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An Analysis of Pesticide Practices in Maharashtra and its Impact on Farm Revenues

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ABSTRACT

According to the data[1] based on the States/UTs Zonal Conferences on Inputs (Plant Protection) for Rabi & Kharif Seasons, the state of Maharashtra has been using the highest number of pesticides in India. Thus, studying the pattern of usage of pesticides and their impact on farming is essential to exploring the relationship between pesticide use and farm output. This research paper presents the findings of research based on primary and secondary studies conducted in the Maharashtrian districts of Nashik, Pune, Konkan, and Vidarbha (during 2022-23). The paper examines the patterns observed in the usage of pesticides to aid the production of rice in Maharashtra. Primary research was conducted in Nashik and Pune involving 121 district participants. Nashik consisted of small farmers, with a relatively low level of awareness related to pesticide usage and its impacts on the farmland and farm products as compared to the farmers from Pune. The study also examined the level of awareness among farmers about the use and consequences of pesticides on farmlands. The results show that most farmers depend on pesticides for crop protection in times of attacks from pests. These farmers are also reluctant to adopt modern, sustainable technology owing to higher costs accompanied by a lack of adequate knowledge and appropriate training.

Key words: Pesticides, Farm Revenue, Land Size, Accessibility

[1] https://ppqs.gov.in/sites/default/files/pp-rabi-minutes.doc

INTRODUCTION

Pesticides are essential for crop protection, playing a crucial role in enhancing agricultural productivity and ensuring food security by reducing crop losses from pests and diseases while enhancing crop quality and marketability. Despite their contribution to environmental pollution, pesticide use remains integral to modern agriculture in agro-based economies like India. This paper focuses on a study conducted in the agro-based regions of Maharashtra, selected strategically due to its notable pesticide consumption practices.

The rural regions of Maharashtra boast a diverse agricultural landscape, cultivating crops like *rice*, sugarcane, jowar, bajra, fruits, and vegetables, with a significant portion earmarked for exports. *Rice*, a staple grain grown across various regions in Maharashtra, was selected as the focal point of observation due to its widespread cultivation. Pesticides play a crucial role in safeguarding these crops from pests and diseases, enhancing their yield and quality. However, the indiscriminate use of pesticides can pose risks to human health and the environment, including pesticide residues, water contamination, and biodiversity depletion.

The study included multiple regions like Raigad, Chandrapur, Bhandara, Pune, and Nashik, with primary data collected from over 15 villages in Nashik and Pune, such as Dev Dongre, Khairapali, Murbi, Tryambak, Goldari, Gadadavane, Bhoi, Morambi, Nandurkipada, Hewri in Nashik, and Narayangaon in Pune. This study offers a comprehensive analysis of pesticide usage in rice cultivation across the state.

OBJECTIVES

I. To assess effective pesticide use by studying the relationship between pesticide use and farm output.
II. To assess the relationship between land in use and revenue generated.
III. To evaluate farmers' knowledge of pesticide usage concerning its impact on farmlands, soil fertility, and the produce.

LITERATURE REVIEW

Pathak, K. et al. (2022) review the global impact of pesticides on the environment and human health, emphasizing the importance of responsible pesticide use. This study delves into eco-friendly management strategies, emphasizing the importance of understanding pesticide properties to mitigate their impact.

Chakraborty, N. et al. (2023) examine the current status of biopesticide consumption in India, emphasizing formulations derived from natural compounds for eco-friendly pest management. Biopesticides, categorized into three classes, provide target-specific alternatives to chemical pesticides, constituting a small fraction (4.2%) of India's pesticide market.

Singh, N. et al. (20029) discuss the role of pesticides in Indian agriculture, highlighting their contribution to increased yields and disease control while addressing the health and environmental challenges associated with pesticide exposure.

Deshmukh, R. (2023) conducted research in western Maharashtra's Kolhapur district, shedding light on the rising preference for biopesticides over chemical alternatives among farmers, with 60% adopting bio-pesticides. Factors such as farmer education, age, and farm size influence this shift, highlighting the importance of education and incentives for fostering sustainable agricultural practices in the region.

Ware M. et al. (2023) conducted a study in Beed district, Maharashtra, focusing on the impact of pesticides on soil health for chickpea cultivation, emphasizing the need for managing pesticide use to maintain soil fertility.

The research underscores the potential risks of pesticide exposure to farmers' health and the environment, highlighting the importance of responsible pesticide practices in agriculture.

