

RESEARCH REPORT

COST-BENEFIT ANALYSIS OF PESTICIDE USE FROM FARMERS' HEALTH PERSPECTIVE

A RESEARCH FUNDED UNDER REGIONAL RESEARCH GRANT

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Pesticide use is increasing in an alarming rate in agricultural sector which might have created severe health hazards among exposed people. Cost-benefit analysis is an important aspect to recommend whether or not to use pesticide and if yes, the appropriate level of pesticide. Data was collected from 90 households engaged in commercial farming in Shantinagar VDC, Jhapa for one crop cycle (April to August 2008). In an average, each household found using 1.2 kg or litre of pesticides per annum and each household found spending NRs.1,514.50 in pesticides per annum which resulted in an extra NRs.487.42 spending on health. However, no compensating benefit was found from increased pesticide use that led to drastically decreasing benefit to cost ratio with increased pesticide use. Benefit to cost ratio among pesticide none user was 1.0049 which decreased to 0.9865 among medium level users and 0.7432 among high level of pesticide users.

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1. INTRODUCTION

1.1. Background

Pesticides are significant and growing component of the modern agricultural sector that has been widely adopted across the country. Pesticides are commonly expected to contribute to increase crop yields by minimizing damages caused by pests. However, a continuous increase in pesticide application in excess of the necessary level will cause spillover effects on both economic return and ecological environment, especially on farmer's health (2). Therefore, it is essential for farmers to keep the pesticides amount at the optimal level in order to maximize profit and reduce cost to environment in which cost of farmer's health is a serious concern. Despite the high cost of the chemicals, farmers still rely on pesticides to control pest and diseases due to the efficacy and cost-effectiveness of pesticides. Overuse, misuse and abuse of pesticide were often seen and heard of (1).

Farmers do not typically utilize recommended doses of pesticides nor do they utilize the producers' recommended practices for safe storage, handling, and application. On the one hand, most small-scale farmers in Nepal have little or no formal education. A wide and changing array of insecticides, herbicides, and other pesticides are available to farmers, but little, if any, research and extension is available to guide farmers in their use, and most farmers rely on the recommendations of chemical dealers or their own experience in deciding how to use pesticides (1).

While concerns have been expressed for more than a decade about the adverse effects of pesticides on human health and the environment in developing countries, there is a need to systematically assess and quantify the health and environmental effects of pesticides (2).

1.2. Statement of the Problem

On the eve of modernization of agricultural sector to increase agricultural production in the developing world, rampant use of chemical pesticides, not only deteriorate the human and environmental health, but also a threat to soil health and productivity. Effect of irrational/over use of pesticide leads to decline in productivity in long run which may further increase the problem of food insecurity resulting in poorer health status and increased health and social costs of pesticide use. Upto our knowledge, pesticide use pattern in agricultural sector, costs of the pesticide use, health hazards and associated costs and benefits of pesticides use is not studied in Nepal till now.

Nepal being a member of World Trade Organization (WTO) must have to comply with the need of sanitary and phyto-sanitary measures which have created barrier in exporting Nepalese products in international market arena from time and again. To protect the health status of Nepalese people, Nepalese society need to study the health hazards associated with increased pesticide use and develop appropriate regulatory policies. The first step towards promoting eco-friendly agricultural modernization with protection of human health and assurance of benefit to the farmers, as proposed by this study, is to conduct cost-benefit analysis of pesticide use from farmers' health perspective.

1.3. Research Questions

Following research questions are attempted to be answered by this study:

- What are the costs of pesticides used in agriculture sector?
- What are the health problems faced in different levels of pesticide use?
- What are the costs incurred for treatment of health problems associated with the different level of pesticides use?
- What are the benefits associated with different levels of pesticides use?
- What is the benefit to cost ratio of pesticide use?

2. LITERATURE REVIEW

2.1. Pesticide use and trend

Very few literatures are found which assesses health hazards, and costs and benefits of pesticide use. However, review done by Palikhe (2006) has shown that during the past three decades, indiscriminate use of chemical pesticides in agriculture has created serious health and environmental problems in many developing countries. The World Health Organization and the United Nations Environment Program estimate pesticide poisoning rates of 2-3 per minute, with approximately 20,000 workers dying from exposure every year, the majority in developing countries where less protection against exposure is applied, knowledge of health risks and safe use is limited and harmful pesticides are easily accessible (1).

About 290 types of formulations by trade name (Insecticides-202, Fungicides-51, Herbicides-19, Rodenticides-8, Acaricides-2, Bio-pesticides-5 and others-3) and 71 by technical or common name have been registered for use under Pesticides Act and Rules. In terms of the number of pesticides applied, there were a total of 71 different active ingredients. Classifying these by the WHO risk classification system, on average, 9.86% were highly hazardous (WHO class Ib), 32.4% moderately hazardous (WHO class II), 2.68% slightly hazardous (WHO class III) and 42.26% were low risk (1).

2.2. Health hazard and related costs of pesticide use

Study conducted by Antle and Pingali (1995) in Philippines compared samples exposed to pesticides with the unexposed samples and revealed that the exposed group face significantly higher acute and chronic health effects can be attributed to prolonged pesticide use. Eye, skin, pulmonary, and neurological problems are significantly associated with long term pesticide exposure. The average health cost for farmers exposed to pesticides was approximately 40 percent higher than that for the unexposed farmers. Even after accounting for age, nutritional status, smoking, and drinking, health costs

increase by 0.5 percent for every 1 percent increase in insecticide dose above the average level. In addition to the direct health costs, the loss in labor productivity associated with impaired health is quantified. Prolonged exposure to pesticides can lead to cardiopulmonary disorders, neurological and hematological symptoms, and skin diseases. These symptoms can lower productivity because of the farmer's absence from work during treatment and recuperation and impaired capacity to work. Farmers do not know about the harmful effects of pesticides sometimes overvalue their benefits and use them beyond the private and social optimum levels (2).

As mentioned by Palikhe (2006) annual percapita spending on household pesticides is over US \$0.49 and the annual cost of illness per household as a result of pesticide exposure is estimated to be \$ 4.10 in Nepal (1).

