed, traded and used should not possess threat to health and the environment. Large persistent chemical pesticides have been banned for agriculture and public health from April 2001 and other hazardous pesticides have been phased out from the use since April 2001. At present, prohibition on the use of quinalphos, ethion, monocrotophos and phorate in the tea field has already been campaigned and implemented from May 2005. Integrated Pest Management (IPM) approach has been widely accepted as the alternative to pesticide application. Government of Nepal has now phasing out toxic pesticides and application or use of the newer and safer pesticides has been prescribed. Government program at field level is regularly providing training programs on pesticides handling techniques to the farmers.

PESTICIDE ISSUES IN FOOD SAFETY

Pesticides are the potential health hazards which have drawn attention to food quality control agencies, certification bodies, international community and trading partners. Due to the lack of regular monitoring of pesticides at the field level, the export of tea, honey and other food commodities are adversely affected in the recent years.

Pesticides analysis facility is limited in Nepal. Only few institutions are involving in it and the data available are not sufficient. The laboratories require sophisticated equipments to carry out the residue analysis. Laboratories require reference standard, valid analytical method and are one of the tough jobs. No organized national survey has so far been conducted periodically. Therefore, a valid comparison on use pattern of pesticides cannot be made. The gap between the availability of manpower and other resources requirement is very high which demands the infrastructure support to government as well as to private sector. Similarly, exchange visits, training and other supports by the donor agencies are necessary in order to improve the situation.

The country like Nepal has export potentials for agriculture and processed products. This is not possible unless and until the country doesn't have safe food production. As Nepal has already become a member of WTO, export opportunity can be utilized. It will generate employment and earning to the local people.

Being a member of WTO, Nepal must comply with the SPS requirements. Considering the present pace of implementation, it needs to be done a lot to attain the goal with appropriate harmonization of standards, rules/regulations, guidelines as well as mechanism of inspection and certification of import/export food commodities. In the emerging scenario, there is a need to have MRA at the regional and international level. Risk assessment program should be carried out whenever necessary.

There is no coordinating team for research work on pesticides at field level for the recommendation of appropriate pesticides on crop production. Training /workshop about the use and safety of pesticide should be provided to farmers, retailers and distributors in regular basis.

CONCLUSION AND RECOMMENDATION

Global warming will result in an increase in risks of pathogens and chemicals from agriculture to human health. It will fuel increased use of pesticides and biocides as farming practices intensify. The pesticide risk can be reduced from its injudicious use by using IPM approach, and organic manure including vermi-compost, bio fertilizers and pesticides and organic farming. Pesticide Act, 1991 and Pesticide Regulations, 1993 should be effectively implemented. On the other hand, there is an urgent need to establish a national pesticide residue monitoring programme. Likewise, periodic assessment of pesticides and its level of use or limits should be studied for consumers' safety. MRLs of pesticides should be established for vegetables, fruits, and other food grains in accordance with Codex. Introduction of Good Agricultural Practice in the country will help to reduce pesticide risk on food products which will decrease on the pesticide consumption ultimately conserves food safety.

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LAND DEGRADATION ISSUES IN NEPAL AND ITS MANAGEMENT THROUGH AGROFORESTRY

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ABSTRACT

Land degradation is major challenge of Nepal. The paper focuses mainly on causes and consequences of land degradation and their management approaches. Land degradation may occur through different physical, chemical and biological processes induced directly or indirectly by human activities like deforestation, shifting cultivation, overgrazing, steep slope farming, over use of chemical fertilizers and forest resources. These create many social problems like poverty, poor health and nutrition and demographic dynamics by lowering agricultural productivity. Agroforestry approaches like use of Multi Purpose Tree Species (MPTs), relay-cropping, terracing and contour cultivation, strip and alley cropping are appropriate to fulfill the needs of low resource farmers by restoring and increasing land productivity. The potentiality of the approach can be made more effective through holistic efforts, based on needs with active participation of farmers in planning and implementation stage.

Key Words: Biodiversity, deforestation, ecosystem, natural resource, productivity, erosion

INTRODUCTION

Land is one of the major natural resource of a developing country like Nepal. More than 90% of the population is dependent upon the land for their fulfillment of basic needs (food, fodder, fuel, fiber and timber) (LRMP, 1986). Land degradation is decline in land quality or reduction in its potential productivity of land. Land degradation may occur through different physical, chemical and biological processes which are directly or indirectly induced by human activities. These include soil erosion, compaction, acidification, leaching, salinization, decrease in cation retention capacity, depletion of nutrient, reduction in total biomass carbon and decline in biodiversity. Soil structure is major factor for all forms of degradative processes. It also affects the provision of ecosystem services. Human activities are responsible not only for the degradation of land but also important for improvement of land through prevention, rehabilitation and reclamation (MoEST, 2008).

Nepal has extreme climate ranges from subtropical to arctic (High Mountain) and vegetation ranges from sub tropical forests to arctic like Tundra. Nepal has been divided into mainly 3 physiographic regions Terai, Hills and Mountains of which the mountains and hills make up about 83 percent of the area, and the 17 percent Terai. It shows that about $1/4^{th}$ and $1/3^{rd}$ of the area is suitable for agriculture and forest covers respectively. Much of the hill and mountain areas are very fragile and vulnerable to landslides. Terai lands are regularly threatened by flooding and sedimentation (Karkee, 2004).

More than 9 million hectares of forest are being converted into non forestland, and at least double that amount of forest ecosystem is being fragmented and degraded each year over the world. Converted land is generally agriculturally unproductive, biologically impoverished, and more flammable than the forests (Uhl and Buschbacher, 1985; Uhl, 1987). Rural livelihoods in

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the hills of Nepal are directly linked with forest ecosystems for human needs, animal rearing, crop production, and providing environmental and spiritual needs. As a result, there is greater human pressure on the hill forest ecosystems due to which about 200 hectares per day of forest conversion in non-forest land, or degradation and fragmentation into shrub/bush lands. These cause loss of plant species and high levels of erosion resulting in further loss of soil nutrients. Lowering agricultural productivity from loss of soil nutrients has lowered rural communities' income and livelihood support. This has adversely affected poverty levels, resulting in 45% of hill population having to survive below the poverty line in Nepal (Gautam, 2000).

OBJECTIVE

The objective of the paper is to present causes and consequences of land degradation and their management approaches through agroforestry. The paper also aims to way out restoring land ecosystem and improving rural livelihoods through agroforestry.

DISCUSSION

LAND DEGRADATION: STATUS, CAUSES AND CONSEQUENCES

Land degradation is one of the greatest challenges faced by Nepal. Both the natural conditions and human activities have contributed to the degradation of land in Nepal. Some of the major causes of land degradation are fragile geological structure, forest fire, avalanches and dry landslides in which increasing population, fragile economy and sometimes farm policies add fuel to it in its natural condition. Natural calamities like landslides in the hills, drought in the most of the areas of the country and flooding in the foothills and the Terai have frequently occurred. Most of all, flooding is a major cause of land degradation leading to the poor socio-economic conditions and the deterioration of the natural ecosystems. Anthropogenic causes such as deforestation, excessive use of chemical fertilizers, overgrazing, construction works, and unscientific farming in the hills (steep slope) have resulted in the loss of flora and fauna, erosion of top soil, occurrence of land slides in the hills and flooding in the plain areas. This has led to severe environmental degradation leading to poor socio-economic condition and disruption of natural ecosystems in Nepal (Karkee, 2004).

The repeated pressure of grazing on grasslands beyond its carrying capacity, shifting cultivation in the mountains and overgrazing in the open public lands lead to land degradation and damage the ground vegetation and grassland ecosystems. The heavy grazing pressure in the mountain areas has speeded up the soil erosion, which lead to increase run-off and compaction of soil. Cultivation on steep slope without taking considerations of improved farming such as terracing, use of organic manures has contributed to increase in soil erosion resulting in high water turbidity which leads to harmful effects to the aquatic flora and fauna including fish species. Development activities such as construction of roads, buildings, dams have added effect to it (Neupane and Thapa, 2001). In Nepal, land and forest resources have been intensively used to meet the basic requirements of food, fuel-wood, fodder, and small timber (Karkee, 2004).

