RR Interdisciplinary Journal
Vol. 5, No. 5, 35-46, December, 2024 (2081 Mangsir)
https://doi.org/10.3126/rrij.v5i5.78920

Towards Sustainable Agriculture: Socio-Economic and Environmental Impacts of Pesticide and Fertilizer Use in Changunarayan Municipality

Khila Nath Sapkota[1]

ABSTRACT

Chemical fertilizers and pesticides are widely used in agriculture to boost productivity. However, their extensive application poses significant socio-economic and environmental challenges. Sustainable agricultural practices are essential for addressing poverty, protecting environmental quality, and achieving global sustainable development goals. This study examined the socio-economic and environmental impacts of pesticide and fertilizer use in Changunarayan Municipality, Nepal. It focused on health and environmental risks as well as the awareness levels of farmers. A descriptive research design was employed, integrating primary and secondary data, with purposive sampling of 120 households. Data collection involved structured questionnaires, interviews, checklists, and field observations. Quantitative data were analyzed statistically, while qualitative data were interpreted descriptively. The findings reveal that while chemical inputs have improved agricultural productivity, they significantly threaten soil health, water quality, and human health. Over 71% of surveyed farmers reported health issues related to pesticide exposure. The study underscores the urgent need for sustainable alternatives, such as organic farming and Integrated Pest Management (IPM), to mitigate these adverse effects and promote long-term ecological and economic sustainability.

Keywords: *agriculture,* fertilizer, *environmental impacts, pesticide, socioeconomic impacts*

INTRODUCTION

Agriculture remains a major occupation in Nepal, though its contribution to GDP has declined from 36.64% in 2005 to approximately 23% by 2022 (Giri, 2023). This sector continues to support livelihoods for many while facing challenges related to commercial investment and sustainability. Sustainable agricultural practices are crucial for addressing poverty and ensuring environmental quality, which aligns with global goals for sustainable development.

Chemical fertilizers and pesticides are applied in agricultural land to increase its productivity. Fertilizer consumption in Nepal officially began in 1965/66, when 3196 metric tons of fertilizers were received as aid (Pandey et al., 2017). Fertilizer consumption significantly increased in the following decades. For instance, from 1969/70 to 1993/94, the sales of fertilizers grew at an annual rate of 12%. After the government reintroduced subsidies in 2009, fertilizer consumption accelerated further, reaching 259,061 metric tons in 2015/16 under the subsidy program (Bista et al., 2018).

The use of pesticides, particularly organochlorine and organophosphate types, is common in Nepal, where they are primarily employed to control pests and vectors, such as those responsible for malaria and other vector-borne diseases. However, despite their benefits in boosting crop yields and public health, the overuse or improper application of these chemicals can lead to serious environmental

[1] Assistant Professor (PhD Scholar), Department of Rural Development, Ratna Rajyalaxmi Campus, Tribhuvan University, Nepal. Email: khila_sapkota@yahoo.com

and social consequences. These include soil degradation, water pollution, biodiversity loss, and health hazards for both humans and wildlife.

In Nepal, nitrogen-based fertilizers, particularly urea, are widely used, with subsidies continuing since 1992. However, the subsidies have led to an imbalance in fertilizer use, with excessive reliance on nitrogen and insufficient use of phosphorus and potash fertilizers. This imbalance has caused environmental and economic issues, such as soil nutrient depletion, higher production costs, and long-term yield reductions (López-Benítez et al., 2024)

The beneficial aspects of pesticide and fertilizer use are obvious. To protect human health from vector-borne diseases an extensive application of pesticide is often needed to control the vectors. However, fertilizers and pesticides create many specific problems such as increased toxic residues in food products, destruction and degradation of natural resources resulting loss in biodiversity, lowering ground water level, causing water, air and land pollution, loss of soil fertility, health hazards, decreased productivity and increased cost of production and much more. There is no doubt that pesticides and fertilizers, if properly applied can help increase agricultural yields in certain conditions. The problems begin when pesticide and fertilizer use (or misuse) grows excessively that these benefits are outweighed by its costs in terms of long-term yield losses, health effects, environmental damage and financial expenditure (WHO, 2021).

