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PESTICIDE EXPOSURE, ENVIRONMENTAL DEGRADATION, AND FARMER HEALTH: EVIDENCE FROM PUNJAB, PAKISTAN

EXPOSIÇÃO A PESTICIDAS, DEGRADAÇÃO AMBIENTAL E SAÚDE DOS AGRICULTORES: EVIDÊNCIAS DE PUNJAB, PAQUISTÃO

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Abstract
This study examined pesticide use and associated human health effects in Punjab, Pakistan, with particular focus on the cotton-growing belt of South Punjab. A descriptive and correlational research design was adopted. Three districts, Attock from North Punjab, Sargodha from Central Punjab, and Multan from South Punjab were selected based on regional representation and feasibility. Sample size (384) was determined using a 95% confidence level and 5% margin of error. Data were collected through a structured interview schedule developed from literature and expert consultation. Data were coded in Microsoft Excel and analyzed in SPSS using descriptive statistics, and regression. Weighted scores were calculated to rank Likert-scale responses. Findings revealed that a high dependence on pesticides combined with unsafe application practices and limited environmental awareness. Farmers possess general knowledge

Resumo
Este estudo analisou o uso de pesticidas e os efeitos associados à saúde humana em Punjab, Paquistão, com foco particular na região produtora de algodão do sul de Punjab. Foi adotado um desenho de pesquisa descritivo e correlacional. Três distritos, Attock, no norte de Punjab, Sargodha, no centro de Punjab, e Multan, no sul de Punjab, foram selecionados com base na representatividade regional e na viabilidade. A dimensão da amostra (384) foi determinada utilizando um nível de confiança de 95% e uma margem de erro de 5%. Os dados foram recolhidos através de um calendário de entrevistas estruturadas desenvolvido a partir da literatura e de consultas a especialistas. Os dados foram codificados no Microsoft Excel e analisados no SPSS utilizando estatísticas descritivas e regressão. Foram calculadas pontuações ponderadas para classificar as respostas da escala de Likert. Os resultados

about immediate health risks but lack technical understanding of safe use, environmental protection, and alternative pest control methods. Weak engagement with formal advisory services and heavy reliance on dealers and peers further increase the risk of misuse. The study highlighted a dire need for simplified label communication, strengthened extension services, farmer training on safe pesticide handling, and promotion of integrated pest management (IPM) to reduce health and environmental hazards.

Keywords: Pesticides Application. Environment. Human Health. Farming Community Punjab. Punjab (Pakistan).

revelaram uma elevada dependência de pesticidas, combinada com práticas de aplicação inseguras e uma consciência ambiental limitada. Os agricultores possuem conhecimentos gerais sobre os riscos imediatos para a saúde, mas carecem de compreensão técnica sobre o uso seguro, a proteção ambiental e métodos alternativos de controlo de pragas. O fraco envolvimento com serviços de aconselhamento formais e a forte dependência de revendedores e pares aumentam ainda mais o risco de uso indevido. O estudo destacou a necessidade urgente de uma comunicação simplificada nos rótulos, serviços de extensão reforçados, formação dos agricultores sobre o manuseamento seguro de pesticidas e promoção da gestão integrada de pragas (IPM) para reduzir os riscos para a saúde e o ambiente.

Palavras-chave: *Aplicação de Pesticidas. Ambiente. Saúde Humana. Comunidade Agrícola do Punjab. Punjab (Paquistão).*

1 INTRODUCTION

Punjab's agricultural sector is one of the most critical economic and food-producing subsectors in the state. Punjab mainly focuses on agriculture due to availability of good soil & appropriate climatic conditions; it grows many crops. However, increased use of pesticides in increasing farm yields and controlling pests has been associated with environmentally and health effects on the farmers (Khan & Damalas, 2014). Pesticide has always been on the farming system as a tool that is commonly used in enhancing crop production through the removal of pests (Mehmood et al. 2020). The environmental impacts include the degradation of soil, water contamination, and also loss of biodiversity, all of which tend to pose a threat to the sustainability of agricultural ecosystems (Banerjee et al., 2014). Furthermore, the health impact on the farming population is enormous, which, upon exposure to acute poisoning, also triggers chronic illnesses in the form of cancers and also neurological dysfunctions (Mittal et al., 2013). Health risks include acute poisoning and long-term health effects, while environmental issues involve soil degradation, water contamination, and harm to non-target species such as beneficial insects, birds, and aquatic life (Tarar, 2019).