Rivers in Nepal have damaged more than 400,000 hectares of productive agricultural lands (LRMP, 1986). The Shiwalik hills and middle mountainous regions are highly vulnerable to soil erosion. The extent and severity of damages have increased continuously due to frequent changing nature of mountain-rivers. Farmlands near river banks are washed away by flooding, crops are ruined and widths of rivers widen every year during monsoon. Nepal's rivers carry around 336 millions tons of soil per year to the main river systems entering to India (Brown, 1981). The bed level of Terai's rivers has been rising by 35-45 cm annually (Dent, 1984). The productivity of riverside lands has been seriously affected by silting, flooding and deposition of pebbles. Furthermore, the river-damaged areas of middle mountains of Nepal suffer from excessive grazing pressures of domestic animals. Pioneer plants which are indicator species for degraded lands like *Imperata cylinderica*, *Saccharum munja,* and *Cassia occidentalis* have colonized in such areas (Kafle, 1995). Nearly 45.5% area of the country is seriously affected by water erosion. Similarly, 4% area mostly in higher altitude and trans-Himalayan region is affected by wind erosion. Land degradation due to chemical and physical processes is less than 2% of the total area of the country (Gautam *et al*., 2003). The land area under degradation is presented in table 1.

Table 1. Land area under degradation

S.N.	Land use category	Degraded area (million ha)	Total land area (million ha)	% of degraded land
1	Forest (poorly managed)	2.100	5.828	36.02
2	Agriculture (poorly managed slopping terraces	0.290	2.969	10.00
3	Pasture/rangeland (degraded)	0.647	1.75	37.00
4	Areas damaged by floods and landslides (1984-2003)	0.106	11.551	0.92
5	Forest encroachment	0.119	5.828	2.04
	Nepal	3.262	11.551	28.24

Source: MoEST, 2006.

The land degradation is associated with soil erosion on the hill slopes, sedimentation/siltation in river valleys and the Terai which reduce crop yields due to decline in soil nutrients, acidification, and pollution. The estimated annual soil erosion is given in table 2.

AGROFORESTRY SYSTEM FOR LAND DEGRADATION MANAGEMENT

Farmers have cultivated trees on farm from time immemorial. Agroforestry system in Nepal is diversified and integrated with livestock, trees and crops. Any change in any component of the whole system will have effects on the other components. Households keep different types of animals for meeting their livelihood. Households plant fodder trees on under utilized lands. The average fresh fodder requirement for each household is 73.68 kg/day. The increased number of fodder trees on farm enables one third of the households to practice stall-feeding.

However, the rest of the households still practice both stall feeding and grazing due to lack of land to produce sufficient fodder to maintain sound health of animals (Regmi, 1998).

Table 2. Estimated annual soil erosion

S.N.	Land use category	Erosion rate (ton/ha/yr) (1)	Area (million ha)(2)	Approximate soil loss (ton/yr)(1x2)
1	Well managed forest	5-10	2.71	13.55-27.1
2	Poorly managed forest	25-40	1.559	38.98-62.36
3	Well managed paddy terrace	5-10	1.50	7.5-15.00
4	Well managed bari (dry terrace)	5-15	0.83	4.15-12.45
5	Poorly managed sloppy terraces	20-100	0.29	5.80-29.00
6	Degraded rangeland/open land	40-200	1.75	112.4-562.00
	Total		9.699	182.38-707.91

Source: MoEST, 2006.

The components of agroforestry exploit different vertical layers both above and below ground which signifies greater resource utilization efficiency for optimizing resource use. Farmers can play leading role in development and testing of MPT technology, assessing on-station trials, conducting researcher-designed and farmer-designed trials, and providing feedback to the researchers. Hence, efforts are needed to model and assess the long-term impacts of the multipurpose trees on productivity (Karkee, 2004).

It has been reported that financial returns generated from agroforestry system are generally much higher than return from continuous unfertilized food crops around the developing world. The higher return associated with agroforestry can translate into improved household nutrition and health, particularly when the income is controlled by women. Monitoring and impact assessment studies need to give more attention to how agroforestry affects household resource allocation and consumption (Fleming, 1983).

Agroforestry can contribute to human nutrition through increased production and availability of particularly nutritious fruits and leaves Improving livelihood support in lessening rural poverty along with degraded hill environmental restoration on highly populated lower and mid hills are prioritized in the plan of Nepal. The government of Nepal has launched its Hills Leasehold Forestry and Fodder Development Project with assistance from FAO and IFAD to achieve the national goal. The government has leased degraded forestlands and granted the leasehold land tax-free to eligible families who are below the poverty line, and has provided training and minimum inputs. This has resulted in an increase in forest coverage of up to 70%, and an increase in the income levels of leasehold families during the last seven years. This increase in families' income helps to support children's schooling, health and daily family expenses (Gautam *et al.*, 2003).

Integration of trees in the production system

Different agroforestry species used for the management of land degradation are given in table 3 (Kerkhoff, 2003).

Table 3. Agroforestry species used for land degradation management

Local name	Scientific Name	Uses
Fodder		
Badahar	*Artocarpus lakoocha*	Fodder, fuel, fruit
Bhatmase	*Flemingia congesta*	Fodder, fuel, soil conservation
Dabdabe	*Garuga Pinnata*	Fodder, fuel
Ipil Ipil	*Leucaena spp.*	Fodder, fuel, soil conservation
Kabro	*Ficus lacor*	Fodder, fuel, soil conservation, pickle
Khanyu	*Ficus semicordata*	Fodder, fuel, fruit
Khasreto	*Ficus hispida*	Fodder, fuel
Kimbu	*Morus alba*	Fodder, fuel, sericulture
Koiralo	*Bauhinia variegata*	Fodder, fuel, pickle
Rahar	*Cajanus cajan*	Fodder, fuel, food
Kutmero	*Litsea monopetala*	Fodder, fuel
Tanki	*Bauhinia purpurea*	Fodder, fuel
Fuelwood/Timber trees		
Bakaino	*Melia azedarach*	Timber, fuel, fodder, medicinal
Sal	*Shorea robusta*	Timber, fuel, fodder
Sissoo	*Dalbergia sissoo*	Timber, fuel
Fruit trees		
Amba	*Psidium guajava*	Fruit, fuel
Amp	*Mangifera indica*	Fruit, fuel
Anar	*Punica granatum*	Fruit, fuel
Aru	*Prunus persica*	Fruit, fuel
Bhui-katahar	*Ananus sativus*	Fruit, soil conservation
Kagati	*Citrus aurantifolia*	Fruit, fuel
Kera	*Musa sapientum*	Fruit
Lichi	*Litchi chinensis*	Fruit, fuel
Mewa	*Carica papaya*	Fruit
Naspati	*Prunus communis*	Fruit, fuel
Nibuwa	*Citrus lemon*	Fruit, fuel
Rukh-katahar	*Artocarpus integrifolia*	Fruit, fuel, fodder

Some other species targeted on agroforestry for scientific land degradation management are also identified (Kumar, 2005). *Australian Wattle (Acacia auriculiformis)* is suitable in Agroforestry system. It is conveniently grown along borders of field crops, sometimes laterals removed. It is suitable for checking soil erosion and reducing wastelands. It is suitable to grow on poor soil as it synthesizes atmospheric nitrogen. Not only this, it adds profuse quantity of litter to the soil.

Khair *(Acacia catechu)* is suitable to grow for soil conservation. It is useful for afforestation of tropical, dry, arid traits, especially in irrigated and canal plantation. It is useful for social forestry. It is also host for lac insect.

Babul *(Acacia nilotica)* is best suited in agroforestry system. It has shown excellent performance in soil conservation (sand-dunes stabilization) in dry and arid region of the country. It can be grown along farm boundaries marginal land, tank beds, wasteland like saline and alkaline soil. It is best grown in black cotton soil where other trees hardly survive.

Bael *(Aegele marmelos)* is a long lived tree; therefore it is suitable to grow on borders of the field that will act a good wind breaker. Time to time lopping will control its canopy 'manageable' that will also reduce shading effects on agricultural crops. This tree is suitable in hortipastoral system. Besides, the bael can be grown in parks, gardens, along road side and canal banks. It produces copious root sucker.

Siris (Albizia lebbeck) is grown as shade tree for plantation crops like tea and cardamom. It is also suitable to grow as wind breaks for the protection of seasonal crops.

Uttish (Alnus nepalensis) is very fast growing trees therefore; it can be selected in Agroforestry system. Its raising is suitably adopted in abandoned tanguay areas where the seed is broad casted during the last year of cultivation. The tree has good capacity for nitrogen fixation therefore avoiding any competition between agricultural crops for nitrogen hunger. It is also good coppicer.

Cashew (Anacardium occidentallis) is planted on poor soils on hill slopes. They help in reducing soil erosion caused by water during rainy season. These species are suitable for hortisilvipastoral system.