In Nepal Pesticide Act (1992) provides for a registrar and a pesticide board to develop regulations and guidelines but the effective implementation of the regulation has not yet happened. The act does not recognize the issues of environmental justice. The new policy required for the proper arrangements and effective application of pesticide and fertilizer. Historically, Nepal has not paid much attention to the aspects of social equity and environmental justice in the use of pesticides and fertilizers. Various policies, acts, regulations and research have emphasized the quality and quantity of the chemicals much more than socio-cultural and environmental aspects. Most of the studies on the use of pesticide and fertilizer in Nepal very often pay attention to the issues of financial costs, and technical aspects only, with no or less consideration towards the issues of equity, access to opportunities and social and environmental justice. This resulted to social inequality, environmental destruction, and social malpractices. One major ultimate result is poverty. In Changunarayan Municipality, the unbalanced application of fertilizers and pesticides, coupled with limited focus on social equity, has likely exacerbated these issues, disproportionately affecting vulnerable groups within the community. Marginalized farmers may lack access to the benefits of fertilizers and pesticides, while the environmental consequences, such as soil depletion, water contamination, and health risks, negatively impact the broader community. As such, this research explores how the overemphasis on chemical inputs has led to unequal outcomes in rural livelihoods and environmental health in Changunarayan Municipality. By addressing these gaps, the study aims to contribute to a more holistic understanding of agricultural practices, emphasizing not only their productivity benefits but also their social and environmental costs. The specific objectives of the study are as below:

- To assess the socio-economic and environmental impacts of pesticide and fertilizer use on rural livelihoods
- To identify the health and environmental risks and awareness levels among farmers and local communities regarding pesticide and fertilizer use.

LITERATURE REVIEW

The first scientific approach to pest management was documented by John Curtis in his book (1866) Farm Insects. While farmers had long recognized the losses caused by pests, Curtis was the first to highlight their significant economic impact. One notable case was the control of the Colorado potato

beetle in the western United States. When the potato was introduced to Colorado, this beetle devastated crops, spreading across the country and eventually reaching Europe. American entomologist discovered a practical control method by spraying the plants with water-insoluble chemicals like London purple, Paris green, and calcium and lead arsenates (Smith et al., 2021).

Research during World War II in Germany led to the development of more powerful insecticides and acaricides, including organophosphorus compounds. These chemicals were absorbed by plants, which became toxic to insects but generally harmless to the plant itself. However, despite their low cost, these compounds were toxic to humans and other warm-blooded animals, requiring workers to wear protective gear (Jones & Peterson, 2023).

Studies on pesticide residue by Smit (1988) revealed the presence of BHC residue in cattle milk, with levels ranging from 0.04 to 6.12 mg/kg. Jacobson et al. (1989) identified the presence of PCBs, PBBS, and DDT in the serum samples of Michigan children. These findings underline the unintended consequences of pesticide use on human health. The Green Revolution in Asia saw widespread adoption of synthetic fertilizers and pesticides, which boosted productivity. In the 1970s, economists began formulating decision rules for pesticide use based on pest damage functions. By the 1980s and 1990s, the focus had expanded to environmental concerns, with Swinton (1996) emphasizing that farmers were increasingly aware of the health and environmental impacts of chemicals.

Schauber et al. (1995) examined how vegetation height influenced pesticide residue persistence on alfalfa and soil. Their study showed that variations in vegetation structure could significantly affect pesticide exposure for herbivores. Similarly, fertilizer application, as explored in FAO (1966), demonstrated that while fertilizers boost crop yields, their long-term application, especially when unbalanced, could lead to detrimental effects on soil conditions and succeeding crops. Pant and Jain's Agricultural Development in Nepal (1994) highlighted significant policy challenges in Nepal's agricultural sector, with a focus on the constraints posed by pesticide use. The World Health Organization (WHO) estimates that pesticide poisoning causes over one million cases and 20,000 deaths annually worldwide (WHO, 2021). Similarly, Kabra (1998) identified that pesticides, by antagonizing folic acid, contribute to neural tube defects in infants, further stressing the need for integrated approaches.

Integrated Pest Management (IPM), introduced as an alternative, aims to reduce chemical pesticide use while maintaining crop productivity. It involves cultural, biological, genetic, and chemical control methods, with pesticides applied only when necessary. A key success story from Indonesia in 1975 showed that banning broad-spectrum insecticides and adopting IPM increased rice yields by 20% (Dahal, 1995). Despite demonstrated success, the countrywide adoption of IPM remains limited. Current research into the socio-economic and environmental justice aspects of pesticide and fertilizer use remains insufficient. There is a pressing need for more studies to improve our understanding of these issues and inform policy development (Khadga, 2024).