Farmers reported upto 13 acute symptoms due to the use of pesticide in a study conducted by Atreya (3) in mid-hill vegetable growing area of Nepal. Major health problems faced were eye irritation, headache, skin irritation/burn and weakness. Annual household expenditure due to the use of pesticides ranged from zero to NRs.4,451 with an average of NRs.1,261 (3).

Atreya (2007) in another study found that the magnitude of exposure to insecticides and fungicides can significantly influence the occurrence of health problems. The predicted probability of falling sick from pesticide-related symptoms is 133% higher among individuals who apply pesticides compared to individuals in the same household who are not directly exposed. Households bear an annual health cost of NRs.287 as a result of pesticide exposure. These costs vary with fungicide exposure. A ten percent increase in hours of exposure increases costs by about twenty-four percent (4).

Devi IP (2007) in Kerala found that toxicity level and dose of pesticides can exert a significant effect on the health of pesticide applicators. The average expected health costs from pesticide exposure are IRs.38 per day or 24% of the average daily earnings of the applicators (5).

2.3. Benefits from pesticide use

Khan *et. al.* (6) have conducted an economic evaluation of pesticide use externalities in the cotton zones of Punjab, Pakistan considering a wide variety of variables such as occupational poisoning, pests resistant, poisoning to domestic animals, pesticide residue in blood and food constituents, evaluation and monitoring costs and awareness program costs, and data sources such as review of scientific papers, laboratory analyses of blood and food constituents and field survey. The data were analyzed for the period of 1987 to 1998. The study found that the productivity of using pesticide was initially increased however, within a decade of pesticide use productivity started to fall down. The benefit to cost ratio without considering externalities was 1.34 which reduced drastically to 0.43 when externalities were also considered.

3. RESEARCH OBJECTIVES

3.1. General objective

- To analyze costs and benefits of the pesticide use in agricultural sector.

3.2. Specific objectives

The specific objectives of the study are:

- To assess costs incurred for purchasing and application of pesticides;
- To assess health costs associated with pesticide use and exposure in terms of costs of health service utilization and days lost due to sickness;
- To assess benefits generated from pesticide use in terms of increased productivity;
and
- To conduct a cost-benefit analysis of pesticide use.

4. MATERIALS AND METHODS

4.1. Research design

This is an Analytical Study using quantitative data collected from panel survey. The study identifies health problems associated with pesticide use and costs and benefits of using pesticides in different intensity.

4.2. Study site

Commercial farming is rapidly growing since around last decade in Eastern and Central Development Region of Nepal. Along with such development, use of pesticide and chemical fertilizers are also increasing in an alarming rate. Shantinagar VDC of Jhapa is one of the year round vegetable producing areas. The sloppy land with high organic matter containing soil and easily drainable soil is the most congenial condition for year round vegetable production. Farmers in that area generally produce off-season vegetables which are marketed to many parts of Nepal and north-east India. The off-season farming demands enormous amount of chemical pesticides and fertilizers. Hence, Shantinagar VDC is named as one of the highest pesticide and chemical fertilizers using area in Jhapa district and was selected as the study area.

4.3. Research methodology

4.3.1. Study population

All farmers involved in commercial farming in the Shantinagar VDC are target population of this study.

4.3.2. Sample size and sampling

The study collected data from three equal proportions of farmers using pesticides in low, medium and high level so as to determine costs and benefits associated with different levels of pesticide use ensuring dose-response effect of pesticide on farmers' health and productivity. Hence, the study used non-probability purposive quota sampling based on rapid participatory appraisal in the study area. A total of 90 households were selected, consisting 30 each with high, medium and low level of pesticide use as assessed by opinion leaders of the study area. The households were later categorized into heavy, medium and low level pesticide users from statistical calculation based on average quantity of pesticide use per hectare cultivated land during the study period.

4.3.3. Tools and techniques of data collection

Opinion leaders were interviewed for selecting study households. Household panel survey is being conducted to collect data. Interview using pre-tested interview schedule translated and developed in Nepali language (attached herein annex) was method and tools used for data collection. Pre-testing of the data collection tool was done in similar setting in Shanishare VDC. A verbal consent was taken from the respondent explaining the objective, purpose and methodology of the study. The respondents were also informed about their right not to participate or leave in between.

Research instruments also collected background variables like alcohol consumption, tobacco use habit in terms of smoking and chewing tobacco, water source and toilet use because such variables significantly affects health status and needs to be controlled while finding out the proportion of disease caused by pesticide use alone.

4.3.4. Procedure Used for Assessing Costs and Benefits of Pesticide use

Cost calculated in this study covered the one full crop life and harvesting period. Costs calculated consisted of costs incurred for nursery preparation, seed treatment, seed purchase, main field preparation, fertilizers (chemical fertilizers, cowdung and compost), insecticides, pesticides used in the nursery and main field, travel cost, wage paid and opportunity lost during purchase, procurement and application of fertilizers, pesticides and other materials, irrigation, labor cost for ploughing, *godmel*, cost of other materials like bamboo for giving support to crop plants, harvesting and marketing.

As effect on health from the use of pesticide and resulting costs were to be assessed, the acute and chronic health conditions of the studied households were also collected fortnightly. The health costs were calculated in terms of direct and indirect. Direct health costs included costs of treatment including registration charge in health facilities, cost of diagnostic tests and check-up, cost of drugs, travelling cost and cost incurred for lodging and food. Indirect cost consisted of wage paid to alternative person to get work done in the farm (opportunity cost). Whether the sick one was exposed to pesticide or not, if yes, type of pesticide used, pesticide exposed to, exposure duration, probation period of pesticide resulting in health problem, quantity of pesticide applied, whether any precautions were used during pesticide application or exposure and the precautions used were also recorded.

Benefits were calculated in terms of monetary value of the produced crops. Monetary value was calculated by multiplying quantity produced in killo gram by prevailing market price. As data was collected fortnightly the selling price was recorded the real selling price for the products sold in the market as well as for that consumed in household and distributed without taking money to the relatives and neighborhoods.