Neem (Azadiracta indica) tree is suitable to grow in agroforestry system in which annual crops can easily be grown in the interspaced and even very near to its base. Neem tree does not compete with intercrop because it has deep rooting system. It is suitable to grow in calcareous soil. It is an excellent tree for afforestation of arid region. It is good shade tree grown on farm borders, near buildings and suitable for growing along roadside as an avenue tree and along canal sides. For reclamation of wastelands, growing of Neem, is the best.

Tanki (Bauhinia variegata) is suitable as an attractive ornamental avenue tree. Tree produces good fodder through its leaves therefore planting in field boundaries will benefit growers. It can be tried with other agricultural crop; the tree does not grow large and is readily managed by canopy lopping. Tanki is grown as shelterbelts in coastal areas in mixed planting. The tree has the ability to coppice well and can withstand heavy lopping.

Sissoo (Dalbergia sissoo) is fast growing long lived tree. During early growth up to 4 to 5 years arable crops can easily be grown economically. Thereafter plantation is converted into silvipastoral system. It is suitable to grow as windbreaks and shelterbelts. It acts as good shade tree in tea gardens. Being a leguminous tree it grows well on poor soil as it improves soil fertility. It is also suitable to grow for soil conservation, ravine reclamation etc. It has good coppicing ability and produces root suckers and fixes nitrogen.

Giliricidia (Gliricidia maculate) is very suitable in agroforestry system because it is fast growing species. Unpruned trees act as windbreaks. It is suitably grown along roadsides, on the borders of the garden, on wastelands improvement as its roots contain root nodules in which atmospheric nitrogen is fixed.

Ipil –lipil (Leucaena leucocephala) is one of the best trees suitable for agroforestry and social forestry program. It is suitable to grow as windbreaks or shelterbelts. Being a leguminous plant, it improves soil forestry. It is suitable to grow as an effective shade tree for plantation crops like tea, coffee, cocoa, and nursery beds. It has been reported to be most suitable in alley cropping in which it contributes nitrogen and conserves soil moisture. It has strong coppicing and pollarding capacity.

Bakaino (Melia azedarach) is fast growing trees which are very suitable to grow on boundary of the fields. It is also suitable to grow on alkaline soil which is free from water logging conditions. It has beautiful dense foliage, therefore suitable to grow as hedge along roadsides, canal sides and in gardens.

Poplar (Populus spp) is deciduous and has the habit of remaining leafless for 3-4 months and ideal for agrisilviculture and social forestry. Poplar is well suited for growing various vegetables crops, fodder crops, and grasses.

Restoring soil fertility

Soils in many parts of the mountainous region are already seriously degraded. Restoring fertility levels will be essential if cropping systems are to be intensified. Due to high cost and poor transportation, chemical fertilizer use is limited in the mountainous region, so, *in-situ* restoration methods for soil fertility must be applied. Relay-cropping of legumes is one of the more promising methods for restoring the soil fertility. Terracing and contour cultivation could minimize soil erosion and help to restore the physical and chemical property of the soil. These restoration methods, however, may only be effective under specific edaphic conditions and have limited applicability on steep slope land (Kerkhoff, 2003).

Maintenance and enhancement of soil fertility is vital for global food security and environmental sustainability. Ecologically sound agroforestry systems such as intercropping and mixed arable-livestock systems can increase the sustainability of agricultural production. Agroforestry is a useful path, complementary to chemical fertilizers, to enhance soil fertility. Alternate land-use systems such as agro-horticultural, agro-pastoral and agro-silvipasture are more effective for soil organic matter restoration. Soil fertility can also be regained in shifting cultivation areas with suitable species. The planting of stem-cuttings and flooding result in greater biological N_2 fixation, 307 and 209 kg N ha^{-1} by *Sesbania rostrata* and *S. cannabina* respectively for restoring fertility (Pandey, 2007).

Even when trees are not removed through total harvest, the species combination should be designed for nutrient release that benefits crops. Chemical characteristics and decomposition patterns of six multipurpose tree species, viz. *Alnus nepalensis*, *Albizzia lebbek*, *Boehmeria rugulosa*, *Dalbergia sissoo*, *Ficus glomerata* and *F. roxburghii* in a mixed plantation established on an abandoned agricultural land at 1200 m altitude in Central Himalaya gave the highest rates of N and P release during the rainy season. Thus, *kharif* crops (rainy-season crops) have high nutrients even if leaf litter is the sole source of nutrients to crops in mixed agroforestry. A diverse multipurpose tree community provides diverse products as well as stable nutrient cycling (Kerkhoff, 2003).

The leaf litters enrich the soil fertility by providing organic matters. Trees leaves control the speed of the raindrops and allow them to go down to the land surface slowly. It helps water to infiltrate into lower part of the soil surface. After the soil is saturated, plants growing on it can utilize the excess water. The excess water is leached to the inner part of soil and supports to originate natural well and streams in the lower areas. It also makes the water table high. Such natural conditions will be favorable for growth of plants and micro-organisms in the soil (Pandey, 2007).

Although trees are expected to improve soil fertility, the extent to which different agroforestry practices depend on tree species, stocking level, growth rate and the input of litter. Achieving synchrony in nutrient release through organic matter turnover is yet another challenging task. This calls for proper selection of tree species, which requires a thorough understanding of the rates and patterns of decomposition and nutrient release (Kafle, 1995).

Reclamation of degraded farmland through agroforestry

Agroforestry approaches are appropriate to the needs of low resource farmers with physical and socioeconomic constraints. In this regard, Government policies for agricultural, forest land such as per family land holding ceiling, land categorization and taxation based on the land types have to be focused. Stall feeding system will be emphasized. Terrace farming in the hills will be emphasized to reduce the soil loss. Program should be launched with close coordination with farmers or users group in every stage. It should be give attention on balance of land degradation and restoration rates to break further land degradation. Community forestry, private plantation and leasehold forestry concepts are to be implemented effectively in order to reduce human pressure on natural forests. In addition, various alternative methods such as contour farming, strip and alley cropping, and gully improvement activities are to be practiced. More emphasis should be given on formal and non-formal environmental education (Swallow and Ochola, 2006).

CONCLUSION

The land degradation problem is increasingly becoming a challenge for the economy and natural ecosystems in Nepal. The major causes of land degradation are fragile geological structure, forest fire, avalanches, landslides in the hills, river-damaged areas, deforestation, excessive use of chemical fertilizers, overgrazing and unscientific farming in steep slope, flooding in the plain areas, and shifting cultivation in the mountains. About 45.5%, 4%, and 2% area of the country are affected by water erosion; wind erosion; and chemical and physical processes respectively. It is realized that the balance between the land degradation and restoration rates should be maintained so as not to further degrade the land .Forest and tree cover is declining at alarming rates in Nepal. As a result, essential source of food, fuel, shelter, fodder, medicines, and many other products are disappearing, and the soil and water base for food production is being degraded. Agroforestry, association of trees and shrubs with crops, livestock or other factors of agricultural production, holds great promise for contributing to sustainable land–use systems which can overcome the problem of land degradation and the imminent “food crisis”. It provides diversified production and consequently greater food diversity. Agroforestry practices are implicitly assumed to have higher productivity than mono-specific systems, especially on degraded sites. The potential contribution of agroforestry can be effective if farmers and local communities are fully involved in its planning, development and implementation phase.

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OPPORTUNITY AND CHALLENGE OF ORGANIC CERTIFICATION SYSTEM IN NEPAL

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ABSTRACT

The demand for organic certification is gradually increasing in Nepal although it is in early stage. Organic certification is a written assurance given by an independent third party about the production methodology and quality of products to confirm special requirements. Certification brings opportunities for protection of local resources, better market access, improvement of worker and consumer health, and eventually enhancement of living conditions of rural communities.

The demanding nature of regulatory requirements makes it difficult as well as expensive for local certification initiatives in developing markets to establish themselves to offer export certification. Certification cost, limited awareness of group certification, small and medium-sized farms and inadequate understanding of how organic certification works are some of the constraints for organic certification. Certification Alliance (Cert All), a regional collaboration in certification representing national and international organic certification bodies, addresses the aforementioned challenges. The alliance has recognized the value of collaborating instead of competing. Organic Certification Nepal (OCN), a part of Cert All, offers an internationally accredited inspection and certification service to local operators at a reasonable cost. This paper highlights certification process followed by OCN and potential challenges and opportunities it will likely face.