RESEARCH METHODOLOGY

This study adopts a descriptive research design, combining both primary and secondary data sources to provide a comprehensive analysis of the socio-economic and environmental impacts of pesticide and fertilizer use. Primary data was gathered through field observations and interviews with respondents, while secondary data was collected from a review of relevant literature. The secondary data helped substantiate and enrich the primary data, allowing for a thorough examination of the research topic.

For sampling, purposive sampling was employed to select two wards from Changunarayan Municipality in Bhaktapur District, based on the varying levels of pesticide and fertilizer use. Ward No. 6, known for higher pesticide and fertilizer usage, and Ward No. 1, with lower usage, were chosen to

facilitate a comparative analysis. From each ward, 60 households were purposively selected, focusing on farmers with a long history of chemical use. One member, preferably the household head, was interviewed from each of these households, resulting in a total of 120 respondents. Special emphasis was placed on including marginalized, poor, and female farmers to ensure diversity and inclusivity in the sample.

Data collection involved multiple tools: a structured questionnaire survey to gather both qualitative and quantitative data, a checklist to guide interviews and ensure comprehensive coverage of relevant topics, and direct observation during field visits to capture firsthand insights into pesticide and fertilizer use as well as general agricultural practices. Qualitative data, including personal expressions, implementation practices, and perceived impacts (both positive and negative), were collected through the interviews and field observations.

For data analysis, quantitative data were analyzed using basic statistical techniques such as calculating percentages and means, allowing for a comparative analysis of responses. The results were presented in tabular and graphical formats for clarity and ease of understanding. The majority of the analysis, however, was qualitative, focusing on categorizing and ranking responses, with a descriptive approach used to interpret the findings. These insights were further supported by the qualitative information gathered from interviews and observations, providing a rich, multifaceted perspective on the issues under investigation.

Description of the Study Area

Bhaktapur District, located in Bagmati Province, Nepal, is one of the smallest districts, covering 138.46 square kilometers, but is densely populated. It plays a vital role in the socio-economic structure of the Kathmandu Valley due to its historical, cultural, and agricultural significance (District Profile, 2023). Within the district, Changunarayan Municipality spans 27.5 square kilometers and houses approximately 55,000 residents across nine wards. It is known for the UNESCO-listed Changunarayan Temple. The municipality balances urbanization with agriculture, which remains a key livelihood. Fertile lands support the cultivation of rice, maize, wheat, and vegetables (Profile of Changunaraya, 2022).

The study area, Ward Nos. 1 and 6 of Changunarayan Municipality, represents the agricultural backbone of the region, with many residents engaged in farming. These wards are known for cultivating rice, maize, and vegetables, supported by favorable soils and climatic conditions. However, urban expansion has reduced agricultural land, leading to a growing reliance on chemical fertilizers and pesticides. Despite these challenges, there is significant potential for adopting sustainable farming practices to ensure long-term productivity and environmental conservation. Ward No. 1 has a population of 7,143 across 2,638 households, while Ward No. 6 has a population of 4,936 in 1,833 households (NSO, 2022).

RESULTS AND DISCUSSION

The sampled households for this study were from Ward No. 1 and 6 of Changunarayan Municipality. This section of the paper highlights the types of families and their educational status, the ethnic composition of the beneficiaries, and the practices of pesticide and fertilizer use in agricultural production in the study area. Similarly, the occupations, earnings, and major uses of landholdings are also discussed briefly.

Level of Education of the Respondents

The table below illustrates that the literacy percent of the beneficiaries is nearly equal to the national literacy level. About 58 percent of beneficiaries are literate and the remaining 42 percent are illiterate. Normal literate occupies a higher percentage (23%) among literacy level, which is followed

by primary education (14%). Whereas secondary level and higher secondary level education occupy nearly equal proportions (11% and 10%).

Table 1

Level of Education in the Study Area

Condition/Type	Number	Percentage
Illiterate	50	41.67
Normal Literate	28	23.33
Primary (1-5)	17	14.16
Secondary (5-10)	13	10.84
Higher (10+)	12	10.00
Total	120	100.00

Note. Field Survey, 2023.

No doubt there is a significant relationship between the level of education and proper use of pesticides and fertilizers, it was found that due to low level of education, there is high level of misuse/improper use of pesticides and fertilizers in the study area.