METHODOLOGY

The research methodology employed in this study on the relationship between pesticide usage, production output, revenue generation, cost of pesticides, and land use in Indian farmlands is characterized by a comprehensive approach that integrates both primary and secondary data sources. To collect primary data, a structured questionnaire survey was conducted among 83 households in various villages in Nashik and Pune districts. The questionnaire was designed to gather information on rice production, pesticide usage, revenue generation, cost of pesticides, and land use. Simultaneously, secondary data from reputable government sources was used to supplement the analysis.

Following data collection, two distinct regression models were then developed to explore the relationships between the variables of interest. The first regression model aimed to establish the connection between total revenue and cost of production, while the second model investigated the relationships between revenue generation and land use. Regression techniques were employed in Microsoft Excel to formulate and analyze these models, with the dependent and independent variables carefully defined and incorporated.

ANALYSIS

Annual output in the form of revenue produced by the agricultural household, Farmers in the Nashik and Pune villages provided the cost of production figures. Net output/Revenue made by the agricultural household per year, the data on net output/revenue was obtained from the farmers (It is measured in rupees). A negative output/revenue indicates a loss. It is to be noted that the dependent variable is different for the two models. Other necessary observations were also noted and represented through graphs to support the claims made.**odel 1:**

log Y = α - β log X

Dependent Variable (Y) = Productivity of Input (Total Revenue/Total Cost) (in %)

Independent Variable (X) = (Cost of Pesticide/Cost of Production) (in %)

α = 5.055103

B = - 0.00286

where Productivity is the dependent variable, α is the intercept, and β is the slope coefficient of the independent variable. (Refer to IV, and V in the appendix)

Evaluation of the impact of pesticide usage on revenue:

The regression equation Y = 5.055103 - 0.00286X represents a linear relationship between the productivity ratio (Total Revenue/Total Cost of Production) and the proportion of pesticide cost in the total cost of production (X). This equation provides valuable insights into the relationship between the productivity ratio and pesticide cost. The intercept (5.055103) indicates the expected productivity ratio when the proportion of pesticide cost (X) is zero. In other words, when there is no cost associated with pesticides (i.e., X = 0), the productivity ratio is expected to be approximately 5.055103%. This intercept value provides a baseline for assessing the productivity ratio when no pesticide costs are incurred.

The coefficient of X (-0.00286) represents the change in the productivity ratio (Y) for a one-unit change in the proportion of pesticide cost (X). Specifically, for every one-unit increase in the proportion of pesticide cost in the total cost of production, the productivity ratio is expected to decrease by approximately 0.00286%. Conversely, for every one-unit decrease in the proportion of pesticide cost in the total cost of production, the productivity ratio is expected to increase by approximately 0.00286%. This coefficient allows for the prediction of the productivity ratio based on the proportion of pesticide cost. The significance F-value, R-squared value, and Multiple R-value provide insights into the overall fit and significance of the regression model. The significance F-value (0.978706) tests the overall significance of the regression model. In this case, the F-value of 0.978706 suggests that the independent variable (the proportion of pesticide cost) may not significantly predict the dependent variable (the productivity ratio).

The R-squared value (0.0129%) measures the proportion of the variance in the dependent variable (productivity ratio) that is explained by the independent variable (proportion of pesticide cost). A very low R-squared value (0.0129%) indicates that only a very small proportion of the variability in the productivity ratio is accounted for by the proportion of pesticide cost. This suggests that the independent variable (proportion of pesticide cost) does not explain much of the variation in the productivity ratio. The Multiple R-value (1.1358%) is the correlation coefficient between the observed and predicted values of the dependent variable based on the independent variable. It represents the strength and direction of the linear relationship between the independent and dependent variables. A Multiple R-value of 1.1358% indicates a very weak linear relationship between the productivity ratio and the proportion of pesticide cost. This further supports the conclusion that the proportion of pesticide cost may not be a strong predictor of the productivity ratio.