Key words: Organic Agriculture, Standards, Inspection, Certification, Harmonization

INTRODUCTION

Organic agriculture is still in the early stages in Nepal. The importance of organic agriculture is being realized not only by farmers who have been using chemical fertilizer and pesticides for the last four decades but also by the policy makers, intellectuals and sensitive citizens after observing the deteriorating situation in the agriculture sector. The continuously increasing price of chemicals (fertilizers, pesticides, etc.) is another important factor for farmers looking for alternatives in order to sustain their farm productivity and livelihoods.

Organic agriculture is a production method which manages the farm and its environment as a single system. It utilizes both traditional and scientific knowledge to enhance the health of agro-ecosystem in which the farm operates. Organic farms rely on the use of local natural resources and the management of the ecosystem rather than external agricultural inputs such as mineral fertilizer and agrochemicals. Organic agriculture, therefore, prohibits synthetic chemicals and genetically modified inputs. It promotes sustainable traditional farming practices that maintain soil fertility.

OBJECTIVES

The major objectives of this paper are as follows:

- To provide information on processes needed, opportunities and challenges for organic certification in Nepal.

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- To inform about national initiatives for the establishment of organic certification body in Nepal.
- To highlight the initiation of regional collaboration in organic certification.

WHAT IS ORGANIC CERTIFICATION?

Organic certification is a procedure by which an independent third party gives a written assurance that a clearly identified process has been methodically assessed to provide adequate confidence for specified products and specified requirements. A certificate is a written guarantee issued by an independent certification agency and it officially states that the production processes or product complies with certain standards.

Certification is used to demonstrate that a product has been produced in a certain way or has certain characteristics complying with a clearly-defined standard. It is mainly used when the producer and the consumer are not in direct contact, for instance in international markets where consumers cannot be easily assured of the quality of a product or its production process, because they never see how and where the products are prepared.

Organic certification requires inspections of the operators (producer/ processor/handler). The purpose of the inspection is to verify that the required conditions are in place to meet the certifying agency's certification criteria or standards. Certification includes inspection of farm fields and processing facilities. Inspections of farm practices include long term soil management, buffering between organic farms and any neighboring conventional farms, product labeling, and record keeping.

CERTIFICATION PROCESS

Operators applying for organic certification begin by finding a certifying agency. Once the operator chooses an appropriate certification agency, an application package and organic management plan are submitted to the certifying agency. Organic management plans provide a detailed record of all operational practices, methods of farming or handling; the use of substances like fertilizers and pesticides, invoices, breeding records, ledgers, tax returns, and purchase orders.

After the certifying agency reviews the application package and the organic management plan, it inspects the farm and/or facility. Inspectors review fields, equipment, buildings, neighboring land, records of management practices, seed sources, harvesting methods, storage, composting, transportation, and sales practices. The inspector and applicant complete and sign an affidavit before submitting it to the certifier.

A certifying agent or committee reviews the application, organic system plan and the results of the initial inspection.

There are three outcomes to the review process. If approved, the applicant can begin marketing products as organic and may use the organic seal. An applicant with minor discrepancies may be flagged for non-compliance and must address issues or provide additional information before certification. If an applicant has violated standards that cannot be addressed in the short-term, say they haven't upheld organic farming practices, the application is denied.

OPPORTUNITIES

Certification brings opportunities for protection of local resources, better market access, improvement of worker and consumer health, and eventually enhancement of living conditions of rural communities. Consumers are increasingly aware of social and environmental problems associated with the production and trade of the food they consume. They want assurance about the quality of the produce they purchase and trust only an independent legal body for the information tagged on the produces. In response to these concerns, private organizations or governments have developed different types of the certification programs.

Certification can help differentiate the preferred organic products from other products, which can be helpful to promote organically grown products in the market. Certification can also result in higher producer prices as consumers are willing to pay higher price for quality products. Organic products thus can raise income of producers and improve the quality of life.

With the increasing population in cities and towns, emergence of an urban middle-class and the growth of supermarkets, national markets for quality products are growing strongly. Producers are also becoming increasingly interested in organic agriculture. Producers shift to organic agriculture for a verity of reasons. Some feel that the use of agrochemicals is bad for their health and the environment, while other producers are attracted by the higher price and the rapidly growing market for many organic products in recent years.

Converting to organic agriculture can be easier and more profitable for producers than conventional agriculture because of the following:

- The availability of local recourses and bio-mass to make organic fertilizers
- The low intensity of agrochemical products used
- The availability of and access to labour (as organic production often demands more labour).

CHALLENGES

Organic production takes place under different conditions and norms (private standards as well as regulations). Due to the lack of recognition by both government and non-government institutions, certification of international organic product chains has become a complicated and costly service for producer and consumers.

The demanding nature of regulatory requirements makes certification more difficult as well as expensive, especially in developing markets and for export certification. It is hard for local certification bodies to compete with international certification bodies (CBs) in export certification. Local CBs however offer advantages as a service partner to international CBs due to local presence, familiarity of inspectors with local production methods and growing conditions, fluency of staff in local language, and political support for a local business. International CBs have the possibility of extending their service at competitive rates in the region where they work through collaboration with local CBs. And local CBs can link themselves as part of a service network to offer a one-stop certification service for exports to local operators.

Whilst most local CBs in developing markets cannot realistically grow into global companies even in the medium term, they may offer enough local advantage to maintain independence as members of an international alliance. Development of service networks, where big and small CBs can collaborate productively, can increase the development and mainstreaming of the organic sector worldwide.

It should nevertheless be noted that collaboration between service organizations in a competitive environment is also about developing strategic relationships to enhance competitive advantage; CBs cannot expect to be partners in more than one similar service network.

Beside regulatory requirements, there are other constraints for organic certification. Some of them are:

- Expensive certification cost
- Limited awareness of group certification among small & medium farmers
- Small and medium-sized Nepalese organic producers are not able to access international markets
- Inadequate understanding of how organic certification works: Organic certification is a 'production process certification' as opposed to a 'product certification'. Therefore organic certification is a process and not an instant action
- Inadequate technical capacity to develop certifiable production operations
- Increasing number of new regulations

INITIATION OF REGIONAL COLLABORATION IN CERTIFICATION

Certification Alliance (Cert All) is a regional collaboration in certification representing national and international organic certification bodies, inspectors, producers and development organizations supporting organic movements in the region. While several stakeholders are involved in the process, the alliance has recognized the value of collaborating among them instead of competing. The Certification Alliance represents the commitment of the partner organizations to develop procedures as a certification service network with the aim of offering a low cost one-stop service for organic producers seeking international certification for organic products in the Asia region and elsewhere.

A one-stop service means organic operators can register with a service unit that can facilitate multiple certifications as required for access to European and North American markets as well as within Asia. Collaboration also offers an opportunity for participating partner organizations to mutually share, learn and build competency in inspection and certification, enhancing each other's service performance to secure integrity in the organic supply chain in the interest of producers, the trade and consumers.

The aims and objectives of the Certification Alliance are:

- To facilitate certification required by operators for export markets through Partner Organizations in the countries and regions where they operate.
- To operate a common export inspection service for all Partner Organizations as well as other certification bodies operating in the Asia region and elsewhere.
- To coordinate promotion and marketing of specified inspection and certification services of Partner organizations developed under this agreement.
- To facilitate mutual recognition of certification between Partner Organizations.

- To facilitate institutional and competency development of Partner Organizations in organic and related inspection and certification services.
- To facilitate knowledge of and market confidence in products certified by Partner Organizations under this agreement in suitable markets.

Organic Certification Nepal (OCN) is one of the founder members of Certification Alliance (Cert All). Being part of Cert All, OCN offers an internationally accredited inspection and certification services to local clients and operators.

CONCLUSION

Importance of Organic certification is increasing gradually as organic agriculture is getting attention from development stakeholders in Nepal. Nevertheless, there are several challenges and constraints ahead. In order to overcome these challenges, investment in the organic sector is needed. Similarly, the growing divergence in standards and regulations is a threat to the development of this sector. Harmonization has now become a necessity for fostering organic certification and it needs to be saved from self destruction. Many actors including government organizations, NGOs, private sector and farmers should be involved in different steps of organic agriculture promotion and certification. All these efforts from several stakeholders would provide a strong backing in the days to come for the further institutionalization of organic certification in Nepal.

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NUCLEAR AND RELATED TECHNIQUES FOR ENHANCING LIVESTOCK AND AGRICULTURE PRODUCTIVITY

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ABSTRACT

Uses of isotopes and nuclear related techniques in livestock and agriculture are discussed in this review. How developed countries are using (^{125}I) in radioimmunoassay (RIA) of progesterone hormone in serum/milk of cattle to optimize reproductive efficiency is briefly described. In addition, this paper discusses about the uses of (^{15}N) in soil to know the dynamics of nitrogen and uses of Hydro Probe to determine moisture content in the soil. This review will also shed some light on the potential uses of isotopes and nuclear techniques and the necessity of such technology in Nepal for improving overall agricultural productivity.