Occupation of the Sampled Households

The occupation is the work that determines the life style of a person. So occupation itself gives different status to man in society. And it also can determine how much pesticides and fertilizers were used by the household.

Table 2

Occupation of the Sampled Household

Type	Number	Percentage
Agriculture	79	65.84
Service	16	13.33
Foreign employment	3	2.50
Business	18	15.00
Others	4	3.33
Total	120	100.00

Note. Field Survey, 2023.

The occupation may be of different types but categories, which are illustrated in the above table, are agriculture, service, foreign employment, business and others. The table (Table 2) shows that about 66 percent Households are engaged in agriculture sector as a primary occupation. About 15 percent respond are also doing their own business besides Agriculture followed by service holder (13%), whereas nearly 2 and 3 percent are engaged in foreign employment and other types of occupation as their secondary source of income.

Major Use of Landholding of the Sampled Households

Since Agriculture is the primary occupation of the household, most of their land has been used for agricultural purpose. As illustrated in the table 3 more than 82 percent of land has been used for agriculture production such as paddy, wheat, maize, legumes, vegetables, livestock rearing etc and about 9 percent land has been used for horticulture and remaining 8 percent land has been used for business purpose and other purposes. It means respondent in the study area used large quantity of chemical pesticides and fertilizer for agriculture purpose.

Table 3

Major use of Landholding of the Sampled Household

Use	Number	Percentage
Agriculture	99	82.50
Horticulture	11	9.17
Business/Rent	6	5.00
Others	4	3.33
Total	120	100.00

Note. Field Survey, 2023.

Earning/Income from Agricultural Production

Level of pesticide and fertilizer use, highly depends on earning/income of the people. Analysis on this heading can identify economic surplus of the respondent. The earning of HH in this heading includes cash and other kind like crop they grew in their land.

Table 4

Earning/Income from Agricultural Production

Earning/Year	Number	Percentage
More than 80,000	4	3.34
60,000-80,000	22	18.33
40,000-60,000	63	52.50
20,000-40,000	24	20.00
Less than 20,000	7	5.83
Total	120	100.00

Note. Field Survey, 2023.

It is found from the above table that about 52.50 percent of respondent earn NRs 40,000 to 60,000 annually. The table also illustrates that about 26 percent HH lies under annual income less than 40,000, which comprises about 20 percent with annual income NRs 20,000 to 40,000 and about 6 percent with annual income less than NRS 20,000. Remaining 18 percent earn about NRS 60,000 to 80,000 per year while only about 3 percent HH in the study area earn more than NRs 80,000 annually from agriculture production.

Using Chemical Pesticides and Fertilizers

The below table shows that more than one-third of the farmers using chemical pesticides and fertilizers for 7 to 9 years and more than one-fourth of the farmers using it for 5 to 7 years. Likewise about 22 percent farmers using chemicals for more than 10 years and nearly 17 percent farmers applying chemicals in recent years.

Table 5

No. of Years Farming Using Chemical Pesticides and Fertilizers

Duration	Number	Percentage
Less than 5 years	20	16.67
5-7 years	32	26.67
7-9 years	42	35.00
More than 10 years	26	21.66
Total	120	100.00

Note. Field Survey, 2023.

Types of Fertilizers and Pesticides Used

Among various kind of pesticide and fertilizers most commonly used type are listed here below, and percentage of farmers using these chemicals are also listed in the table below:

Table 6

Types of Fertilizers and Pesticides Used

Types	Number	Percentage
Urea	102	85.00
DAP	100	83.33
A/sulphate	96	80.00
Potash	96	80.00
Insecticdes	113	94.16
Weedicides	15	12.50
Rodenticides	38	31.67
Fungicides	36	10.00
Others	14	11.67

Note. Field Survey, 2023.

Table 6 illustrates that about 94 percent of the farmers used insecticides as a pesticides followed by rodenticides and fungicides (31% and 30%). Whereas 85 percent of the farmers used urea as a major fertilizer followed by DAP (83%) and A/Sulphate, Potash were other largely used fertilizers.

Level of Awareness about Safety Measure

Receiving advice regarding safety precautions is necessary but at the same time, following this advice is even more important. It was found that nearly 81% farmers have taken some form of precautionary health measure while applying chemical inputs (Table 7).