Model 2:

Dependent Variable (Y) = Revenue

Independent Variable (X) = Land Use (Land Size Units in rupees)

Revenue = $\alpha + \beta$ Land Size

$\alpha = 61082$

B = 139.2253

where Revenue is the dependent variable, α is the intercept, and β is the slope coefficient of the independent variable. (Refer to VI, and VII in the appendix)

Impact of land holdings on revenue generated:

The insights derived from the regression analysis on the relationship between total revenue (R) and land area in hectares (H) reveal a linear connection, as demonstrated by the regression equation R = 61082 + 139.2253 H. The intercept (61082) represents the total revenue when the land area is zero, although in this context, where revenue generation is inherently tied to land use, this value may not hold practical significance. The coefficient of H (139.2253) signifies the change in total revenue (R) for a one-unit change in land area (H). Specifically, total revenue is expected to increase by Rs. 139.2253 for each additional hectare of land, while a reduction of one hectare is predicted to lead to a corresponding decrease in revenue. This coefficient highlights the proportional relationship between land area and total income, indicating how revenue varies with changes in land area.

The significance F-value (0.968102), R-squared value (0.1%), and Multiple R-value (0.1%) offer crucial insights into the overall fit and significance of the regression model. The F-value near 1 suggests a lack of meaningful explanatory power in the model, indicating that the land area, as the independent variable, may not significantly predict total revenue. The low R-squared value of 0.1% indicates that only a small fraction of the variation in total revenue is explained by land area, further emphasizing the limited explanatory capacity of this variable. Similarly, the Multiple R-value of 0.1% signifies a weak association between total revenue and land area, reinforcing the notion of minimal correlation between the two variables.

Accessibility to facilities:

Table 1 shows access to various other facilities that aid in the development process.

The figures are indicative of extreme deprivation in terms of access to the facilities namely irrigation, tractors or machinery at subsidized rates, pesticides, cooperative societies, and adequate electricity supply. None of the respondents responded positively when asked about the access to irrigation facilities. They are completely dependent on rainfall. Only 1 out of 83 respondents had access to tractors or machinery at subsidized rates. 7

other people were in the registration process. Access to pesticides and cooperative societies was null. It was noted that 43 out of 83 respondents were eager to have a Farmer Producers Organization (FPO) in their village. Proper and viable strategies must be implemented to improve these villages.

Table 1: Assessment of Accessibility to Facilities

Facility	Accessibility to respondents
Pesticides or Insecticides	52.08%
Animal Husbandry Other than Farming	43.75%
Commercial Farming	0.01%
Pesticide Removal Techniques	8.33%
Mobile Applications for payments, purchase of Pesticides	31.25%

Source: Primary Data (2022-2023)

The relatively high percentage (52.08%) of respondents with access to pesticides or insecticides suggests a reliance on chemical solutions for pest control. Further investigation could explore the types of pesticides used, awareness of potential environmental and health impacts, and the availability of alternative pest management strategies. The significant percentage (43.75%) of respondents involved in animal husbandry activities beyond conventional farming indicates a diversification of livelihoods. Understanding the specific types of animal husbandry, such as dairy farming or poultry, and the reasons behind this diversification could inform strategies for promoting sustainable and integrated farming practices.

The extremely low percentage (0.01%) engaged in commercial farming suggests that a large portion of respondents may be practicing subsistence or small-scale agriculture. Exploring the barriers to scaling up to commercial farming, such as access to markets, financial resources, or agricultural infrastructure, could guide interventions to support economic growth in the agricultural sector. The relatively low adoption (8.33%) of pesticide removal techniques highlights a potential gap in awareness or implementation of practices to mitigate the environmental and health impacts of pesticides. Investigating the reasons behind this low adoption can guide the development of extension services and educational programs to promote sustainable agricultural practices.

The use of mobile applications (31.25%) for agricultural transactions indicates a certain level of technological adoption among respondents. Exploring the factors driving this adoption, such as ease of use, access to information, or financial incentives, can provide insights into how technology can be leveraged to enhance efficiency and productivity in agriculture. Understanding the nuances behind these trends is crucial for designing targeted interventions and policies that address the specific needs and challenges of the agricultural community. This may include promoting sustainable farming practices, providing access to markets and financial resources for scaling up, and leveraging technology for improved efficiency and connectivity in the agricultural value chain. Additionally, considerations for environmental sustainability and the well-being of farming communities should be integrated into future agricultural development initiatives.

GOVERNMENT SCHEMES FOR PESTICIDE

The government has introduced schemes to encourage safe and sustainable pesticide use in these regions:

1. The Department of Agriculture and Farmers Welfare in India has been actively engaged in advocating for *Integrated Pest Management (IPM)* as a sustainable and eco-conscious approach to pest management. IPM adopts a comprehensive strategy that integrates diverse pest control techniques to mitigate environmental and human health risks, all while efficiently controlling pest populations.