Key words: Radioimmunoassay, progesterone, productivity, reproductive efficiency

INTRODUCTION

Developed countries have been enjoying the benefits of nuclear and related technologies for enhancing animal productivity and health since last 2-3 decades whereas countries like Nepal is yet to realize their importance for augmenting ever increasing demand of agricultural and livestock products to feed exploding population growth. As of February 2009, 146 countries have become the Member States of International Atomic Energy Agency (IAEA), the United Nations' regulatory body for the peaceful uses of atomic energy in the world (IAEA, 2009). The neighboring countries, India and Pakistan which are also members South Asian Association for Regional Cooperation (SAARC) became the Member States of IAEA five decades ago during 1957 while another neighbor, Bangladesh received the membership in 1972 that has similar economy like ours. Sri Lanka and Afghanistan also became member states of IAEA long time ago. Most of our neighbors have been exploiting nuclear technologies for peaceful uses in the diverse fields such as agriculture, animal production and health, disease diagnosis and cancer therapy. Nepal is unable to exploit the multiple usages of nuclear technologies except in the medical field for diagnostic imaging with x-rays and cancer therapy. The vast agrarian Nepalese economy has yet to exploit nuclear technologies and enjoy their fruition.

Remarkable improvements in livestock productivity in the developed countries have achieved through research into how animals grow and how yields can be influenced and protected, followed by the widespread uptake of new techniques and materials. Many of the advances in improving the feeding, fertility and health of livestock have been possible with use of nuclear techniques. Biological processes responsible for growth, reproduction and disease resistance in different farm animals are manipulated for greater productivity through the use of radioisotopes (Dargie, 1990).

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The impact of isotopic methods in the development of feeding strategies for farm animals has been very heavy. Animal nutritionists establish the nutritional value of all the materials potentially available to feed animals through tracer techniques by tagging feed constituents, amino acids and other metabolites with isotopes such as ^{14}C, ^{125}I, ^{51}Cr, and ^{15}N. With tracer technique, the fate of the feed constituents, amino acids and metabolites can be followed within the digestive system and other parts of the body. Isotopic methods have developed the modern nutritional concepts and the adoption of these concepts has increased the rates of growth and yields of milk and meat besides improving the quality (Dargie, 1990). The following table gives an insight about the production trend of livestock products in developed and developing countries.

Table1.Comparative performance of cows in developing and developed countries (Dargie, 1990)

	Developing countries	Developed countries
Milk yield/cow	300 litres	5000 litres
Calf crop	In every 2-3 years	Annually

USES OF RADIOIMMUNOASSAY (RIA) FOR IMPROVING ANIMAL REPRODUCTION

Before 1960, bioassays were used for hormonal assays but since last three decades, RIA kits have been used to assay small ligands like tyrosine, progesterone and cortisol. Highly sensitive RIA using ^{125}I or ^{3}H has been developed and used to measure the minute quantities of reproductive and other hormones circulating in the blood that control reproduction. RIA of progesterone (P_4) has been essential to the development of the present day highly efficient breeding practices that go in hand with better feeding to increase productivity. RIA has made it possible to determine when animals are ready for breeding, diagnose pregnancy earlier than would be otherwise possible, check whether animals have been inseminated at the correct time, devise corrective measures for reproductive disorders and improve the efficiency of artificial insemination and embryo transfer programs (Dargie, 1990).

Although widely used in many laboratories in developed countries, RIA technology has not been transferred to many countries in the third world. Still many countries of the developing world have not gained membership of IAEA and Nepal being a new member has to fulfill financial obligation before making her eligible for getting technical projects in the diverse areas of agricultural and medical sciences. Moreover, the short life of RIA kit reagents is one of the major problems besides the problems associated with the cost and the regular supply of kits overseas. Handling of radiochemical and the subsequent disposal of radioactive waste is another problem. Although single channel readers are relatively inexpensive, the time taken to read large numbers of samples precludes their use for large-scale epidemiological surveys. The larger automated gamma counters are prohibitively expensive and difficult to maintain under local conditions. The health hazard of inexperienced staff handling radiochemical must also not be overlooked (FAO/IAEA, 1993).

In recent years, livestock productivity has been increased by improved reproduction. Excepting few leading farmers in Nepal, majority of the farmers are waiting till full term pregnancy (9-10 months period) after mating on the pretext of being pregnant without opting for pregnancy diagnosis. But when the animal fails to calve at the end of full term pregnancy, farmers are losing a lot and despite of that they seem least concerned and unaware of economic losses incurred for rearing the unproductive animal. By adopting a simple technique of assaying blood/milk progesterone (P_4) at 24 days after mating, one could find out whether the animal is non-pregnant or not. Once the farmer knows that his/her animal non pregnant, he/she can go for immediate re-mating in the subsequent cycle (Dargie, 1990) days oestrus cycle) without wasting time and money. In this way, reproductive efficiency can be optimized. Besides, P_4 assay will help to monitor the state of pregnancy as its low level in already pregnant level may warrant exogenous administration in case of threatened abortion. Likewise, repeat breeders can also be monitored with P_4 assay (FAO/IAEA, 1993)..

USE OF NUCLEAR TECHNIQUES (DNA PROBES) IN ANIMAL HEALTH:

Conventional approaches of disease diagnosis involving isolation and direct detection of microorganism by microscopy and immunoassay usually take long time while nucleic acid hybridization techniques are very promising in terms of time and sensitivity. This hybridization technique is unique as it focuses on the genome of the organism and not its products, viz., the proteins. Most common label used in DNA probe technology is a radioactive one (^{32}P, ^{35}P, ^{125}I) incorporated directly into the nucleic acid by one of the several techniques available. After hybridization, the duplex (probe-target) is detected by liquid scintillation counting or by auto-radiography. This technology is very sensitive. However, major drawbacks are short half-life of the radioisotopes (14 days for ^{32}P), requiring frequent preparation of new probes, and requirement for special equipment for handling and storage of radioactive products and health risks inherent in the use of isotopes (Dargie, 1990). Recently, Technetium 99m is routinely used for diagnosing hyperthyroidism in dog and cats, cases of chronic lameness in horses and portosystemic shunt in liver. The most common indication for bones scan is lameness that cannot be localized by physical examination, survey radiographs or ultrasound scan. "Hot spots" are areas of increased bone remodeling activity produced by neoplasia, infection or trauma (Lavin, 1999).

Nuclear techniques have played the vital role in the field of animal health. Ionizing irradiation from ^{60}Co or X-ray sources have been used to eliminate the virulence of some parasites to produce safer and cost effective vaccines. In UK alone, the commercial use of an irradiated vaccine against lungworm disease in calves saves livestock producers over US $10 million each year (Dargie, 1990). Radioactive Iodine (^{131}I) is most valuable for treating small functional nodules of metastatic disease that are hard to find or treat surgically. Radiation therapy in dog and cat is given mainly for the treatment of primary brain tumors (total dose 45 Gy in 3.75 Gy fractions over 28 days) (Lavin, 1999).

Nuclear and related techniques make an important contribution to efforts to improve livestock productivity and food security through better management of feed resources, reproduction and control of diseases (FAO/IAEA, 2008).

USES OF RADIOISOTOPES IN METABOLIC STUDIES:

Radioactive amino acids can be used for metabolic labeling of tissue culture cells. Most commonly used radioactive precursors for labeling protein is (^{35}S) Methionine because its decay is easier to detect and it is easily incorporated into protein and its incorporation is linear over a wide range of added label. Other amino acid labels used are: (^{3}H) Proline, (^{35}S) Cysteine and (^{3}H) Leucine (IVRI, 2001).

MISCELLANEOUS USES OF RADIOISOTOPES:

Commercial manufactures sterilize surgical sutures, syringes, cotton wool, gauzes and different biomaterials used in patients by ^{60}Co (IAEA, 2009). Besides, for characterization of chemical ingredients ^{1}H-NMR and Solid State ^{13}C-NMR are often used.

USES OF RADIOISOTOPES FOR FOOD SAFETY:

In many countries, health and safety authorities have approved irradiation of more than 40 different foods, e.g., spices, grains, chickens, fruits and vegetables based on the standard adopted by the Codex Alimentarius Commission, a joint body of FAO/WHO. The irradiation is ideally suitable for foods of animal origin, especially those to be consumed raw or minimally processed (FAO/IAEA, 2008). Irradiated food commodity presents no toxicological hazards and requires no further testing since it introduced no special nutritional or microbiological problems in foods. The presence of potentially harmful substances in meat and other food products can also be monitored using RIA to safeguard their quality.