Agricultural personnel such as farmers or agricultural workers are prone to contracting acute pesticide poisoning because of possibility of direct contact with the chemical during application. The acute effects of mining are manifestation of symptoms such as headache, dizziness, nausea and skin rashes (Rashid et al., 2022). There is more to the health effects of Pesticides effects on farmers and their families. It is high transference since it can be carried into homes through the clothes and affects family members including children. This secondary exposure might result in development difficulties and other health complications to children (Kaur et al., 2018). The health of the entire family can be affected throughout their lifecycle, but the special attention should be paid to the children and prenatal women to decrease pesticide exposure for them (Bakhtawer & Afsheen, 2021). With this background, present study is going to be designed to assess the effects of pesticides application on human health and environment in the Punjab, Pakistan.

2 MATERIALS & METHODS

The rich agricultural legacy of Punjab, largely rural area, is intricately woven into the socioeconomic fabric. Growing a wide variety of crops, the area makes a significant contribution to Pakistan's agricultural production. The present study is descriptive and correlational in nature since it gives an opportunity to this social science researcher to describe research in question with utmost detail and necessary measures are explained at each level with assessing significant relationship through different statistical techniques such as correlation and regression analysis. Since the study focus is North, Central and South of Punjab, therefore three districts of Punjab i.e. Sargodha (from central Punjab), Attock (from North Punjab) and Multan (from south Punjab) to assess the effect of pesticides use on human health were conveniently selected keeping in view the available time, distance and financial constraints.

The study population was heterogeneous with varying characteristics and was unknown. Therefore, the sample size for the present study was calculated through online website http://www.raosoft.com/samplesize.html keeping 5% margin of error, 95% confidence level, random population size as 4000000 and response distribution as 49%. The survey instrument and comprehensive interview schedule depicting all the objectives

of the study was well prepared. The survey instrument was prepared after thorough discussion with the experts and after going through relevant literature and formulating research objectives. Keeping in view the nature of the study, the structured interview schedule (as per objectives of the study) was used as an instrument for data collection. An interview schedule can be defined as a survey instrument that comprises of items that are to be asked for data collection. It is formulated according to the study objectives. It is a technical research instrument which enables researcher to collect the data accurately as much as possible. Validity and reliability of the survey instrument developed were checked by the panel of experts and pre-testing on 21 respondents. Minor doubts were identified and removed by making some revisions in interview schedule before actual execution of the study.

A face to face interview schedule was employed for data collection. The data were very comprehensively analyzed for the study. Firstly, data were coded and entered into Microsoft Excel. This software is helpful for data entry and data management. It is easy to handle and can be used for all types of editing and correction with ease. Secondly, the data were exported to SPSS for analysis including regression. Results were easy to interpret in this software. The researcher also calculated weighted score for different variables rated by the respondents on 5-point scale. The formula used for calculation is given by:

Weighted score = $\sum$ (weight of each response on scale x frequency of each scale)

3 RESULTS AND DISCUSSION

3.1 Socio-economic characteristics of the respondents

In social research surveys, normally the first part is always consisting of demographical information of the respondents which you are interviewing (the interviewees). Therefore, this study also consisted of first section as demographics which includes age, education level, experience, Landholding, Crops grown and different questions related to Plant Health Clinics.

3.2 Age of the respondents

Age was defined by Hashmi (2016) as "the cumulative number of years since a person's birth." Age is the cumulative sum of a person's years since birth. The data regarding the age of the respondents are presented in the following table.

Table 1

Age group of the sampled individuals

Age Group	**Frequency**	**Percent**
Upto 25 Years	30	7.8
26-40 Years	108	28.1
41-45 Years	89	23.2
46-50 years	70	18.2
51-55 years	30	7.8
56 Years or above	57	14.8
Total	**384**	**100.0**

The Age Group of the Sampled Individuals table divides the respondents' age into four groups that show the farmers' demographic characteristics of the surveyed group. Out of 384 participants, 49.2% of clients are between 41 to 55 years representing the largest cluster. This is then succeeded by 28.1% in the 26-40 age group, which consists of youths who have adequate experience to perform activities. 7.8% are up to 25 years of age, thus admitting a very small portion of the youth. The oldest group, 56 years and above, forms 14.8% of the total population. It is evident from this data that most of the farmers in the surveyed area are middle aged most probably due to experience and physique to handle farming activities. On the other hand, low participation rate from those in young and elder age might partly be due to issues like lack of entry point for the young or decreased patronage due to old age. It reaffirms this research's main discovery, namely the fact that farming activities remain predominated by younger people, which has consequences on the magnitude and heeds of preserving the farming practices and knowledge.