Table 7

Level of Awareness about Safety Measures

Safety measures	Number	Percentage
Wearing apron	7	7.21
Wearing gloves	88	90.72
Wearing mask	87	89.69
Read expiry date	42	43.29
Read composition	4	4.12
Safety disposing	16	16.49
Washing hand with soap	23	23.71
Caring wind direction while spraying	13	13.40

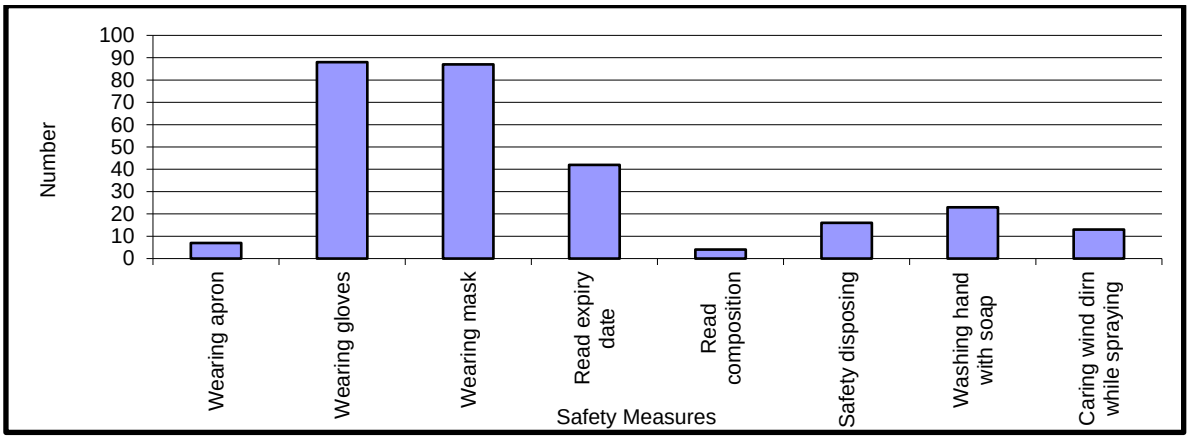
Note. Field Survey, 2023.

The table 7 reveals, out of 81 percent of the respondent who took precautionary health measure while applying chemicals, 91 percent wear gloves and nearly 90 percent covered their mouth and nose with mask, while 43 percent respondent read expiry date but only about 4 percent of respondent care about composition. Similarly, 24 percent of respondent washed their hands with soap after applying chemicals and only 13 percent farmers cared about wind direction while spraying (figure 1).

It should be noted here that the respondent who used precautionary measures, was ineffective protection against toxic chemicals and there was also low level of awareness regarding safety disposing of pesticides only about 16 percent respondent dispose chemicals safety.

Figure 1

Level of Awareness about Safety Measures



Note. Plot from Table 7

Problems Regarding the Use of Fertilizers and Pesticides

Social inequity increases due to various difficulties regarding the use of chemical pesticides and fertilizers, it was found that low-income level and marginalized people in the society have faced these difficulties.

Table 8

Difficulties Faced in Using Fertilizers and Pesticides

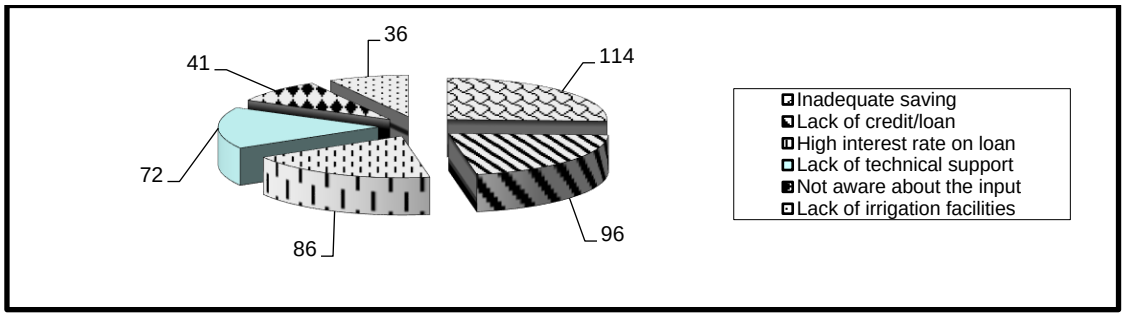
Difficulties	Number	Percentage
Inadequate saving	114	95.00
Lack of credit/loan	96	80.00
High interest rate on loan	86	71.67
Lack of technical support	72	60.00
Not aware about the input	41	34.16
Lack of irrigation facilities	36	30.00

Note. Field Survey, 2023.