OTHER USES OF RADIOISOTOPES IN AGRICULTURE:

In developed countries, nuclear related technologies are being used routinely for studying soil fertility, plant breeding, plant mutation, crop production, insect and pest control, animal production and disease diagnosis. Multifaceted uses of radioisotopes in agricultural sciences include (FAO/IAEA, 2008):

a) Soil science: To optimize the use of soil resources (nutrients and water), to increase crop productivity and to optimize the impact on the environment of the excessive use of fertilizers. ^{15}N is used to quantify the amount of biologically fixed nitrogen in field grown legumes and also to know the dynamics of ^{15}N applied to soil for crop production. An accurate measurement of soil moisture content using nuclear (soil moisture neutron probe) is essential for establishing the optimal soil-water balance for irrigation scheduling under different irrigation systems and soil management practices.
b) Plant breeding: Radiation can be used to induce mutations and generate genetic variation from which desired mutants with improved agronomic traits are selected. In addition, seed can be irradiated using nuclear techniques. This contributes to the intensification of food production and the achievement of food security.
c) Entomology: The sterile insect technique (SIT) is based on the mass rearing and release of male insects, which has been sexually sterilized (infertile) by radiation. At mating, they cannot fertilize the females and no progeny is produced. This technique eventually leads to the control or eradication of insect pests of major crops and insect vectors of diseases with a substantial reduction in the use of insecticides. In Africa, SIT has been found promising in the control of the fruit fly causing damage to more than 200 varieties of fruits and vegetables, and the tsetse fly, the vector of trypanosomiasis.
d) Agrochemicals: Farm to fork approach to food safety is promoted through analytical methodologies for detecting contaminants such as mycotoxins, pesticides and veterinary drugs in food and environmental samples.

CONCLUSIONS:

Although Nepal is far behind the developed countries in terms of food security, she has to start from the scratch with no further delay in exploiting the nuclear and related technologies to enhance food and animal productivity for meeting the ever increasing demand of food security.

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MICROBIAL CONTROL OF WHITE GRUBS IN NEPAL: THE WAY FORWARD

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ABSTRACT

Nepalese economy is largely dependent on agriculture. Over the time, there has been gradual transformation in the agricultural production system and the hitherto dominant chemical based agricultural system has been gradually changing with the latest aspects of bio-rational approaches. Emphasis towards these aspects has been seen both in the governmental and non-governmental level through their commitments in long term prospective plans. However, there is long way to go towards bio-rational approach of pest control in Nepal. This aspect is newer concept in case of Nepal

Institute of Agriculture and Animal Science (IAAS), Department of Entomology, Rampur, in support of Helvetas had initiated bio-pesticides production. The major effort was the production and use of bio-pesticide based on fungal pathogen (*Metarhizium anisopliae* Sorokin) against white grubs in particular and soil insect in general. The research was carried out for about a decade and results so far indicated the ample scope of producing and using this agent against this dreaded pest. The research results so far obtained are at get set position, however, to gear up the further works, it has been felt that joint efforts from possible counterparts such as Nepal Agricultural Research Council (NARC), IAAS, Department Of Agriculture (DOA), private organisations, NGOs and INGOs would be vital. It has been realised to form national working groups for the development of microbial pest control. Major lead should be taken by national organisations in full support of private organisations. This paper has been brought forth in order to bring into the information of the works so far done in Nepal and to arouse the interest among the possible counterparts, producers, consumers, planners, and policy makers.

Key words: Bio-rational compounds, Bio-pesticides, IPM, *Metarhizium anisopliae,* white grubs

BACKGROUND

With increasing population pressure, the need for the adoption of improved technologies has been widely realised at all levels (planners to rural farmers). Use of new technologies has increased crop intensities, and has lead to the adoption of high yielding varieties and high chemical input (fertilisers and pesticides). These practices have lead not only to increased production and productivity and greater monetary returns to the farmers but also invited severe problems such as insect pests to an extent never faced in the past. Losses due to insect pests is regarded one of the important production constraints of the major crop produce. Several dozens of pest involve in crop damages. Some of them have gained nationally important pests notably, *Helicoverpa,* white grubs (many species of Coleopteran beetles within the Scarabaeidae family), aphids *(Aphis* sp), white fly (*Bemisia tabaci),* caterpillar pests (mainly moth larvae) depending on the season and locality. Field reports from various sources indicate that white grubs are among the most difficult soil pest insects to control in cash crops (e.g. vegetable, potato or ginger) and food crops (e.g. maize, millet, etc.) grown in upland areas. Collaborating institutes of the Sustainable Soil Management Programme (SSMP/ Helvetas-Nepal), IAAS, Rampur and several other organisations have reported white grubs as a major limiting factor affecting soil productivity. They were, for

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example, causing an average of about 25% yield loss in groundnut (*Arachis hypogea)* in Baitadi (far western Nepal) district, 30% losses of finger millet in Parbat (western Nepal) district (personal communication with farmers and field observation) and up to 50% losses in maize and millet in Sindhupalchowk district. Similarly, they are reported to be an increasing nuisance in several other crops such as cereals, vegetables and cash crops from eastern to western parts of Nepal as reported by Government organisations and several INGOs/ NGOs. Despite of the increasing pest problem, their systematic control initiative involving quantification of losses, identification of most damaging species, pest biology and eco-friendly control measures has not yet been implemented countrywide. However, research results conducted by IAAS, Rampur in different parts of the country has indicated ample opportunity for controlling white grubs using fungus based (*Metarhizium anisopliae)* microbial control agent. In addition to the research results of Nepal, the scopes of the work have been greatly supported by the research results conducted in European conditions mainly Switzerland and other central European countries. Moreover, this is not harmful to the human beings and useful organism rather it is environmentally benign approach which should replace or reduce the input of chemical pesticides in Nepalese agriculture.

CURRENT MEASURES OF WHITE GRUBS CONTROL

Because of the lack of eco-friendly control measures such as biological control, insecticides are only the readily available and dominant means of white grub control in Nepal. This situation is mainly due to poorly developed infrastructure coupled with lack of trained manpower and pesticide oriented pest control methods prevailing in the country. In addition, alternative pest control measures that are compatible with existing farmers practices are not readily available in the country which has also accelerated into the reliance on pesticides. These situations have compelled to the farmers for using highly persistent and ecologically destructive pesticides. In recent years, pesticide use in Nepal has increased several folds, and this trend is likely to continue and even accelerate in the near future. The area along the open and porous border with India where agrochemical production is growing without much quality control is particularly vulnerable. In some instances banned insecticide such as BHC (class II, moderately hazardous, banned in 28 countries) followed by metacid (class 1a, extremely hazardous, banned in five countries) are still been used in some areas (Dahal, 1995).

The most commonly used insecticides in Nepal include BHC- dust, Aldrine and Endosulphane and several other poor graded chemical pesticides. Highly hazardous chemical like Phorate (Thimet) is still been used against soil insects without considering their residual effect inside the soil and likely hazardous effects to the non target organisms. In a farmer's field survey in Parbat district, farmers also use some fungicides aiming to control white grubs because of the confusion between fungicides and insecticides. Moreover, they treat such chemicals indiscriminately and very inappropriately which has a very damaging effect on the water bodies as well as to the beneficial micro-organisms inside the soil environment. Farmers have popular misconception that pesticides are though out as "medicines" to kill pests but not as "poison" that also affects other living organisms. Because of this, farmers first attempt to use highly poisonous compounds rather than seeking moderate group of chemicals in the beginning. Their search on other biorational compounds is very far. Hazards due to pesticide related problems are increasing at many levels and are very common when attempting to control soil insect pests.

Neither traders nor the users are well aware in the aspect of safe handling of chemical compounds and it is rather haphazard in case of soil pest control. Soil is the major habitat for useful as well as harmful organisms. It is not uncommon of using obsolete pesticide in Nepal because the lack of mechanisms of strict regulation on pesticide uses. In some vegetable growing of Nepal, hazards related to pesticide use has becoming serious threat than the pest incurred losses themselves. Some of the issues related to appropriate choices of the pesticide, their formulation, application, and consideration for waiting period are seldom considered. As a means of soil pest control, farmer use some of the dreaded chemicals without considering pest biology, residual effect of pesticides in the soil environment and on the health of the consumers. These factors have led researchers to focus on the development of alternative control measures of pesticides. The best possible alternative would be the use of microbial pest control based on insect killing fungus within the genera of *Metarhizium anisopliae* and *Beauveria bassiana* (G. C. *et al.*, 2006). Similarly, other options would be insect parasitic nematodes within the genera of *Steinernematids* and *Heterorhabditis* (G. C., 1998). Search on other control agents such as protozoa (*Nosema locusta)* are underway in some of the developed agriculture. However, in our context, use of further groups of biocontrol agent such insect killing fungus would be possible.