3.3 Education of the farmers

Ahmad et al. (2020) identified in his research a very important role in teaching how to experience innovation. Teaching reading is great because it affects a person's behavior. The data regarding the education level of the respondents are presented in the following table.

Table 2

Education level of the literate individuals

Educational Levwl	**Frequency**	**Percent**
Illiterate	66	17.2
upto Matriculation	165	43.0
Intermediate	104	27.1
Graduation or above	49	12.8
Total	**384**	**100.0**

More details about the respondents' literacy levels were presented in the Education Level of Literate Individuals table to show the variety of their education. Out of 384 people 17.2% have no formal education even though they are literate this might be as a result of functional illiteracy attained through work experience. Matriculation education level is the most common level among the respondents since 43.0% has completed it. In addition, 27.1% have intermediate qualifications and clearly, there is a well-educated segment of farmers. While 12.8 % of the women have graduation level or above education allowing them to cross the below and above basic education level. Such variation in education levels indicates that the capacities to assimilate and adapt to improved agricultural practices vary. Higher education farmers may undertake more of the new facility innovations while lower levels of education farmers may require more practice and guidance. According to the data, it is crucial to incorporate flexible health literacy styles into the design of agricultural literacy material and programs.

3.4 Income source of the family

The data regarding family income sources is given in the following table:

Table 3

Family income sources

Income Source	**Frequency**	**Percent**
Farming only	242	63.0
Both farming and non-farming	142	37.0
Total	**384**	**100.0**

Income Source of Families indicates the major functions that the respondents' source their income. The largest percentage, 63% depend solely on farming as their principal source of income supporting the fact that the community is mostly engaged in farming activities. However, 37% combine farming with other off-farm income sources, though the level of diversification is low. This diversification appears to offer risk mitigation of chances linked to agricultural earnings including low crop yields or low market prices. Despite being considered second sources of income, non-farming incomes have an important function of meeting households' needs and financing farming activities. This further means that farming is the main source of income and this exposes the community to shocks which are climatic as well as those that affect agriculture in the market. This work underscores the need for the continued support of the Agricultural Sustainability with provision of non-farming income generating activities to improve the household financial security among farming households as indicated below.

3.5 Size of landholding

Size of a landholding denotes the farm size of a farmer and his family's for crops/plants and animal output. Concerning technology transfers a core assumption that innovation will occur in larger farms earlier than in smaller farms (Yassin et al., 2002). The scale of land ownership plays a very important role in the application of new technologies or new methods. Hence, the categories of landholding of the farmers include; up to 5 acres, 6 to 10 acres, 11 to 15 acres and above 15 acres. The following table shows the distribution of respondents by size of their landholding.

Table 4

Landholding size of the farmers

Land Holding Size	Frequency	Percent
Upto 05 Acres	44	11.5
6-10 Acres	91	23.7
11-15 Acres	223	58.1
16 Acres or more	26	6.7
Total	**384**	**100.0**

The percentage of respondents having farmland size is reflected by the Landholding Size of Farmers table. Nearly two-third 58.1% own 11-15 acres, whereas 23.7% own 6 -10 acres, therefore showing that the farm was mostly of moderate size. Only a very small percentage of farms, 6.7 percent own 16 acres or more, while only 11.5 percent owns 5 acres or less. These statistics show the numbers of relatively medium size of land holding which is may be significant bearing in mind the availability of resource for managing a piece of land. Small farmers may have difficulties attaining scale economies or adopting appropriate technologies or high yield inputs and outputs whereas large farms may benefit from mechanized farming and high yields. The distribution provides a basis to suggest that most farmers are well suited for such intervention measures as cooperative farming or credit facility for purposes of upgrading on technology. An analysis of the distribution of landholding is important especially when making policy decisions and planning what to provide for large and small farms.

Table 5

Years of using pesticide

Years of using pesticide	Frequency	Percent
Up to 10 years	19	5.0
11 to 20 years	179	46.6
21 to 30 years	141	36.8
Above 30 years	45	11.7
Total	**384**	**100.0**

The Duration of Pesticide Use table looks at the number of years farmers have been using pesticide. Of those who responded 46.6% reported that they have applied pesticides for more than 11 – 20 years while 36.8% have applied of pesticides for more than 21 – 30 years. A proportion of 11.7% has used them for 30 years or more while only 5% has used them for a one to 10 years only. These findings attest to the fact that the use

of pesticide is not a new thing in the society as more than nine out of ten farmers have more than twenty years' experience in the use of the product. However, such use if not conducted with appropriate understanding of safe operations poses some danger to human health and environment in the long run. The information discussed in the data also underlines the importance of campaigns to inform farmers about the proper use of pesticide as many of pesticide-requiring crops have long histories of utilization, and farmer may need to adapt to the modern and environmentally friendly practices.