Data was collected every fortnightly in both costs and benefit aspects so as to reduce potential recall bias.

Pesticide use level was classified into three levels based on quantity of pesticide used per hectare farm: no use, medium level and high level based on three equal groups made from percentile analysis. Costs and benefits in each of those levels were calculated and benefit to cost ratio was calculated for those three levels of pesticide use.

4.3.5. Validity and reliability of the research

The research findings will be valid for similar settings. To ensure validity and reliability of the research following measures were taken:

- Research tools were prepared to cover objectives of the research after reviewing tools used by previous similar studies.
- Interviews were conducted in simple Nepali language (see tools in annex).
- Questionnaire was pre-tested in similar setting by the researchers.
- Researchers themselves were involved in all research activities including instrument development, pre-testing, finalization, supervision of data collection and data management and analysis in line with their expertise.
- Supervision (back checking of data collector, scrutinizing the filled up research tools, discussion on the collected data) and feedback to the data collector was provided intensively in the initial days of orientation, pre-testing and data collection.
- Adequate literatures were reviewed.

Biases

- Best effort were put on rapport building explaining objective of the study and ensuring anonymous presentation of the findings to avoid response bias.
- Best efforts were made to remind the past events to minimize recall bias.

Supervision and Monitoring

- Supervision (back checking of data collector, scrutinizing the filled up research tools, discussion on the collected data) and feedback was provided intensively to the data collector in initial days of data collection with regular monitoring by researchers.

4.3.6. Data management and analysis

Data collected were scrutinized and cross-verified with the surrounding households. Data has been entered in a data entry formate developed in MS Excel. Validity of data was checked using filter command and looking responses in other related variables. Inappropriate responses identified were checked in the filled up forms and edited as present in the forms.

Variables like age, sex, tobacco and alcohol consumption, source of water and toilet used, contraceptive method used, fertilizers and micro-nutrient use concentration and irrigation is controlled during calculation of productivity explained by pesticide use.

MS Excel and SPSS 13 were used for analyzing data. Stepwise multiple regression analysis and logistic regression analysis were used to identify factors associated with variation in the health problems, costs and benefits.

4.3.7. Outcome of the research and Dissemination plan

Study identified different level of pesticide use and costs of pesticide purchase and application, health hazards, health costs and benefits associated with different levels of pesticide use were assessed.

Dissemination of research results

One copy of final research report is submitted to NHRC. Dissemination will be held in study site: Shantinagar VDC itself inviting local farmers and representatives from District Health Office, Jhapa, District Agriculture Office, Jhapa and other interested stakeholders.

4.3.8. Operational Definition

Pesticide

Chemicals used by farm with an intention to protect cultivated crops from fungus, insects and pests. Pesticide includes both insecticides and fungicides.

Health problems

Health condition faced during last fortnight from the date of data collection which is considered as illness by the respondents and/or family member(s) and reported as a health problem to the data collector at the time of data collection.

Chronic disease

Health problem or disease condition which exist for more than 30 days.

5. RESEARCH FINDINGS

As the objective of the study is to assess costs and benefits and find out benefit to cost ratio of pesticide use in different levels, findings from the study is presented in the flow of background characteristics of the studied household and their family members, pesticide use pattern and intensity, costs of pesticide and pesticide use, health problems faced by the family members of the household under study, treatment seeking behavior, costs of treatment, opportunity lost and costs of replacement labor. Benefits and benefit to cost ratio could not be calculated by the data available in the hand and hence, the aspect will be dealt in final report to be submitted by completing data collection upto next four months.

5.1. Background characteristics of the study household

As exposure to pesticide, pesticide use, precautions, health problems faced, treatment seeking behavior and cost of treatment might have been influenced by different variables such as background characteristics like age, sex, education, occupation, family size, caste, alcohol consumption, smoking habit, water source for drinking, type of toilet used, contraceptives used, chronic disease sufferings and participation in preventive knowledge and skills gaining trainings such as Integrated Pesticide Management (IPM) training. Such variables are studied under background characteristics.

5.1.1. Household characteristics: Caste and family size

Majority of the households visited were relatively advantaged castes (Brahmin/Chettri) (Ref.: Table 1). Majority of the households (42.2%) visited were medium sized families having 5-6 members.

Table 1: Background characteristics of the household visited

Caste	Frequency	Percent
Brahmin/chettri	65	72.3
Mangolian	17	17.8
Newar	7	7.8
So called lower castes	1	1.1
Family size		
4 or less	32	35.6
5-6	38	42.2
7 or more	20	22.2
Total	90	100.0

5.1.2. Population characteristics: Age, sex, education and occupation

Majority, 51.3% of the people studied, were male; 42.7% were of age group 26-60 years (Ref.: table 2). Most of the people were literate (85.9%). Agriculture was the major occupation among the people studied (64.9%).

Table 2: Background characteristics of the sampled population under study

Age group	Frequency	Percent
<5 yrs.	32	6.6
5-15 yrs.	89	18.4
16-25 yrs.	117	24.1
26-60 yrs.	207	42.7
>60 yrs.	40	8.2
Sex		
Male	249	51.3
Female	236	48.7
Education among people aged 6 years or more		
Illiterate	63	14.1
Primary level (grade 1-5)	143	32.1
Grade 6-10	206	46.2
College level (11-15)	34	7.6
Occupation		
Agriculture	315	64.9
Student	116	23.9
Child	32	6.6
Job	16	3.2
Tailoring	4	0.8
Business	2	0.4
Total	485	100

5.1.3. General factors related to health status: smoking habit, alcohol consumption, water source, sanitation and participation in IPM training

Most of the people studied were non-smokers (96.1%) and were not consuming alcohol as well (97.9%). Tap water was the only source for drinking water and three in four (73.6%) were using waterseal toilet with rest using bore-hole toilet (Ref.: Table 3).