It was found from the above table that 95 percent farmers faced difficulty due to inadequate saving, 80 percent respondent told that they have lack of credit/loan in chemical inputs. Sometimes, they got loan but high interest rate on loan is a great problem for nearly 72 percent of respondent. Lack of technical support and lack of irrigation facilities are also major difficulty in the use of pesticides and fertilizers according to 60 percent and 30 percent of respondent respectively. The figure below reflects the situation more clearly.

Figure 2

Difficulties Faced in Using Fertilizers and Pesticides



Note. Plot from Table 8

Economic Impacts of the Use of Fertilizers and Pesticides

For this, crop yield (production) and expenditure in chemical are taken as a measuring instrument. It is also noted that for the same quantity of production inputs should be increase every year, which means cost of production increases every year.

The survey revealed that production increased by the use of chemical fertilizers and pesticides. Besides these improved seeds and irrigation are also major inputs for production increase.

Table 9

Crop Yield

Production	Number	Percentage
Highly increased	21	17.50
Moderately increased	50	41.67
Slightly increased	47	39.17
Decreased	2	1.66
Total	120	100.00

Note. Field Survey, 2023.

Among all respondent farmers, only about 2 percent claimed for decrease in production whereas nearly 42 percent found moderately increased in production and 39 percent found slight increase in production. But 17 percent respondent claimed for high increase in production with the use of chemical pesticides and fertilizers. More than 75 percent of respondent believe chemical fertilizer and pesticides is the main reason for increase in production.

Reason for Production Increase

The majority of respondent who believed in increase in agricultural production stated various reasons for its rise. More than half of them agreed chemical fertilizers to be the main cause while the remaining said chemical pesticides, improved seeds, irrigation and other factor are responsible to promote crop yield which are given in table below:

Table 10

Reason for Production Increase

Due to	Number	Percentage
Improved seeds	14	11.67
Chemical fertilizers	63	52.50
Chemical pesticides	28	23.33
Irrigation	11	9.17
Others	4	3.33
Total	120	100.00

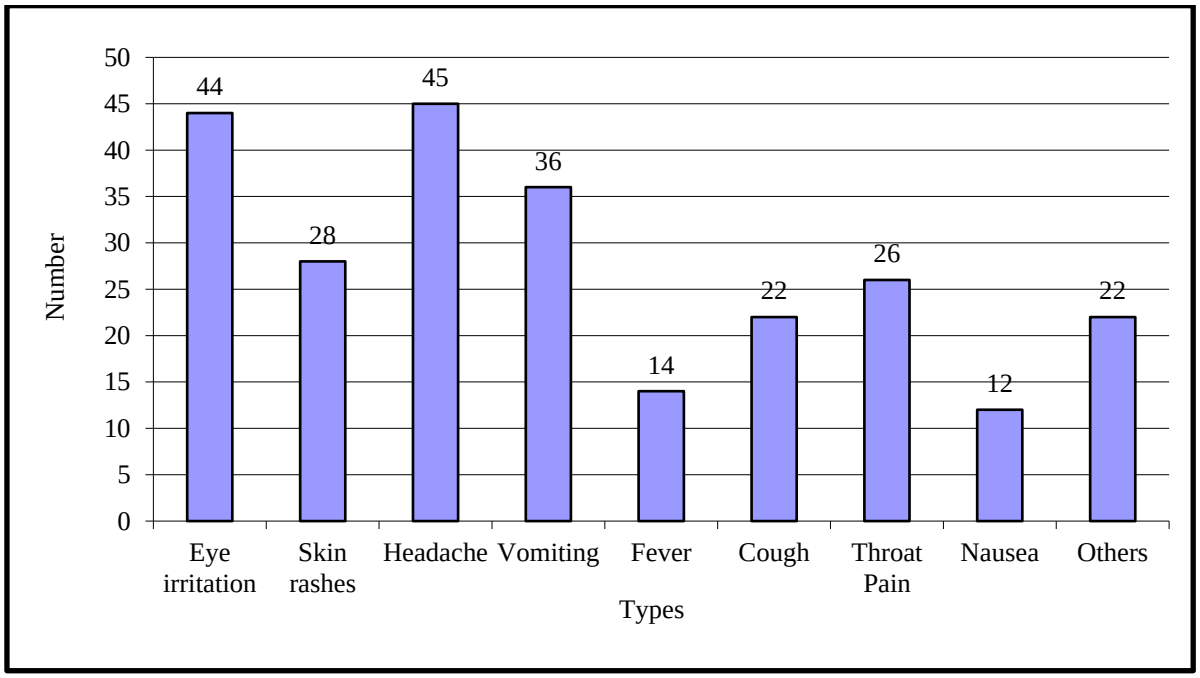
Note. Field Survey, 2023.