2. The Government of India introduced *mKisan*, a mobile-centric platform aimed at delivering agricultural information and services to farmers. "mKisan" derives from "Mobile Kisan," with "Kisan" translating to "farmer" in Hindi. This platform harnesses mobile technology to furnish farmers nationwide with timely and pertinent agricultural insights.
3. The Government of India established the *Central Integrated Pest Management Centre (CIPMC)* in Nashik to advocate for Integrated Pest Management (IPM) approaches in agriculture. Its main goal is to offer technical assistance, training, and awareness initiatives to farmers and other interested parties, aimed at proficiently managing pests while reducing environmental harm.
4. The Monitoring of Pesticide Residues at National Level (MPRNL) scheme, initiated by the Department of Agriculture, Cooperation & Farmers Welfare, systematically monitors pesticide residues in food commodities, soil, and water across India.
5. The *NHRDF* has established advanced laboratories specializing in various fields such as Seed Testing, Plant Pathology, Entomology, Plant Physiology, Soil Testing, Biochemistry, Wine Analysis, and pesticide residue Analysis. These facilities are committed to analyzing plant, soil, and seed samples acquired through extensive research and development endeavors.

RECOMMENDATIONS

1. Encourage the adoption of Integrated Pest Management (IPM) practices that combine biological, cultural, and chemical methods. This holistic approach reduces reliance on chemical pesticides, promoting sustainable and eco-friendly pest control.
2. Implement comprehensive programs to educate farmers in Maharashtra about proper pesticide use, application techniques, and associated risks. Responsible pesticide management can prevent overuse.
3. Strengthen and enforce existing pesticide regulations, including registration, usage, and labeling. Regular reviews ensure safety standards are met, and risky pesticides are withdrawn.
4. Support research on biopesticides as alternatives to chemical ones. These natural sources can reduce environmental impact, enhance biodiversity, and protect human health.
5. Establish a robust system to track pesticide residues in soil, water, and produce. Regularly publish findings to raise awareness and guide policymakers in regulating pesticides effectively.

CONCLUSION

The examination of pesticide application in crop production unveils significant disparities in resource utilization and land use, presenting opportunities for enhanced production efficiency. However, the persistent challenge of accessing essential resources, such as cost-effective pesticides, continues to hinder optimal agricultural practices and livelihoods. As such, there is a pressing need for targeted interventions aimed at improving farming techniques, promoting sustainable practices, and enhancing technological adoption.

Addressing these challenges necessitates a comprehensive approach that not only bridges gender disparities but also ensures inclusive access to resources for all farmers. By fostering sustainable agricultural development, we aim to achieve equitable growth and improve the livelihoods of those dependent on the agricultural sector. This holistic strategy encompasses the promotion of eco-friendly farming practices, the development of innovative technologies, and the empowerment of marginalized communities, ultimately paving the way for a resilient and prosperous agricultural sector in the face of evolving environmental and socio-economic challenges.

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8. APPENDIX

I. STATE-WISE CONSUMPTION OF CHEMICAL PESTICIDES

Quantity: Metric Ton (Tech. Grade)

S. No.	States/UTs	2017-18	2018-19	2019-20	2020-21	2021-22
1	Andhra Pradesh	5.25	10.00	8.79	8.79	45.22
2	Bihar	320.00	350.00	360.00	360.00	360.00
3	Chhattisgarh	405.00	505.0	605.00	605.00	705.00
4	Goa	4.50	6.00	6.00	1.78	5.30
5	Gujarat	353.50	306.00	307.00	320.00	392.00
6	Haryana	390.00	410.00	400.0	430.00	440.00
7	Himachal Pradesh	1.45	1.50	4.20	18.04	5.02
8	Jharkhand	37.88	41.43	91.00	91.00	97.00
9	Karnataka	544.00	544.00	564.00	561.00	561.00
10	Kerala	717.28	861.74	778.64	757.69	607.80
11	Madhya Pradesh	326.00	322.00	322.00	346.00	349.00
12	Maharashtra	1271.46	1164.17	1082.14	934.41	934.44
13	Orissa	310.00	310.00	333.00	165.00	121.97
14	Punjab	259.00	246.00	219.00	210.00	NR
15	Rajasthan	10.00	15.00	929.00	1021.00	1268.00
16	Tamil Nadu	630.00	500.00	820.00	861.00	891.00
17	Telangana	77.00	84.00	329.80	496.00	522.00
18	Uttar Pradesh	46.22	46.85	47.73	47.94	50.88
19	Uttarakhand	50.14	51.68	154.58	111.23	231.03
20	West Bengal	951.00	997.00	1017.00	1017.00	1017.00