Table 3: Potential risk behavior, water and sanitation indicators of the studied population

Smoking (sticks per day)	Frequency	Percent
Non smoker	466	96.1
1 to 2 sticks per day	2	0.4
3 to 5 sticks per day	9	1.8
6 to 9 sticks per day	2	0.4
10 sticks and above	6	1.2
Alcohol consumption (ml per day)		
Not at all	475	97.9
Upto 250 ml/day	4	0.8
Above 250 ml/day	6	1.2
Water source		
Tape water	485	100.0
Toilet used		
Bore hole toilet	128	26.4
Waterseal toilet	357	73.6
Total	485	100.0

Participation in IPM training

Integrated Pesticide Management (IPM) training provides people knowledge and skills about how to produce more farm products with lower level of chemical pesticide use and also equip with the knowledge on how to protect oneself from pesticide hazards. Such knowledge and skills may have effects on level of pesticide use and resulting health conditions. Hence, this study deemed necessary and collected data on whether farmers participated in IPM training or not.

Around four percent (3.7%) of the populatin had participated in Integrated Pesticide Management (IPM) training (Ref.: Table 4).

Table 4: Participation in Intergrated Pesticide Management (IPM) training

People aged 6 years or above got IPM training	Frequency	Percentage
No	423	94.8
Yes	23	5.2
Total	446	100.0

5.2. Health problems and pesticide exposure

Whether study population had suffered from acute and/or chronic health problems within the study period starting from last fortnight from the date of first round of data collection and what health problems were they suffering from were assessed. Cross-comparison of acute and chronic health problems with exposure to pesticide was made as presented in this section.

5.2.1. Chronic disease sufferings and exposure to pesticide

About every one in 8 (13.4%) were suffering from at least one chronic health problems. Major chronic health problems were skin problem (24.6%), headache and giddiness (23.1%) and abdominal problems (15.4%). Other chronic health problems recorded were breathing difficulty, eye irritation, heart problem, ringworm, arthritis, asthma, backache, diarrhoea, excessive salivati, excessive thirst, gynaecological and obstetric problem, hernia, hypertension, itching of vagina, jaundice, mental problem, nasal allergy, stone and urinary problem (Ref.: Table 5).

Table 5: Existence of chronic disease sufferings among people in Shantinagar VDC

Suffering from chronic disease?	Frequency	Percent
No	420	86.6
Yes	65	13.4
Total	485	100.0
Chronic diseases present		
Skin rashes	16	24.6
Headache and giddiness	15	23.1
Abdominal problem	10	15.4
Breathing difficulty	3	4.6
Eye irritation	3	4.6
Heart problem	3	4.6
Ringworm	3	4.6
Arthritis	2	3.1
Asthma	2	3.1
Neurological problem	2	3.1
Others (backache, diarrhoea, excessive salivation, excessive thirst, gynaecological and obstetric problem, hernia, hypertension, itching of vagina, jaundice, mental problem, nasal allergy, stone and urinary problem 1 each	13	20.0
Total (N)	65	100.0

No significant difference was found in chronic disease suffering among people who were exposed and not exposed to pesticide (Ref. table: 6).

Table 6: Chronic disease prevalence and exposure to pesticides among the studied population

Chronic disease suffering	Exposure to pesticide (%)		Total
	No	Yes	
No (n = 420)	85.6	91.4	86.6
Yes (n = 65)	14.4	8.6	13.4
Total (N)	404	81	485

Chronic disease suffering was not found to be significantly different with respect to whether the person was exposed to the pesticide or not ($r = -0.0654$ with $p = 0.151$). The reason for negative correlation might be because people who are suffering from chronic diseases are less likely to be involved in pesticide application because of their poor health condition. However, methodology used and duration of this study does not provide information to identify whether and how much chronic disease burden is produced by pesticide use in the farm.

5.2.2. Sufferings from acute health problems and exposure to pesticide

More than six percent (6.2%) of the studied people were found suffering from acute health problems during the study period (Ref.: Table 7). Around one percent (1.2%) had suffered from the acute health problems more frequently (3 or more times).

Table 7: Number of times health problem faced during the study period

Number of times health problem faced	Frequency	Percent
0	455	93.8
1	19	3.9
2	5	1.0
3	4	0.8
4	2	0.4
Total	485	100.0

Headache, giddiness, nasal allergy, abdominal problem, skin rashes and eye irritation were the acute health problems faced by majority of the sufferers during the study period.

Number of times acute health problems faced was positively correlated with quantity of pesticide use ($r = 0.115$, $p < 0.05$), number of times exposed to: pesticide ($r = 0.224$, $p < 0.01$), insecticide ($r = 0.243$, $p < 0.01$) and fungicide ($r = 0.234$, $p < 0.05$), duration of exposure to: insecticide ($r = 0.109$, $p < 0.05$), fungicide ($r = 0.198$, $p < 0.01$) and pesticide

($r = 0.169$, $p < 0.01$) and quantity of chemical micro-nutrients used ($r = 0.172$, $p < 0.01$), contributing in significant increase both in costs of pesticide use as well as health costs ($r = 0.112$, $p < 0.05$ and $r = 0.599$, $p < 0.01$). Number of precautions used was found to have protective effect on health ($p < 0.05$).

5.3. Pesticide use and cost

5.3.1. Pesticide use level and cost of pesticide

Average use of pesticide per hectar farm was 300.000 mg/ml (median value). The range of pesticide use was divided into three equal groups in 33.3 and 66.7 percentile partition values to classify as low, medium and high level. Low level of pesticide use was the one with no use of pesticide. Medium level was pesticide(s) use upto 3,450.040 mg/ml per hectar and high level was more than 3,450.040 mg/ml pesticide use per hectar farm (Ref.: Table 8).