POTENTIAL ALTERNATIVES TO WHITE GRUBS AND OTHER SOIL INSECT CONTROL

Use of indigenous fungal pathogens in the genera *Metarhizium* and *Beauveria* are excellent candidates for the control of white grubs. Beside this insect, they are reported to be useful against red ants (*Dorylus orientalis),* cut worm (*Agrotis segetum)* etc. Use of *Metarhizium* commercially available as “Green Muscle” has long been practiced in Africa against locust and grasshoppers. Microbial control has been a component of integrated pest management (IPM) strategies in developing country for many years, enjoying particular success in Asia and South America, although successful approach for microbial control have evolved worldwide (Fx, 1949). Similarly, *Metarhizium* and *Beauveria* based mycopesticides are successfully used in Switzerland and some other European countries, where health consideration are more rigorous. Suitability of these agents to control white grubs is also reported in India by a number of scientists. An attribute making the fungi as ideal biological insecticide is due to broad host range, high virulence, safety for non-target organisms, compatibility with some pesticides, ease of production with local materials and application without using costly equipments.

M. anisopliae is well known for its ability to control pest insects. It has been developed into commercial products for use in several countries, especially in USA, New Zealand, Brazil, Cuba, and Africa and to some extent in Germany, Switzerland, and Austria. A few examples include Bio-Green and Bio-cane granules for control of soil pests of pasture and sugar cane in Australia, Green Muscle for control of locusts in Africa, Ago Bio-control of various pests of ornamental crops in South America, and Bio-Path for control of cockroaches in the United States. In general, different strains of *M. anisopliae* are species specific. While this limits its use as a general pest control, it makes the fungus safer by limiting its effects on non-target organisms. Moreover, the research history of *M. anisopliae* against soil pests is sparse and successful in developed countries where the health consciousnesses are higher. However, it is entirely a unique approach in Nepal.

WHY FUNGUS BASED MICROBIAL CONTROL IN NEPAL?

Use of fungal pathogen, *Metarhizium anisopliae* is an appealing alternative and established practice against white grubs control in some of the developed agriculture including in Switzerland. Significance advances on the production and application of *Metarhizium* based bio-pesticide is done in some European and American countries, where health consideration is more rigorous (Zimmermann, 1993). Progresses are also continued in India and other Asian countries (Despande and Tour, 2003). Commercially product of *Metarhizium* "Green Muscle" has long been practiced in Africa against locust and grasshoppers (Prior *et al.,* 1992). Control of European cockchafer, *Melolontha melolontha* is a long established practice in Swiss meadow and farmland. It has been used with good success in grassland and orchards for many years. In the earlier days, swarm of *M. melolontha* was targeted with blastospores which subsequently would carryout the disease to the breeding sites of swarming beetles. This method was extensively tested in the north-eastern Switzerland as pilot trials during 1976 and 1982 with a tractor-pulled mist blower followed by large field trials in 1985 and in 1988 with a helicopter (Keller *et al.,* 2000; 1998). Keller *et al.* (2003) reported that sufficient control was achieved to avoid the damage by white grubs. Following application the fungus grows and sporulates on the kernels and the larvae gets into contact during their movement.

In Nepal, microbial control is entirely a new approach however, attribute making the fungi as ideal biological insecticide is due to broad host range, high virulence, safety to non-target organisms, compatibility with some pesticides, ease of production with local materials and application without using costly equipments (Cisneros, 1984; Moutia, 1936). The prime objective of microbial control in Nepal would be to reduce the indiscriminate use of chemical pesticides and bring down the pest population in a sustainable means so as to increase the farm income. These biopesticides are the major tools for producing organic produce as the country has been the member of World Trade Organisation (WTO), and it has adopted sanitary measures. Biopesticide can be used for producing valuable commodities like organic tea, honey, coffee, pulses and many other crops. There is ample scope of making foreign income by exporting these materials.

Initiatives towards microbial control in Nepal are almost in embryonic stages. However, the studies carried out for about a decade in IAAS, Rampur in several fields in Nepal has shown great promise (G.C. and Keller, 2003; G. C. *et. al*., 2006). Studies of the production and utilisation of fungal based microbial agents should be prioritised with the involvement of different organisations in Nepal. Working with biopesticides can be done with joint efforts of likely counterparts from national research institutes such as NARC, IAAS, Nepal Academy of Science and Technology (NAST), etc. and development and extension organizations such as DOA, other governmental and non-governmental organizations, private organization, etc. It is highly important to form a national working group team and develop the infrastructures in the appropriate places. Establishment and strengthening of laboratory facilities are necessary to gear up the work. With a defined set of terms of references (TOR), each stakeholder may contribute in their respective roles and responsibilities. At the same time, it is highly important to support with the human and financial resources.

HOW MICROBIAL CONTROL OF WHITE GRUB WAS INITIATED IN NEPAL?

The overall modality of the study was with three tiers approach: the search of the insect pathogens in the natural environment in Nepal, laboratory screening, tests and knowledge on their handling and field tests of the fungus to devise the microbial control. This study had two components, the study about the hosts' insect, the white grubs and its fungus, *Metarhizium anisopliae*. Systematic work such as identification of the soil fungus and noxious species of white grubs with its biology, production and application of *M. anisopliae* for white grubs control are being planned in collaboration with the University of Basel, Switzerland and IAAS, Nepal. Additionally, research and extension counterparts are involved through the network of working group concept of the 'bio-control of white grubs' project'. Similarly, some of the related research works, such as the effect of insect pathogens on the non-target beneficial organisms are being addressed by the M. Sc. students of IAAS, Rampur. Besides, *M. anisopliae* another insect pathogenic fungi able to cause white muscardine diseases in the insect, *Beauveria bassiana,* is also been maintained at IAAS.

WHAT HAS BEEN ACHIEVED SO FAR?

Until the mid of 2003 no work had been initiated on insect pathogenic fungi in Nepal. However, biological control research financed by Helvetas-Switzerland and initiated by the IAAS, Rampur in collaboration with Federal Research Station for Agriculture and Agroecolgy (FAL) and University of Basel, Switzerland indicated a high potential for biological control with insect pathogens, *Metarhizium anisopliae,* in Nepal. The research was prompted by the serendipitous discovery of *M. anisopliae* (in case of Nepal) infected white grubs during the exploratory study at IAAS, Rampur in 2002. The indigenous species of *Metarhizium anisopliae* was identified by Dr. Siegfied Keller, scientist, FAL, Switzerland and damaging species of white grubs by Prof. Dr. Peter Nagel, Basel University, Switzerland. Efficacy of indigenous pathogens and foundation work were conducted during the exploratory study.

Immediately following the initial discovery of the insect fungus *M. anisopliae* in Nepal, series of experiments were initiated since the beginning of 2003. Harvesting of the new isolates of insect fungus was conducted from the soil and insects body cadavers. They were isolated, re-isolated and maintained in the semi selective medium comprised with peptone, agar-agar, glucose, streptomycin, tetracycline, cyclohexamide and dodine. Regular host passage was performed in the original hosts in order to maintain the virulence of the isolates. Preliminary screening of the fungus isolates was carried out from the time and dose related bioassays. Identification of virulent strains of the fungus followed by mass production into suitable substrate, peeled barley kernels. Field releases were done in three different cropping patterns in lower altitude (Chitwan and Nawalparasi), mid altitudes (Tanahun) and high altitude (Sindhupalchowk). Preliminary results were encouraging towards the goal of the study.

Laboratory facility has been established in IAAS, Rampur at the premises of Entomology Department. In order to produce the fungus in larger scale, it is necessary to up grade or establish the similar facilities in the private organisation. Similarly, present method of production into barley kernels seems somehow tedious and expensive because of the barley substrate. Also, it is bulky in transportation and may require higher doses to a limited area of experimentation. Therefore, the production method may be adopted into different formulation such as dust and liquid. This later method may allow the access for applying the fungus against different target pests such as aerial feeding as well as soil hibernating etc. For this it is important to establish the link with the likely partner organisations that are active in the country and also at the international level.