Health Effect and Health Hazard

Health problems noted by the respondents after the application of chemicals are headaches, vomiting, skin rashes, eye irritation, throat pain, cough, fever and nausea. The figure 3 shows that more than half of respondent are suffering from headache and eye irritation as a major problem after application. Similarly 42 percent and 33 of respondent have a problem of vomiting and skin rashes. Where as throat pain, cough, fever and Nausea are other problems faced by 30, 18, 16 and 14 percent of respondents respectively. The health hazards that suffer respondents are also shown in below figure.

Figure 3

Health Hazards



Note. Field Survey, 2023.

Environmental Effect

Regarding environmental effect of pesticides and fertilizers, its effect is visible in the long run. It was found in the study area that chemical pesticides and fertilizers causing several types of damages. It is responsible for lowering of biodiversity, water pollution, soil pollution, air pollution and much more. Some major damages found in the study area are discussed here below.

Table 11

Types of Environmental Pollutions

Types	Number	Percentage
Water	32	26.67
Air	11	9.17
Vegetation	21	17.50
Soil	53	44.16
Others	3	2.50
Total	120	100.00

Note. Field Survey, 2023.

The table revealed, nearly half (44%) of the respondents claimed soil pollution in their locality with the use of chemical inputs and one fourth (27%) of respondents claimed for water pollution in their locality, another 17 percent claimed for damages in vegetation and about 9 percent found air pollution in their surroundings.

FINDINGS

The survey revealed an increase in the use of chemical pesticides and fertilizers, with both retailers and farmers having limited knowledge of their hazards to human health and the environment. Chemical inputs are being imported, formulated, and distributed haphazardly, leading to social inequities. Factors such as inadequate savings, lack of credit, high production costs, and limited technical support contribute to these inequities, particularly among low-income farmers.

The misuse of agrochemicals disrupts traditional pest management systems, causing health and environmental risks. Traditional agricultural practices, including the use of natural resources for pest management, were found to be more effective and safer than chemicals. Many farmers reported positive results from non-chemical alternatives, including better crop yield and healthier plants. However, there is a lack of awareness about Integrated Pest Management (IPM) and its benefits.

Key findings identified include:

- The study reveals that the extensive use of pesticides and fertilizers in Changunarayan Municipality has improved agricultural productivity but poses significant risks to soil health, water quality, and human health.
- Socio-economically, while farmers benefit from short-term yield increases, long-term environmental degradation and rising input costs threaten sustainable agricultural livelihoods
- Chemical fertilizers to be the main cause while the remaining said chemical pesticides, improved seeds, irrigation and other factor are responsible to promote crop yield
- Pesticide poisoning due to improper use of chemicals
- Increased production costs from higher pesticide and fertilizer usage
- Social inequities stemming from financial barriers and low awareness
- Environmental pollution from pesticide spraying and improper disposal
- Organic and traditional pest control methods are more cost-effective and eco-friendly than chemicals.

CONCLUSION

Chemical pesticides and fertilizers have significantly boosted agricultural productivity in Nepal and have helped control vector-borne diseases like malaria and kala-azar. However, their use has become increasingly criticized due to negative health and environmental effects. Most pesticides inherently pose risks to humans, animals, and the environment, as they are designed to harm living organisms. While useful in controlling pests and disease-causing organisms, studies show chemicals can cause health issues such as birth defects, nerve damage, and cancer over time.

In Nepal, the misuse of pesticides and fertilizers is widespread, with farmers often using inappropriate chemicals, applying incorrect doses, or failing to take safety precautions during application. As a result, more than 71% of surveyed farmers reported health issues related to pesticide exposure. Pesticides, particularly organochlorines and organophosphates, persist in the environment and cause damage such as reduced biodiversity, water and soil pollution, and broader environmental contamination.