3.6 Reasons behind pesticides application

Table 6

Major factors/reasons behind application of pesticides

Reasons	**Frequency**	**Percent**
Enhance farm production	384	100.0
Control of insect/pest	384	100.0
Weed eradication	382	99.5
Disease control	380	99.0
Household pest's control	98	25.5
No awareness regarding alternate methods of pest control	384	100.0
Alternate pest controlling methods are not easily available	51	13.3
Total	**384**	**100.0**

Presented on the Reasons for Applying Pesticides table, the primary reasons include: All farmers give the following reasons for using fb: to increase farm production, pests control and ignorance of other pest control methods as rated 100%. Almost all, 99.5% also see managing weeds, and 99% diseases as other reasons. Interestingly, none of the respondents mentioned such factors as small landholding size or effectiveness of non-chemical methods which could suggest that, while making their decisions, economic and knowledge factors play a predetermining role. Lack of other strategies indicates lack of consciousness or inadequacy of the means available in the course. Farmer groups and entomologists should encourage the adoption of IPM and help farmers to close these gaps. They could possibly contribute to the improvements of productivity standards without compromising the environmental and health nuts. This also indicates that application of pesticides is essential for crop production but the irrational and non-judicious use of

pesticides is harmful for environment and human health. These findings were also reported by Nafees et al., (2008) and Zulfiqar and Thapa (2017).

Table 7

Which crop/fruit/vegetable receive application of pesticides mostly

**multiple responses*

Crop/fruit/vegetable	Frequency	Percent
Wheat	61	15.9
Rice	104	27.1
Corn	225	58.6
Cotton	384	100.0
Fodder	34	8.9
Sugarcane	147	38.3
Vegetables/Fruits	86	22.4

The list of crops receiving pesticides is presented in the table Crops/Produce Receiving Pesticides. All the respondents used pesticides on cotton which is the crop most dependent on pesticide followed by Rice 58.6%, Sugarcane 38.3% and Corn 27.1%. Wheat pests (15.9%) and fodder pests (8.9%) receive less attention, probably because of low infestation rates, or reduced costs. Meat products take the least proportion at 16.6 percent while Vegetables sit in the middle at 22.4 percent. This distribution comes as a result of differences in pest management requirements of various crops which include the commercial ones such as cotton which have to be treated in a very intensive manner. It also reveals possibilities of implementing mere crop-specific Integrated Pest Management techniques to overcome the overreliance on chemical-based farming and continue to yield as before. This is due to the economic importance of cotton and attack of majority of the insects on it. It was reported that almost 80% of the pesticides are being used in Pakistan to boost cotton production (Haq et al., 2008). Similarly, Shuli et al., (2018) also reported that around 60% of the pesticides are being used only in cotton crop.

Table 8

Response regarding following the instructions available on the bottle/packet of pesticide while applying pesticide in your fields

Response	Frequency	Percent
Yes	186	48.4
No	198	51.6
Total	**384**	**100.0**

The table summarizes the Survey on the Level of Compliance with the Following Instructions on Pesticide Labels and the result reveals that 51.6% of farmers, 48.4% of farmers avail themselves of this information.

Table 9

Reasons not to follow

Response	Frequency	Percent
No awareness	98	25.5
Complex language used	94	24.5
Small font printing	6	1.6
Total	**384**	**100.0**

The reasons by respondents who do not have testicular self-examination include; awareness (25.5%), difficulty in perusing the information provided (24.5%) and small font size (1.6%). This further suggests that despite the awareness campaigns, which probably got to some of the farmers, majority are still disadvantaged when it comes to receiving and implementing instructions. Some ways can help reduce the labelled non-compliance include; keeping the label information simple, labelling in farmers' local languages, and promoting farmers' literacy levels concerning pesticide use.

Table 10

Response regarding application of recommended dose of pesticide as mentioned on the bottle/packet

Response	Frequency	Percent
Yes	73	19.0
No	311	81.0
Total	**384**	**100.0**

The above table showing Recommended Dose of Pesticides indicates that 81 percent of the farmers never use the recommended pesticides while only 19 percent use the recommended ones.