Table 8: Quantity of different types of pesticides used per hectar farm within past three months

Summary statistics	Insecticide (mg or ml per hectar farm)	Fungicide used (mg or ml per hectar farm)	Other pesticidies used (mg or ml per hectar farm)	Total pesticidies used (mg or ml per hectar farm)
N	106	63	41	119
Mean	2,523.512	2.911E-02	265.085	2,339.181
Median	1,735.000	6.364E-03	0.000	300.000
Percentiles: 25	0.000	0.000	0.000	0.000
33.3	0.000	0.000	0.000	0.000
50	1735.000	6.364E-03	0.000	300.000
66.7	3,696.364	1.866E-02	0.000	3,450.040
75	4252.500	3.252E-02	0.000	3980.020

The cost of pesticide use (price of pesticide, travel cost to procure the pesticide, wage paid for pesticide application and opportunity lost because of time used for pesticide application) was positively associated with level of pesticide use with regression coefficient 1.159 (p<0.000) (ref: equation 1).

$$\text{Cost of pesticide purchase and application (NRs.)} = \text{NRs.14.704} + 1.147 * \text{Pesticide used (in ml or mg)}. \quad (\text{R-square} = 0.995, p < 0.000) \dots\dots\dots 1$$

Equation shows that the cost of pesticide use was found increasing by NRs.1.147 with every one milliliter or one gram increase in pesticide use.

5.3.2. Exposure to pesticide, health risk and health costs associated with pesticide use

All most half of the households (49.6%) had used pesticide in the form of insecticide or fungicide during the study period (Ref.: Table 9). However, most of the people were not directly exposed to the pesticide. Only about one in five (16.7%) people were exposed to the pesticide(s).

Table 9: Number of times exposed to pesticides within the study period (three months)

Number of times exposed to pesticide	Population exposed to		
	Insecticide (%)	Fungicide (%)	All Pesticides (%)
0	93.2	95	83.3
1	2.1	1.2	3.1
2	0.4	0.4	2.3
3	1.2	2.7	2.3
4	2.1	0.6	4.9
5	0.2		3.3
6	0.6		0.6
7	0.2		0.2
Total (N)	485	485	485

Exposure to pesticide was significantly associated with health problem ($p < 0.000$). About every one among four people exposed to pesticide had faced health problems, which was about 10 times higher than that among unexposed ones (23.5% vs. 2.7%) (Ref.: Table 10). Number of times health problem faced was found significantly increasing with duration (in minute) of exposure to insecticide (regression coefficient = 0.0001948) and fungicide (regression coefficient = 0.001028).

Table 10: Pesticide exposure and health status in the study period

Exposure to pesticide	Acute health problem faced?		Total	
	No	Yes	%	N
Not exposed	97.3%	2.7%	83.3%	404
Exposed	76.5%	23.5%	16.7%	81
Total: %	93.8%	6.2%	100.0%	
N	473	12	485	485

Total health cost of pesticide use per hectar (both costs directly related to pesticide use and costs of health hazard and treatment) was positively associated with pesticide use (g or ml per hectar) with regression coefficient 0.176 and ($p < 0.000$) (ref: equation 2). Even while controlling for age, education, smoking and alcohol consumption, health costs was found to be positively correlated with the quantity of pesticide use ($r = 0.2392$, $p < 0.01$).

Total health costs (NRs.) = $40.524 + 0.176 * \text{Pesticide used (in ml or mg)}$ (R-square = 0.03, $p < 0.000$).....2

People not exposed to pesticide had percapita health cost NRs.37.18 in the study period which was more than four times higher (318.56% or NRs.118.44 more) among people with medium level of pesticide use (upto 3,450.040 mg/ml per hectar). The health cost was NRs.125.86 (385.52%) more among high level pesticide users (more than 3,450.040 mg/ml pesticide use per hectar farm) compared to those not using pesticides. The difference was significant with p value 0.002.

Table 11: Health Cost in different level of Pesticide exposure in the study period

Level of pesticides use	Mean (NRs.)	N	SD	Median (NRs.)
No	37.18	422	199.11	0.00
Low	155.62	34	440.87	0.00
High	163.04	29	528.51	0.00
Total	53.00	485	256.08	0.00

5.4. Effect of pesticides on productivity and cost-benefit analysis

Benefit of pesticide use is calculated in terms of market price of crop produced in one full crop life.

Productivity was found to be negatively correlated with number of times pesticide applied ($r = -0.199$, $p < 0.05$), insecticide used per hectare farm ($r = -0.257$, $p < 0.01$) and pesticide used per hectare farm ($r = -0.273$, $p < 0.01$) and positively correlated with quantity of cow dung used ($r = 0.194$, $p < 0.05$), quantity of DAP used ($r = 0.468$, $p < 0.01$), man days used in ploughing ($r = 0.416$, $p < 0.01$) and quantity of urea used ($r = 0.419$, $p < 0.01$) resulting in lower benefit to cost ratio among those using higher level of pesticide use. However, while controlling the effect of cropped area, quantity of cowdung, compost, DAP, micro-nutrients and urea applied in the farm and number of times irrigated, no significant relation was found between quantity of pesticides used and quantity produced.

Benefit to cost ratio

Cost of pesticide use (cost incurred for pesticide purchase and application and health cost resulting from increased number of sufferings) was increased in increased level of pesticides use without bringing about a significant increase in production level. Such relation of costs and benefits has suggested decreasing return from increasing level of pesticide use (ref: table 11).

Table 11: Cost-benefit analysis of pesticide use

Level of pesticide use	Number of crops (N)	Average costs	Average benefits	Benefit to cost ratio at actual farm area	Benefits to cost ratio per hectare farming
No pesticide	68	4,937	5,098.34	1.0779	1.0049
Medium	23	9,501	9,233.72	0.9865	0.9865
High	40	10,458	6237.20	0.7432	0.7432
Total	131	7,424	6,172.14	0.9326	0.9014

Though, benefit to cost ratio is found to be very low in all three level of pesticide use, in reality, even the farmers using the highest rate of pesticide are gaining return around in the rate of local labor market (wage rate) because most of the farmers have reported opportunity costs associated with their time used for procuring and using inputs like pesticide, fertilizers, micro-vitamins, ploughing and irrigation.

As productivity was found positively associated with use of fertilizers like cowdung, compost and DAP emphasis on such factors would be beneficial from both farmers health and productivity perspective.

6. DISCUSSION AND CONCLUSION

Perhousehold spending on pesticide for farm use per annum was US\$23.3 (NRs.1,514.5), which is in line with that found by Atreya in mid-hill region ranging from zero to NRs.4,451 with an average of NRs.1,261 (3). However, it was obviously far more than percapita spending on household pesticide as found by Palikhe (2006) (US \$0.49) (1).