REFERENCES

Baker, S. L., & Gyawali, B. K. (1994). Promoting proper pesticide use in Nepal. *Policy Analysis in Agriculture and Related Resource Management.* Ministry of Agriculture/Winrock International.

Bista, D. R., Dhungel, S., & Adhikari, S. (2018). Status of fertilizer and seed subsidy in Nepal: Review and recommendation. *Journal of Agriculture and Environment, 17,* 1–10. https://doi.org/10.3126/aej.v17i0.19854

Changunarayan Municipality Profile. (2022). *Changunarayan Municipality*

Curtis, J. (1866). *Farm insects: Being the natural history and economy of the insects injurious to the field crops of Great Britain and Ireland.* Blackie and Son

DADO. (2003). *Annual agriculture development programme and statistical book.* Bhaktapur: District Agriculture Development Office.

Dahal, L. (1995). A study on pesticide pollution in Nepal. *National Conservation Strategy Implementation Project.* IUCN Nepal.

District Profile. (2023). Bhaktapur district profile. *Bhaktapur District.*

FAO. (1966). *Fertilizer application and its effects on crop yields.* Food and Agriculture Organization of the United Nations.

FAO. (1966). *Statistics of crop responses to fertilizer.* FAO Food and Agriculture Organization of the United Nations.

Giri, P. (2023, July 20). Agriculture growth through investment. *Kathmandu Post.* kathmandupost.com

HMG/N. (1992). *Pesticide Act.* Kathmandu: His Majesty Government of Nepal.

Jacobson, J., Fein, G. G., Jacobson, S. W., Schwartz, P. M., & Dowler, J. K. (1989). DDT and PCB levels in serum samples from Michigan children. *Environmental Health Perspectives, 40* (2), 125–131

Jones, R., & Peterson, D. (2023). Toxicology of organophosphates: Human and animal health risks. *Environmental Toxicology Journal, 45*(2), 102–115.

Kabra, S. G. (1998). Pesticides and their effects on folic acid and neural tube defects. *Indian Journal of Health Sciences, 12*(4), 134–139. https://pmc.ncbi.nlm.nih.gov/articles/PMC6029725/

Khadga, K. (2024). *Socio-economic and environmental impacts of pesticide and fertilizer use in agriculture: Evidence from Changunarayan Municipality.* [Unpublished research]. Tribhuvan University

López-Benítez, A., Guevara-Lara, A., Domínguez-Crespo, M. A., Andraca-Adame, J. A., & Torres-Huerta, A. M. (2024). Concentrations of organochlorine, organophosphorus, and pyrethroid pesticides in rivers worldwide (2014–2024): A review. *Sustainability, 16*(18). https://doi.org/10.3390/su16188066

National Statistics Office (NSO). (2022). *Rastriya Krishi Ganana, 2078.* National Statistics Office, Nepal.

Pandey, G., Khanal, S., Pant, D., Chhetri, A., & Basnet, S. (2017). An overview of fertilizer distribution scenario in Nepal: A time series analysis (1991/92–2015/16). *International Journal of Research in Agricultural Sciences, 4*(6), 2348–3997

Pant, B., & Jain, R. (1994). *Agricultural development in Nepal: Constraints and opportunities.* Kathmandu: Agricultural Development Publishers.

Schauber, E. M., Edge, W. D., & Wolff, J. O. (1995). Influence of vegetation height on the distribution and persistence of insecticide residue on alfalfa and soil.

Sharma, K. C. (1990). Pesticide policies and strategies. *Paper Presented at the Seminar on Pesticides and Our Environment on the Occasion of World Environment Day.*

Smit, L. E. (1988). Survey of pesticides in milk. *South African Journal of Dairy Science, 20*(1). https://pubmed.ncbi.nlm.nih.gov/35876099/

Smith, D., et al. (2021). Pest control and insecticide history: From Curtis to the modern era. *Journal of Agricultural History, 34*(3), 214–230. https://styluspub.presswarehouse.com/

Swinton, S. (1996). Farmers' health concerns and environmental impacts of pesticide use. *Agricultural Economics Review, 28*(4), 300–310. https://agris.fao.org/

WHO. (2021). *Global pesticide poisoning statistics.* World Health Organization.