Sub Total		**6709.68**	**6772.37**	**8378.87**	**8362.88**	**8603.65**
North-Eastern						
21	Arunachal Pradesh	NR	17.25	18.05	18.05	18.00
22	Assam	217.10	233.50	242.85	247.85	256.85
23	Manipur	1.05	NR	0.85	1.43	NR
24	Meghalaya	75.10	NR	8.49	8.87	8.55
25	Mizoram	NR	NR	NR	NR	NR
26	Nagaland	14.00	17.50	19.00	4.40	8.12
27	Sikkim	NR	NR	NR	NR	NR
28	Tripura	141.96	137.58	167.28	NR	NR
Sub Total		**449.21**	**405.83**	**456.52**	**280.60**	**291.52**
Union Territories						
29	Andaman & Nicobar	NR	NR	NR	NR	NR
30	Chandigarh	NR	NR	NR	NR	NR
31	Dadra & Nagar Haveli and Daman & Diu	NR	NR	NR	NR	NR
33	Delhi	NR	12.60	NR	NR	NR
34	Jammu & Kashmir	1.40	1.60	1.63	3.67	3.75
35	Ladakh	NR	NR	NR	NR	NR
36	Lakshadweep	NR	NR	NR	NR	NR
37	Pondicherry	14.14	11.08	9.90	NR	NR
Sub Total		**15.54**	**25.28**	**11.53**	**3.67**	**3.75**
Grand Total		**7174.43**	**7203.48**	**8846.14**	**8647.14**	**8898.92**

Source: States/UTs Zonal Conferences on Inputs (Plant Protection) for Rabi & Kharif Seasons. **NR**- Inputs Not Reported

II. THE COST OF PRODUCTION REGION-WISE

Region	**Cost of Production UNIT**	**Cost of Pesticide**	**Total Revenue**	**Cost of Pesticide / Cost of Production**
Igatpuri	30000	2500	55650	8.333333333
Nashik	19500	1425	24500	7.307692308
Bhandara				
small	35115	918	48249	2.614267407
medium	36404	1059	51539	2.909020987
large	36289	1136	54029	3.130425198

overall	35936	1038	51246	2.888468388
Konkan				
small	46071.56	400	59912.09	0.8682145775
medium	48582.22	510	70253.82	1.049766767
large	50895.77	312	72282.29	0.6130175455
overall	49393.85	386	69599.89	0.781473807
Kolhapur	50000	800	127600	1.6
Chandrapur	78457.7	985.39	101095.27	1.255950659
Gondia				
small	27,350.57	2469.38	40125.71	9.028623535
medium	25,813.00	2469.38	42426.81	9.566420021
large	29,211.00	2469.38	46252.76	8.453596248
overall	28,131	2469.38	44085.2	8.777995328
Jalgaon				
T Aman	46,116	1,467	68,131	3.181108509
Boro	73,275	3,293	89,743	4.494029342
Aus	40,758	2,058	50,172	5.049315472

SOURCE: Primary data

III.

Regression Statistics	
Multiple R	0.011358
R Square	0.000129
Adjusted R Square	-0.16652
Standard Error	0.250651
Observations	19

IV.

ANOVA					
	df	***SS***	***MS***	***F***	***Significance F***
Regression	1	0.0000486	4.86E-05	0.000774	0.978706
Residual	6	0.376956	0.062826		
Total	7	0.377004			

V.

Items	***Coefficients***	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	5.055103	0.145131	34.83124	1.43E-07	107.0717	177.1051	107.0717	177.1051

Cost of Pesticide	-0.00286	0.102726	-0.02782	6.81E-05	-2283.22	-970.319	-2283.22	-970.319

VI.

Regression Statistics	
Multiple R	0.009842
R Square	9.69E-05
Adjusted R Square	-0.05872
Standard Error	24688.92
Observations	19

VII.

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1003871	1003871	0.001647	0.968102
Residual	17	1.04E+10	6.10E+08		
Total	18	1.04E+10			

VIII.

Items	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	61082	9978.839	6.121153	1.13E-05	40028.49	82135.52	40028.49	82135.52
Land	139.2253	3430.689	0.040582	0.968102	-7098.9	7377.346	-7098.9	7377.346