The risk of falling sick from pesticide exposure was found to be 7.61 times higher than that of people not exposed to pesticide, which was quite higher than that found by Atreya 133% and Antle and Pingali in Phillipines (2).

Households health cost attributable to pesticide exposure is found to be NRs.487.42 which is slightly higher than that found by Atreya (NRs.287) (4), which could be a result of higher morbidity found in this study along with sharply increased price level after the study period of Atreya.

The health problems were found to be skin rashes, eye irritation, headach, giddiness, nasal allergy, abodominal problems are in line with that found by other studies (2) (3) (4) (5). Sufferings from acute health problems was found to be more than 7.61 times higher among people exposed to pesticide compared to those not exposed, which is quite higher than any of other study findings. The reason might be that the intensity of pesticide use in vegetable farming is heavier compared to that in other crops.

Hence, it can be concluded that there is increased health risk with increasing pesticide use, which also increases costs incurred for treatment. On the other hand cost increased use of pesticide increases the cost of pesticide purchase and application. However, there was no significant increase in productivity with increased level of pesticide use resulting only in reduced benefit to cost ratio with increasing level of pesticide use. The benefit to cost ratio was reduced to 0.7432 at high level of pesticide use from 0.9865 at medium and 1.0049 at no pesticide use respectively. The finding was similar to that found by Khan, Iqbal, *et. al.*

(6), which found the benefit to cost ratio to be 0.43 with externalities and 1.14 without external costs. The extremely lower ratio found by Khan *et. al.* might be because of their wider spectrum of social costs and externalities considered such as occupational poisoning, pesticide residues in food chain, pest resistance, domestic animal poisoning, wild honey bee and sunflower production losses, loss in bio-diversity, cost of toxicity analysis and monitoring and public awareness campaigns, which is beyond the scope of this study.

Hence, the overall finding shows pesticide use is a detrimental to human health without compensating increase in productivity leading to reduced level of return to increased level of investment in pesticide.

7. RECOMMENDATIONS

Benefit to cost ratio is found decreasing with increasing level of pesticide use. Cost of pesticide purchase and application increment with increased level of pesticide use is normal but increased health costs in the similar fashion has suggested a heavy loss of health and healthy state of people resulting in higher costs of increased pesticide use. Hence, interventions should be made to reduce the level of pesticide use which will ensure better health of people who otherwise are being exposed to pesticides at hazardous level.

As an alternative, interventions should be made emphasizing increased use of cowdung, composts and DAP which were found contributing to increased productivity and use of natural pesticides such as integrated pest management which has no health hazards.

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2. Annexes

a. Data Collection Instruments:

किसानहरुको स्वास्थ्यको दृष्टिकोणबाट किटनाशक विषाधि प्रयोगको नाफा नोक्सानको लेखाजोखा गर्ने सर्वेक्षण

घरका सदस्यहरुलाई दिने जानकारी, घरमूली वा घरको मुख्य सदस्यसंग लिने सहमति र जानकारी

नमस्कार, मेरो नाम हो । केहि वर्ष यता कृषि उपजको उत्पादन बढाउनको लागि खेतिपातिमा किटनाशक विषाधिको प्रयोग तिब्र रुपमा बढ्न थालेको छ । किटनाशक विषाधिको प्रयोग किसानहरुको स्वास्थ्यको दृष्टिकोणबाट के कति नाफा र नोक्सानमूलक छ भन्ने कुराको लेखाजोखा गर्नकोलागि जनस्वास्थ्य, स्वास्थ्य तथा कृषि क्षेत्रमा काम गरिरहेका ब्याक्तिहरुको सुरुवात र नेपाल स्वास्थ्य अनुसन्धान परिषदको सहयोगमा यो सर्वेक्षण कार्य गर्न लागिएको छ । यस सर्वेक्षण कार्यबाट किसानहरुलाई तुरुन्तै कुनै फाइदा नपुग्ने भएपनि यस सर्वेक्षणबाट पत्ता लाग्ने कुराहरु हाम्रो जस्तो कृषि प्रधान देशका किसान र कृषि उपजको उपभोग गर्ने ब्याक्तिहरुको लागि फाइदा जनक हुने आशा गरिएको छ । यो सर्वेक्षणको लागि तथ्याङ्क संकलन प्रत्येक १५/१५ दिनमा घटिमा दुई महिना सम्म गरिने छ । किसान तथा उपभोक्ताहरुको भलाईको लागि यो सर्वेक्षणलाई लामो समय सम्म सञ्चालन गर्न आवश्यक परेमा र यो सर्वेक्षण सञ्चालन गर्न आवश्यक सहयोग जुटाउन सकिएको खण्डमा यो सर्वेक्षणमात्र वा अन्य आवश्यक कार्यक्रमहरु सहित थप समयको लागि लम्ब्याउन सकिने छ । उक्त कार्यको लागि पनि तपाईंहरुको निरन्तर सहयोग आवश्यक पर्ने छ । हामी तपाईंलाई यस कार्यक्रममा भाग लिई सहयोग गर्नहुन सबिनम्र अनुरोध गर्दछौं । के तपाईं यस अनुसन्धान कार्यमा भाग लिन तयार हुनुहुन्छ ?

छु

छुईन्

यदि भाग लिन तयार भए तयार हुनेको दस्तखत :

भाग लिन तयार हुनेको पुरा नाम थर:

अर्न्तवार्ता मिति : २०६५ साल महिना गते

ठेगाना : जिल्ला गा. बि. स. वडा नं. : टोल : घर नं. :

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प्र. नं. १. घरमा बस्नेहरुको बिबरण

क. परिवार सदस्य सं.	ख. नाम	ग. उत्तरदाता संगको सम्बन्ध	घ. उमेर (पुरा भएको वर्ष वा महिना)	ङ. लिङ्ग	च. शिक्षा (पुरा गरेको वर्ष)	छ. पेशा (मुख्य)	ज. धूम्रपान को मात्रा (खिलि प्रति दिन)	झ. रक्सि सेवन (मि. लि. प्रति दिन)	ब. कुनै दिर्घकालिन स्वास्थ्य समस्या छ ? (प्रश्न नं. १०बाट कोड नं. लेख्नुहोस्)	ट. (महिला हरुको लागि सोध्ने) परिवार नियोजनको कुन अस्थाई साधन प्रयोग गरिरहनु भएको छ ?	ठ. गत पन्ध्र दिन भित्रमा कुनै अस्वस्थता देखा पर्यो कि परेन ?	ड. विषाधि प्रयोग सम्बन्धि कुनै तालिम लिएको थियो वा थिएन ?
उत्तरदाता												
१												
२												
३												
४												
...												
...												