LESSONS LEARNT FROM SWISS AGRICULTURE RESEARCH

Swiss Development Co-operation (SDC), HELVETAS, Sustainable Soil Management Programme-Nepal (SSMP-N) are some of the Swiss Government funding organisations in Nepal. Since its inception, SSMP-N, has demonstrated greater success in improving the production and productivity of the hill farms through the improvement of soil health especially in upland agriculture in Nepal. Within the framework of the soil health improvement programme, it has emphasised the eco-friendly control of soil inhabiting pests such as white grubs, red ants, termites, etc. Considering these facts, an exploratory study on microbial control of white grubs was initiated by IAAS, Rampur, Nepal with the encouragement and financial support of SSMP. Technical backstopping for the study has been provided by Agroscope Federal Research Station for Agriculture and Agroecology (FAL), Reckenloz, Zurich, Switzerland. The foundation work so far done in IAAS, Rampur could be inspiring sources for Nepal where further activities can be geared up.

Use of insect pathogenic fungi as a means to control *Melolontha melolontha* (Coleopter: Scarabaeidae) is a long established practice in Swiss farming. *Metarhizium anisopliae* and *Beauveria bassiana* based mycopesticides have been used with good success to control the white grubs prevalent in the meadows. Long term experimentation are been carried out in controlling *Melolontha* and *Hoplia* species of white grubs in the grazing and cultivation area in Switzerland. In the long term experimentation plots, the initial dose of the fungus has been significantly reduced, which has saved labour as well as capital resources. Efficacy of mycopesticides and economics of production have been verified over the years in number of developed countries. In addition, the demand for microbial pesticides is globally increasing because of the health consciousness of the bio-product consumers. Therefore, this idea was considered worthy to explore the use of *M. anisopliae* as a potential biological control of white grubs in Nepal.

THE WAY FORWARD FOR MICROBIAL CONTROL OF SOIL PESTS IN NEPAL

Since the government and donor organisations have been playing a significant role in creating awareness against pesticides, present situation in Nepal is favourable for the initiation of bio-control programmes against several insect pests in general and soil pests in particular. Similarly, Government of Nepal (GoN), has emphasised the need for integrated pest management (IPM) and the use of natural resources in its long term planning. There is widespread concern about the hazardous effect of chemical pesticides. As a result health consciousness has been increased through the IPM networks of the Department of Agricultural of Nepal. The demand for such types of produce that had been produced in chemical free situation is slowly increasing, especially after the emphasis on eco-tourism in the country. Moreover, consumers' concerns towards the organic products are gradually increasing in the country. Because of this, the potential of organic food shops have been realised and a few are already established in some parts of the country. Some of the products are being exported to foreign countries and there are lot of prospects for making good money.

In another hand, there are no chemical pesticide manufacturing industries in the country and almost all synthetic chemicals are imported from abroad, the majority from India, with some from Japan and Korea. The use of chemical pesticides is very costly and can be difficult to access in some parts of Nepal because of the lack of transportation facilities. Additionally, the purchasing power of the farmer is very low. At the same time, hazards related to misuse of pesticides is likely higher because of the farmer's illiteracy. These issues are all contributing towards the potentiality of microbial control in Nepal and are felt that this type of control should be implemented without delay. In the long run, with trained manpower and suitable infrastructure, fungal based pesticides could be one of the best solutions to control white grubs and other soil pests.

Based on the experience of Swiss Agricultural Research, mycopesticides can be produced using local materials such as low quality rice, barley, etc. and applied with existing farmers' practices. In the same way, it can be produced in the form of dust and liquid form suitable to targeting aerial feeding pests besides soil dwelling pests. Application of such biopesticides is compatible with the existing farmer's practices. A better understanding of epizootiology and the environmental constraints are also important and initially could be addressed by the introduction of trained manpower and IPM experts. Farmers can be educated through the network of governmental and non-governmental organisations for the production, application and management of cropping habitats by reducing the use of highly hazardous chemical pesticides. The outcomes so far achieved in this regard will have long lasting effect mainly through the capacity building of the research, extension and teaching organizations of Nepal. These will further contribute in producing quality food through the reduction of the losses due to pest attack in upland crops.

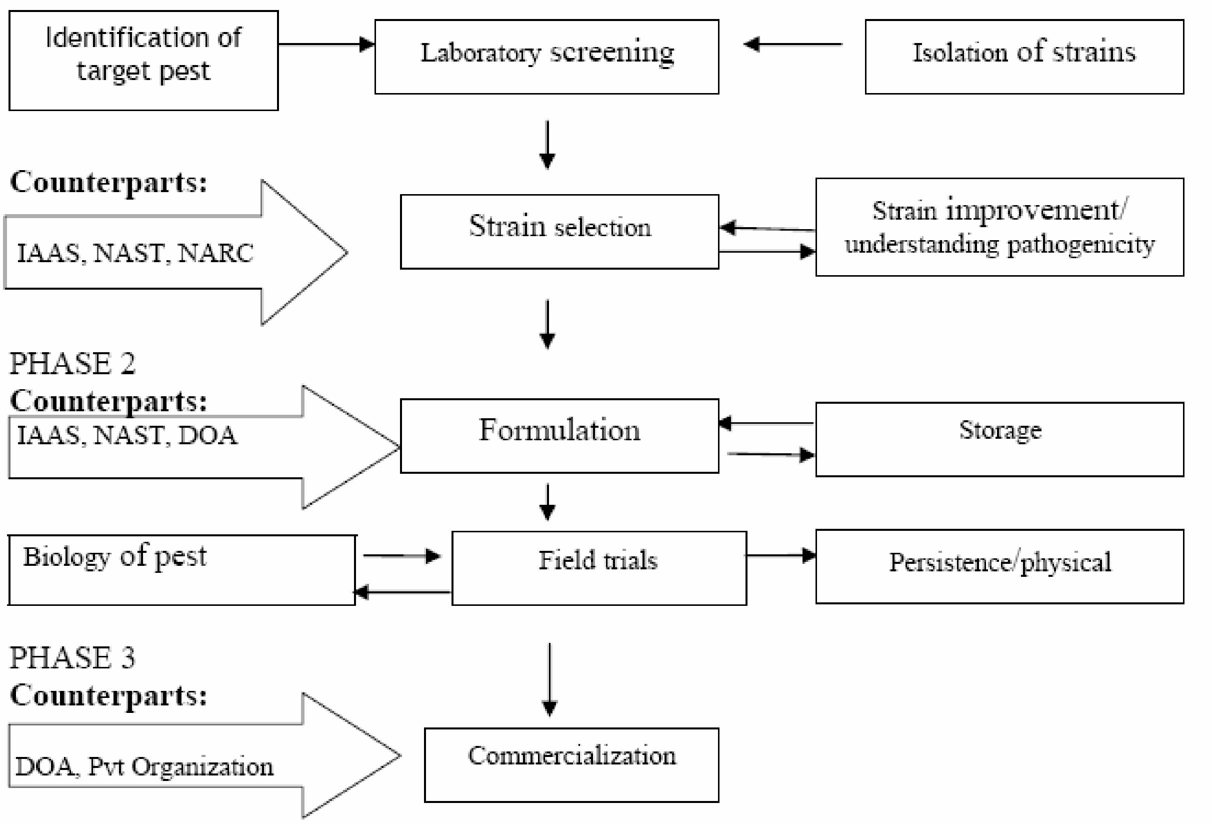

Figure 1: Suggested strategy for the development of fungal based mycoinsecticides in Nepal

FUTURE MODALITY

Entomogenous fungus have great promise for use as biological control agents against different insects however, their infectivity is quite different depending on fungus species and developmental stage of the insects (Samson, 1981). Therefore, when a particular insect pest control program is considered using these fungi, most suitable species or strains of the fungus have to be taken into account. Similarly, dose and time of exposure of the host to insect fungus and time taken to kill the host are also important parameters for evaluating virulence of insect fungus. Fungi which need shorter exposure period and kill the host quickly are very important in the practical application. Until now mass production was followed in autoclavable poly bags which has demonstrated the feasibility but also the importance of the bag quality and assured availability. Good fungus quality was only achieved with such types of bags and used therefore many years (Keller, 2004). Additional efforts must be undertaken to develop a production system which is based only on materials available on the national market. The development of commercial products based on entomopathogenic fungi for the use in integrated pest management program needs several steps. Fungal species and isolates must first be obtained from diseased insects or from the environment, and identified. The most promising candidates are evaluated under controlled condition and produced in large scale as mycopesticides for field tests.

An outline of the major phases of research and major counterparts towards the microbial control of white grubs in Nepal is proposed in flow chart 1.

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