Table 11

Reasons behind non application of recommended dose of pesticide as mentioned on the bottle/packet

Response	**Frequency**	**Percent**
No awareness	58	15.1
Complex language issue	206	53.6
small font printing	47	12.2
Total	**384**	**100.0**

The main reasons for those who do not are understanding learning instructions (53.6%) and lack of learning awareness (15.1%) and printer's information too small (12.2%). This implies that there is a lot of information that is not disseminated properly and this leads to either under use or over use of a product which in turn results in negative consequences. Farmers may need to be taught the correct dosages to use, to get the best results as well as preventing harm, which showing farmers through working models and diagrams may be effective for them.

3.7 Choice of pesticides

Different criteria are being followed and used by farmers while selecting or purchasing pesticides for their fields. The data regarding these criteria were collected though four-point likert scale (Never=1, Rarely=2, Occasionally=3, and Frequently=4) and presented in Table 12 given below:

Table 12

Data regarding criteria followed by respondents while purchasing and application (choice) of pesticides

Criteria	1		2		3		4		Weighted Score
	f	%	f	%	f	%	f	%	
Consultation with Extension Field Staff	0	0.0	19	4.9	349	90.9	16	4.2	1149
Consultation with staff of agricultural research wing	281	73.2	103	26.8	0	0.0	0	0.0	487
Consultation with staff of plant protection department	28	7.3	356	92.7	0	0.0	0	0.0	740
Consultation with sales man of the pesticide's agency/ dealers	0	0.0	18	4.7	337	87.8	29	7.6	1163
Personal previous experience	285	74.2	99	25.8	0	0.0	0	0.0	483
Consultation with fellow farmers	0	0.0	0	0.0	157	40.9	227	59.1	1379
Price of pesticides	0	0.0	15	3.9	331	86.2	38	9.9	1175
Efficacy of pesticides	0	0.0	10	2.6	274	71.4	100	26.0	1242

The Criteria for Pesticide Choice table evaluates the roles that farmers consider when buying and using the pesticides. Out of the choices, farmers' opinions in their management is the most often rated 'always' at 59.1% with efficacy of pesticides rated 26% and price 9.9%. On the other hand, respondents rarely seek professional guidance from the extension field staff (4.2%) and agricultural research staff (0%). Another source of information for these farmers includes the personal experience and many of them rely on their own judgment only. While population is often influenced by their peers' advice with minimal input from experts, there is scarcity of adequate extension services to offer sound knowledge and direction. The data highlights the criteria normally farmers follow at the time of purchasing or applying pesticides. The results confirm farmers frequently consult fellow farmers for selection/purchasing of pesticides. However, farmers also consider efficacy of pesticides while purchasing or applying pesticides whereas price of pesticide is also occasionally considered. Similarly, farmers least consultation for purchasing and application of pesticide was with research wing staff.

3.8 Respondent's knowledge level about pesticides and its application

The knowledge of respondents with regard to pesticides, its impact on human health and environment and its application in the field were collected through the use of

five-point likert scale (1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree and 5=Strongly Agree) and presented in Table 13 given below:

Table 13

Data regarding knowledge level about pesticides and its application

Variable	1		2		3		4		5		Weighted Score
	f	%	f	%	f	%	f	%	f	%	
Affects of pesticides on human body	0	0.0	0.0	0.0	111	28.9	273	71.1	0	0.0	1425
Typology of pesticides	0	0.0	18	4.7	333	86.7	33	8.6	0	0.0	1167
Mode of action of pesticides	0	0.0	0.0	0.0	285	74.2	99	25.8	0	0.0	1251
Unintentional ingestion cause loss of human life	0	0.0	0.0	0.0	0	0.0	380	99.0	4	1.0	1520
Application of inappropriate pesticide cause chronic illness	0	0.0	15	3.9	331	86.2	38	9.9	0	0.0	1175
Affects of pesticides on biodiversity (Aquatic life, damage of beneficial insects, non-targeted vegetation quality and taste especially in vegetables and fruits etc.)	0	0.0	10	2.6	274	71.4	100	26.0	0	0.0	1242
Affects of pesticides on environment (soil and water contamination)	28	7.3	356	92.7	0	0.0	0.0	0.0	0	0.0	880
Affects of pesticides on agricultural products	0	0.0	18	4.7	337	87.8	29	7.6	0	0.0	1163
Affects of pesticides on food safety	285	74.2	99	25.8	0	0.0	0	0.0	0	0.0	1908
Regular application of pesticides disturbs the *pH* of soil	0	0.0	0	0.0	157	40.9	227	59.1	0	0.0	1379
Contaminate the soil nutrients and disturbs the soil fertility	0	0.0	15	3.9	331	86.2	38	9.9	0	0.0	1175
Contamination of ground water (water bodies)	0	0.0	10	2.6	274	71.4	100	26.0	0	0.0	1242
Pesticides application enhances air pollution	28	7.3	356	92.7	0	0.0	0	0.0	0	0.0	880
Affects of pesticides on overall plant growth	0	0.0	18	4.7	337	87.8	29	7.6	0	0.0	1163
Affects of pesticides on nutrients uptake mechanism of plants	261	68.0	123	32.0	0	0.0	0	0.0	0	0.0	1812
Damage and reduce the soil biomass	0	0.0	0	0.0	157	40.9	227	59.1	0	0.0	1379
Affects on the quality of milk by using fodder with pesticide's application	0	0.0	15	3.9	331	86.2	38	9.9	0	0.0	1175
Affects of pesticides on animal health	0	0.0	10	2.6	274	71.4	100	26.0	0	0.0	1242
Safe use of pesticides	28	7.3	356	92.7	0	0.0	0	0.0	0	0.0	880
Application of banned pesticides	0	0.0	0	0.0	349	90.9	35	9.1	0	0.0	1187
Lose of human life (death) due to pesticide's exposure	0	0.0	0	0.0	0	0.0	188	49.0	196	51.0	752
Availability of pure pesticides	28	7.3	356	92.7	0	0.0	0	0.0	0	0.0	880
Consultation regarding choice of pesticides	0	0.0	0	0.0	349	90.9	35	9.1	0	0.0	1187
Efficacy of pesticides being applied	285	74.2	99	25.8	0	0.0	0	0.0	0	0.0	1908
Reduced efficacy of pesticides when applied immediately before irrigation or rainfall	0	0.0	0	0.0	157	40.9	227	59.1	0	0.0	1379
Reduction in beneficial insects due to pesticides application	0	0.0	0	0.0	340	88.5	44	11.5	0	0.0	1196

Methodologies/ways to mitigate risks of pesticides application	0	0.0	0	0.0	220	57.3	164	42.7	0	0.0	1316

The table, on the knowledge level regarding pesticide application and its impacts is focused on the farmers' understanding of the impact of pesticides on health and environment. The highest concerns are attitude towards unintentional ingestion which poses health risks to human beings with 99% awareness. The lowest level of knowledge is on the impacts on the diversity of species with 71.4% and the impacts on the nutrient qualities of the soil with 59.1%. Some of the results include: Percentage of respondents with safe use of pesticides: 10% Percentage of respondents with banned pesticides: 10%. Based on these results, research on the possible long-term impacts of pest practices is seriously limited. Education of farmers on the dangers of pesticides and how to minimize harm is a central factor in encouraging efficiency and health oriented agriculture.

Table 14

Mean Score and Knowledge Level regarding knowledge level about pesticides and its application

Knowledge level of farmers about pesticide and its application in agriculture were assessed on the basis of mean score and divided into three categories as low, medium and high. The data in this regard is given as under:

Variable	**Mean Score**	**Knowledge Level**
Affects of pesticides on human body	3.71	High
Typology of pesticides	304	Medium
Mode of action of pesticides	3.26	Medium
Unintentional ingestion cause loss of human life	3.96	High
Application of inappropriate pesticide cause chronic illness	3.06	Medium
Affects of pesticides on biodiversity (Aquatic life, damage of beneficial insects, non-targeted vegetation quality and taste especially in vegetables and fruits etc.)	3.23	Medium
Affects of pesticides on environment (soil and water contamination)	2.29	Low
Affects of pesticides on agricultural products	3.03	Medium
Affects of pesticides on food safety	4.97	High
Regular application of pesticides disturbs the *pH* of soil	3.59	Medium
Contaminate the soil nutrients and disturbs the soil fertility	3.06	Medium
Contamination of ground water (water bodies)	3.23	Medium
Pesticides application enhances air pollution	2.29	Low
Affects of pesticides on overall plant growth	3.03	Medium
Affects of pesticides on nutrients uptake mechanism of plants	4.72	High
Damage and reduce the soil biomass	3.59	Medium
Affects on the quality of milk by using fodder with pesticide's application	3.06	Medium
Affects of pesticides on animal health	3.23	Medium

Safe use of pesticides	2.29	Low
Application of banned pesticides	3.09	Medium
Lose of human life (death) due to pesticide's exposure	1.96	Low
Availability of pure pesticides	2.29	Low
Consultation regarding choice of pesticides	3.09	Medium
Efficacy of pesticides being applied	4.97	High
Reduced efficacy of pesticides when applied immediately before irrigation or rainfall	3.59	Medium
Reduction in beneficial insects due to pesticides application	3.11	Medium
Methodologies/ways to mitigate risks of pesticides application	3.43	Medium