एक प्रकारको बालि को लागि एउटा फारम भर्नुहोस् (प्रत्येक पन्ध्र दिनमा सोधेर भर्ने)

प्र. नं. ६.१ ब्याड तयार गर्ने क्रममा भएका खर्चहरूको विवरण (यदि एउटै बालिमा एकै प्रकारको औषधि एक पटक भन्दा बढि प्रयोग गरिएको भए दोस्रो वा तेस्रो पटकको विवरण अन्यमा जनाएर टिप्नुहोस्)

क. खर्चको शिर्षक	ख. किटनाशक विषाधि/मल/भिटामिनको नाम	ग. क्षेत्रफल (कठ्ठा)	घ. परिमाण	ब्याड तयार गर्ने क्रममा भएको खर्च					
				ड. मूल्य (ने. रु.)	च. खरिद गर्दाको भाडा (ने. रु.)	छ. गुमेको अवसरको मूल्य रु.	ज. खेति गर्दाको ज्याला (ने. रु.)	झ. अन्य (उल्लेख गर्नुहोस्) ...	ञ. अन्य (उल्लेख गर्नुहोस्) ...
खनजोत									
बिऊ									
बिऊको विषाधि									
गोबर मल									
प्राङ्गारिक मल									
डि. ए. पि.									
युरिया									
पोटास									
किटनाशक विषाधि १									
किटनाशक विषाधि २									
सूक्ष्म भिटामिनहरू									
बनस्पातिक किटनाशक									
जैविक किटनाशक									
अन्य :									

प्र. नं. ६.२ उत्पादन र बिक्री बितरणको क्रममा भएका खर्चहरूको विवरण (प्रत्येक पन्ध्र दिनमा सोधेर भर्ने)

क. खर्चको शिर्षक	ख. किटनाशक विषाधि/मल/भिटामिनको नाम	ग. क्षेत्रफल (स्क्वायर मिटरमा)	घ. परिमाण	उत्पादन र बिक्री बितरण गर्ने क्रममा भएको खर्च					
				ड. मूल्य (ने. रु.)	च. भाडा (ने. रु.)	छ. गुमेको अवसरको मूल्य रु.	ज. ज्याला (ने. रु.)	झ. अन्य (उल्लेख गर्नुहोस्) ...	ञ. अन्य (उल्लेख गर्नुहोस्) ...
मुख्य खेत तयारी									
खनजोत									
गोबर मल									
प्राङ्गारिक मल									
डि. ए. पि.									

क. खर्चको शिर्षक	ख. किटनाशक विषाधि/मल/भिटाभिनको नाम	ग. क्षेत्रफल (स्क्वायर मिटरमा)	घ. परिमाण	उत्पादन र बिक्री वितरण गर्ने क्रममा भएको खर्च					
				ड. मूल्य (ने. रु.)	च. भाडा (ने. रु.)	छ. गुमेको अवसरको मूल्य रु.	ज. ज्याला (ने. रु.)	झ. अन्य (उल्लेख गर्नुहोस्) ...	ञ. अन्य (उल्लेख गर्नुहोस्) ...
युरिया									
पोटास									
किटनाशक विषाधि १									
सुक्ष्म तत्वहरु									
बिरुवा रोपाई									
सिंचाई									
पहिलो चरणको गोडमेल									
सिंचाई									
डि. ए. पि.									
युरिया									
पोटास									
किटनाशक विषाधि १									
किटनाशक विषाधि २									
बनस्पतिक किटनाशक									
जैविक किटनाशक									
दोस्रो चरणको गोडमेल									
सिंचाई									
डि. ए. पि.									
युरिया									
पोटास									
किटनाशक विषाधि १									
किटनाशक विषाधि २									
जैविक किटनाशक									
बालि काट्न/टिप्न/थन्क्याउन									
बेचन लाने र बेच्ने क्रममा									
अन्य :									

गत पन्ध्र दिन भित्रमा परिवारमा भएका प्रत्येक बिरामिको लागि एउटा फारम भर्नुहोस् (प्रत्येक पन्ध्र दिनमा सोधेर भर्ने)

प्र. नं. ७. गत पन्ध्र दिन भित्रमा स्वास्थ्य सम्बन्धि समस्या भोग्ने सदस्यको क्र. सं. नं. र नाम

प्र. नं. ८.बिरामि पनुको कारण के होला ?

प्र. नं. ९. केबिरामि पनु भन्दा अगाडि किटनाशक औषधिको संसर्गमा आउनुभएको थियो ?

१. थियो २. थिएन (यदि थिएन भने १० ज मात्र सोध्नुहोस्) ३. थाहा छैन (यदि थाहा नभएमा १० ज मात्र सोध्नुहोस्)

प्र. नं. १०. बिरामिको किटनाशक विषाधिसंगको संसर्ग सम्बन्धि विवरण

क. बिरामि हुनु अघि संसर्ग भएको किटनाशक विषाधि कुन बालिमा प्रयोग गरिएको थियो?	ख. बालि कुन जातको थियो ?	ग. कुन किटनाशक विषाधि प्रयोग गरिएको थियो ?	घ. कति समय सम्म उक्त विषाधिको संसर्ग भएको हो ? (मिनेटमा)	ङ. कसरि उक्त विषाधिको संसर्ग भयो ? १. विषाधि तयारीमा २. विषाधि हान्दा ३. विषाधि हानेको ठाउँ वरिपरि बस्दा	च. किटनाशक विषाधिको असरबाट बच्न अपनाईएका होसियारि वा उपायहरु के थिए ? (प्र. नं.१२ को प्रश्न नं अनुसारको कोड नं. राख्नुहोस्)	छ. किटनाशक विषाधिको संसर्ग भएको कति समय पछि उक्त स्वास्थ्य समस्याहरु देखिएका हुन ? (मिनेटमा)	ज. भोगेका स्वास्थ्य समस्याहरु (कोड नं. राख्नुहोस्)
फूलकोभी / काउलि							
बन्दाकोभी							
टमाटर							
कांका							
आलु							
सिमि							
मुला							
अन्य :.....							
अन्य :.....							