The data focuses that farmers highest knowledge regarding pesticides application and its impacts on human health and environment remained very important among which farmers view that its highly likely that pesticides can cause loss of human lives. Furthermore, farmers also somewhat likely believe that Unintentional ingestion cause loss of human life while farmers also somewhat likely believe the effects of pesticides on human body. Similarly, farmers seem undecided that regular application of pesticides disturbs the *pH* of soil, damage and reduce the soil biomass and also their knowledge about Reduced efficacy of pesticides when applied immediately before irrigation or rainfall (all three factors as same value). The results also depict that farmers had least knowledge about effects of pesticides on food security and efficacy of pesticides being applied.

Table 15

Data regarding effects of pesticides application on bio-diversity/environment

Variable	**1**		**2**		**3**		**4**		**5**		**Weighted Score**
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	
Damage aquatic life	0	0.0	0	0.0	173	45.1	211	54.9	0	0.0	1363
Contaminate soil and water	0	0.0	0	0.0	157	40.9	227	59.1	0	0.0	1379
Regular application of pesticides disturbs the *pH* of soil	0	0.0	0	0.0	340	88.5	44	11.5	0	0.0	1196
Contaminate the soil nutrients and disturbs the soil fertility	0	0.0	0	0.0	220	57.3	164	42.7	0	0.0	1316
Contamination of ground water (water bodies)	35	9.1	349	90.9	0	0.0	0	0.0	0	0.0	908
Pesticides application enhances air pollution	0	0.0	0	0.0	349	90.9	35	9.1	0	0.0	1187
Contaminate air and diet	285	74.2	99	25.8	0	0.0	0	0.0	0	0.0	1908
Affect of pesticides on nutrients uptake mechanism of plants	36	9.4	348	90.6	0	0.0	0	0.0	0	0.0	912
Damage and reduce the soil biomass	0	0.0	0	0.0	340	88.5	44	11.5	0	0.0	1196
Damage to beneficial insects	48	12.5	336	87.5	0	0.0	0	0.0	0	0.0	960

Scale: Strongly Disagree =1, Disagree =2, Undecided =3, Agree =4, Strongly Agree=5

Specifically, the Bio-Diversity and Environmental Impact of Pesticides table of the comparative study captures farmers' perceptions as to how the use of pesticides impacts on the bio-diversity and the environment negatively. According to the results of the study majority of the respondents are of the view that pesticides have a negative impact on aquatic life (54.9%) and pollute soil and water (59.1%). Nevertheless, knowledge of finer impacts such as change of pH of the soil, or decrease in biomass is scarce. According to these findings, farmers' perceptions are comprehension of the apparent consequences. These knowledge gaps could be filled by custom-made awareness campaigns which would promote the use of environmentally friendly practices. The values presents that most of the farmers agreed that regular pesticide application disturbs the *pH* of soil and in this pesticide application mainly effect bio-diversity environment while farmers reported that second most high effect of pesticides on bio-diversity environment is through contamination of soil and water. Pesticide application also causes contamination of underground water (m. In addition, farmers were undecided if pesticide application disturbs soil fertility and soil nutrients as they stated that if they would disturb soil nutrients and fertility then soil would have not been producing crops and fertile soil would be turned into barren land but it hasn't happened. According to them People are applying pesticides since many decades but still soil is giving high yield hence they are confused on this question how is it possible. Farmers also disagreed with the statement that pesticide application effects nutrient uptake mechanism of plants. Farmers think that they cannot observe this mechanism but it can be observed that if it is true then plant would have died due to food scarcity however, it hasn't happened.

3.9 Pesticides application and human health

The data in this regard is given in following table

Table 16

Data regarding opinion of respondents regarding harmful impacts of pesticides on human health

Response	**Frequency**	**Percent**
Yes	368	95.8
No	16	4.2
Total	**384**	**100.0**

In the Health Effects of Pesticide Application table, the farmers' knowledge and testimonies of the effects of pesticides are reviewed. Though 95.8% of respondents recognized that the use of pesticides is dangerous to human health.