प्र. नं. १ ब र १० ज को लागि स्वास्थ्य समस्याहरुको कोडलिस्ट (एक भन्दा बढि उत्तर आउन सक्ने)

१. ज्वरो
२. पखाला
३. टाउको दुख्ने वा रिंगटा लाग्ने
४. श्वास फेर्न गाह्रो हुने
५. पेट गडबड वा अफठ्यारो भएको
६. आंखा चिलचिलाउने
७. छाला चिलाउने, पोल्ने वा फोकाहरु देखा पर्ने
८. उच्च रक्तचाप (निधान भएको मात्र)
९. क्यान्सर (निधान भएको मात्र)
१०. वाकवाकि लाग्ने वा उल्टी हुने
११. छारे रोग लागे जस्तो भएको
१२. धेरै तिर्खा लाग्ने वा मुख, तालु सुक्ने
१३. धेरै रयाल आउने
१४. किडनि फेलर
१५. जनडिस
१६. अन्य (उल्लेख गर्नहोस्)

११. विरामिको औषधि उपचार सम्बन्धि जानकारी

उपचार गरिएको स्थान	खर्चको शिर्षकहरु र खर्च भएको रकम								उपचारको परिणाम के भयो ? १. निको भयो २. केहि निको भयो ३. निको हुँदैन ४. केहि फरक भएन ५. भुन विग्रियो
	काम गर्न नसकेर गुमेको आम्दानि	विरामिको सट्टा काम गराउंदा भएको खर्च	भाडा खर्च	दर्ता शुल्क	जचाउंदा र टेप्टहरु गर्न लागेको खर्च	औषधि किन्न भएको खर्च	बस्न, खान र सुचना आदान प्रदानमा भएको खर्च	उपचारको क्रममा भएको जम्मा खर्च	
केहि नगरेको									
घरमै उपचार गरेको									
धामि भौतिकोमा लगेको									
औषधि पसल लगेको									
क्लिनिकमा लगेको									
हे. पो., स. हे. पो. वा प्रा. स्वा. के. लगेको									
जिल्ला वा अञ्चल अस्पताल लगेको									
प्राईभेट अस्पताल लगेको									
अन्य (उल्लेख गर्नुहोस्)									

१२. (प्रश्न नं. ९ च को उत्तरदिने क्रममा जवाफ नआइसकेको भएमा मात्र सोध्ने र ९ च को लागि कोड लिस्ट)

किटनाशक विषाधिको असरबाट बच्न अपनाईएका होसियारी र उपायहरु बारे सोध्ने (√ लगाउनुहोस्)

प्रश्न	पदछु	पददिन
१. के तपाईंले किटनाशक विषाधिको खोलमा लेखेको प्रयोग विधि पढ्नुहुन्छ ?		
२. यदि पढ्न नसके भए के तपाईं किटनाशक विषाधिको खोलमा लेखेको प्रयोग विधि पढ्न अरु कसैको सहयोग लिनुहुन्छ ?	लिन्छु	लिन्न
३. के तपाईं किटनाशक विषाधिको खोलमा लेखेको प्रयोग विधि अनुसार गर्नुहुन्छ ?	गर्छु	गर्दिन
४. के तपाईं हावा चलेको बेला किटनाशक विषाधि हान्नु वा छिट्नुहुन्छ ?	हान्छु वा छिट्छु	हान्दिन / छिट्दिन
५. के तपाईं किटनाशक विषाधि छिट्नु भन्दा अघि हावाको बहावको ख्याल गर्नुहुन्छ ?	गर्छु	गर्दिन
६. के तपाईं किटनाशक विषाधि हानिरहेको बेला खाने कुराहरु खाने वा पिउने कुराहरु वा पेय पदार्थ, चुरोट, बिडि पिउने गर्नुहुन्छ ?	खान्छु वा पिउंछु	खान्न / पिउंदिन
७. के तपाईं किटनाशक विषाधि हालेको बोतल वा ट्याङ्कि पोखरि, नाला वा कुवामा धुनुहुन्छ ?	धुन्छु	धुन्न
८. के तपाईंहरु किटनाशकविषाधि राखेको बोतल वा ट्याङ्कि खानेकुरा संगसंगै राख्नुहुन्छ ?	राख्छौं	राख्दैनौं
९. के तपाईंहरु किटनाशकविषाधि राखेको बोतल वा ट्याङ्किमा खानेकुराहरु संचित गरी राख्नुहुन्छ ?	राख्छौं	राख्दैनौं
१०. के तपाईं किटनाशकविषाधि हानी वा छिटि सके पछि नुहाउनुहुन्छ ?	नुहाउंछु	नुहाउंदिन
११. के तपाईंहरु किटनाशकविषाधि हानी वा छिटि सके पछि लुगाहरु फेर्नुहुन्छ ?	फेर्छु	फेर्दिन
१२. के तपाईंलाई किटनाशकविषाधिको हानी बारे थाहा छ ?	छ	छैन
१३. के तपाईं किटनाशकविषाधिको खोल हेरेर वा पढेर कुन किटनाशकविषाधि कतिको हानीकारक छ भन्ने थाहा पाउनु हुन्छ ?	पाउंछु	पाउंदिन
१४. के तपाईंले किटनाशकविषाधिको प्रयोग सम्बन्धि कुनै तालिम, छलफल वा गोप्टिमा भाग लिनु भएको छ ?	छ	छैन

धन्यवाद

सूपरिवेक्षकको नाम :

फाराम जाँचेको मिति :...../...../.....