Table 17

Data regarding ill health symptoms after pesticide's application reported by the respondents

Symptom	**Response**	
	Frequency	**Percent**
Nausea and vomiting	157	40.9
Cough	290	75.5
Body itching and irritation (Dermatitis)	245	63.8
Itching and irritation in eyes	232	60.4
Pain in eyes	204	53.1
Stomach problem/issues	132	34.4
Muscle stretching and pain	83	21.6
Excessive sweating	114	29.7
Shortening of breath	151	39.3
Disturbance in sleeping	31	8.1
Headache	135	35.2
Loss of appetite	68	17.7
Pustules on skin	93	24.2
Formation of scars on skin	209	54.4
Diarrhea	153	39.8
Fever	245	63.8
Hypertension	46	12.0
Hormonal disturbance	40	10.4
Nose burning	62	16.1
Liver damage	60	15.6
Tremor (rhythmic shaking movement in one or more parts of body)	61	15.9
Kidney damage	45	11.7
Cancer	62	16.1

The ill-Health Symptoms after Pesticide Application table classifies the minor health complaints made by farmers. These are cough (75.5%), fever (63. 8%), and eye irritation (60,4 on average. Side effects mentioned by a few at times include DNA damage

and kidney issues, though they are quite rare. The studies presented here show health effects from pesticide exposure, both current and future, should pesticide use persist. Safe application training for farmers should also be provided and adequate medical treatment for farmers exposed to these threats should also be made available.

3.10 Regression model

Table 18a

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.237[a]	.056	.044	1.788

a. Predictors: (Constant), age, landholding, farmer literate or not, education level if he is literate, experience

Table 18b

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	71.703	5	14.341	4.486	.001[b]
	Residual	1208.482	378	3.197		
	Total	1280.185	383			

a. Dependent Variable: Source from where farmer purchased/borrowed the pesticide.
b. Predictors: (Constant), age, landholding, farmer literate or not, education level if he is literate, experience

Table 18c

Coefficients[a]

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	4.753	.809		5.876	.000
Farmer literate or not	.171	.442	.028	.387	.699
Education level if he is literate	.262	.150	.131	1.744	.082
Experience	.520	.221	.274	2.351	.019
Landholding	-.242	.178	-.074	-1.359	.175
Age	-.202	.268	-.090	-.753	.452

a. Dependent Variable: Source from where farmer purchased/borrowed the pesticide.

The specific Model Summary and ANOVA Analysis in the Influence of Sources of Pesticide Purchase section aim at identifying the explanatory variables of pesticide acquisition. Our findings indicate that education level ($\beta = 0.131$, $p = 0.082$) and experience ($\beta = 0.274$, $p = 0.019$) are significant predictors of pesticide source choice. By being more experienced and with a higher level of education farmers are better placed to

make informed purchases. On this premise, there is a need to step up training as well as awareness campaigns to assist in directing the purchasing practices especially by new generation of farmers.

4 CONCLUSIONS

It was concluded that majority of respondents were **middle-aged farmers**, with over half (51.3%). Educational attainment was generally low to moderate, as **60.2% had education only up to matric level or were illiterate**. Most respondents (**63%**) depended solely on farming as their main income source. Landholding patterns showed that a large proportion (**58.1%)** operated **medium-sized farms (11–15 acres)**. Pesticide use experience was high and habitual reliance on chemical pest control. All farmers reported using pesticides primarily to **enhance production and control pests,** and alarmingly**, 100% indicated lack of awareness about alternative pest control methods**. Unsafe pesticide practices were evident. More than half of the respondents (**51.6%)** did **not follow label instructions**, and a large majority (**81%)** did **not apply recommended doses**. The main barriers were **complex language** and **lack of awareness**, highlighting serious communication gaps between manufacturers, extension services, and farmers.

Farmers relied heavily on **informal and commercial sources** for pesticide selection. Farmers demonstrated **high knowledge** regarding **direct human health impacts, food safety, pesticide efficacy, and fatal risks from ingestion**. Most environmental and technical aspects fell within the **moderate knowledge** category. This suggests that while farmers recognize immediate health dangers, they lack deeper understanding of **ecological and safe-use dimensions**. Respondents moderately agreed that pesticides **damage aquatic life, contaminate soil and water, and disturb soil fertility**. An overwhelming majority (**95.8%)** believed pesticides negatively affect human health. Farmers reported a wide range of symptoms after pesticide application. Reports of **chronic and severe conditions** such as liver damage, kidney damage, hormonal disturbance, and even cancer, although lower in percentage, are alarming and suggest prolonged exposure risks.

The regression model examining factors influencing the **source from where farmers purchased or borrowed pesticides** was statistically significant ($F = 4.486$, $p =$

0.001), although the explanatory power was modest ($R^2 = 0.056$). Among all predictors, **farming experience** was the only significant factor ($p = 0.019$), indicating that more experienced farmers are more likely to rely on particular pesticide sources. Age, landholding size, literacy status, and education level did not significantly influence the source of pesticide procurement.

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Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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