A Study of Agricultural Buffers and Rural-Urban Fringes: A Case Study of Deh 202 Taluka, Jhuddo District, Mirpurkhas

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Abstract: The semi-arid areas like Mirpurkhas experience growing environmental pressure because of the loss of vegetation, heat stress, and the growing settlement patterns in rural-urban fringe areas. Agricultural buffers like tree belts, grass waterways, and wetland strips are globally known to enhance microclimates, lower soil erosion, and improve landscape quality. The study explores the perception of six forms of agricultural buffers and three levels of buffer intensity by the stakeholders in the rural-urban fringe of Deh 202, Taluka Jhuddo, District Mirpurkhas. Farmers, residents, and academics were surveyed using a photo-questionnaire survey. A 5-point Likert scale was used to assess six types of buffers and three conditions of the buffers (no buffer, basic buffer, and extensive buffer). The findings showed that there were no statistically significant differences in the stakeholder groups in any type of buffer or condition (all $p > .05$). Descriptive trends indicated a strong preference hierarchy, with the Riparian tree buffers receiving the strongest approval across stakeholder groups. And then the grass waterways, riparian grass strips, wetland buffers, odor buffers, and windbreaks. Although the differences between the groups were not significant, the stakeholders showed a strong inclination towards dense tree-based buffers, which is both a global trend and a response to local climatic requirements. The planned strategies can focus on tree-dominant buffer designs, which are subject to uniform patterns of stakeholder preferences as observed in this study.

Keywords: Buffer zones, Water management, Agricultural buffers, Agriculture, Climate adaptation, Rural-Urban fringe (RUF).

1. INTRODUCTION

Rural–Urban Fringe (RUF) is the mixed-use area between urban and rural land-uses: a dynamic patchwork of agricultural land, dispersed housing, small-scale industry, and bits of natural habitat (De Waegemaeker *et al*., 2021). RUFs are not permanent lines but transitional gradients, which are influenced by the growth of the population, the expansion of the infrastructure system, and market pressures; they often contain mixed land tenure, heterogeneity of livelihoods, as well as patchworks of incompatible uses (Fienitz & Siebert, 2021). There are no universal, strict definitions of clear, operational ones; a conclusive trait is the spatial proximity of urban demand and agricultural production, resulting in the generation of recurring land-use conflict and environmental pressures (De Waegemaeker *et al*., 2021).

The situation in RUFs makes it an immediate policy area in Pakistan because of its rapid urbanization (Rahman & Khan, 2025). From 1951 to 2017, the urban population of Pakistan increased by about 76 million people, with an urban proportion of the population increasing over the same period to about 36%, with the latest estimates showing an urban population of about 84.7 million in 2022-23, suggesting that the pressure on peri-urban farmland is continuing (Ahsan *et al*., 2023). The growth of cities on urban scales is associated with a tangible reduction of productive land: remote-sensing analyses document that built-up area in one rapidly developing city (Lahore) has grown by almost 486 km² over the last several decades, which is mostly agricultural land (Sarwar *et al*., 2025).

The volatility in the crops and productivity of the country is also observed in national agricultural statistics (*e.g.*, 15.9% year-on-year decrease in cultivation area of a key crop in 2022-23), demonstrating the stress on production caused by climatic and land-use factors (Mahmood *et al*.). Another low-tech multifunctional measure, which is extensively researched in other regions, is agricultural buffers, the vegetated strips (grass, trees, wetlands, riparian zones, windbreaks) that are situated between the agricultural land and the urban functions (Senthamizh & Anbarasan, 2025).

Recent field studies record a range of ecosystem service benefits: in certain cases, buffer applications have been found to decrease Total Nitrogen (TN) by about 27-55% and Total Phosphorus (TP) by 19-37% of the total, whereas in other studies, 67-89% of the nitrogen inputs have been observed to be reduced by riparian forest buffers (Bojanowski *et al*., 2025). Studies also indicate that the buffer design (vegetation type and width) has a significant material influence on performance, with grass buffers at times being more effective than tree buffers at the same widths in terms of surface runoff and sediment retention (Akter *et al*., 2024; Jiang *et al*., 2020).

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Although there is clear international evidence on the efficacy of buffers, there are gaps that limit Pakistani planning, which include a limited number of empirical works that quantify the perceptions of local stakeholders regarding the various types and sizes of buffers (Rayan *et al*., 2021). There is also a lack of context-specific evidence on how locals in Pakistan think about different types and sizes of buffers (Salem *et al*., 2025).

The research aims to fulfil this gap through this study by comparing the approval of six types of buffers (grass waterways, riparian grass, wetlands, odor buffers, windbreaks, riparian trees) among farmers, residents, and academics in one peri-urban location in District Mirpurkhas. This study is important because it provides effective prescriptions of buffers, vegetation combinations, and management programs that can preserve productive land, enhance water and air quality, as well as minimize land-use conflict at the interface between urban development and agriculture.

2. LITERATURE REVIEW

2.1. Buffer Functions and Their Influence on Rural–Urban Fringes

The worldwide agricultural buffers adopted as multifunctional landscape elements and used to safeguard ecological integrity at the rural-urban interface include agricultural strips, tree belts, grass waterways, and wetland edges (Ge *et al*., 2024). According to recent empirical research, vegetative buffers are capable of decreasing the Total Nitrogen (TN) runoff by 30-68% and Total Phosphorus (TP), and also reducing sedimentation and stabilizing soil structures (Dal Borgo *et al*., 2025). These ecological functions are more so in peri-urban settings, whereby agricultural and residential activities co-exist and interact (Wang *et al*., 2023).

Land-Use and Land-Cover (LULC) surveys in Bahawalnagar, Sheikhupura, and Peshawar districts in Pakistan show that agricultural land was decreasing by 15–30% in the past twenty years, leading to decreased crop yield and higher surface temperature by 1.5-2.9 °C in built-up fringe areas (Raza *et al*., 2024). These transformations indicate the degradation of the natural buffer systems since uncontrolled urban growth disturbs hydrological processes, vegetative stripping, and increases edge-induced environmental pressures. The global and domestic evidence is unanimous that the availability or lack of buffers largely contributes to ecological setting, agricultural land sustainability, microclimate, and environmental sustainability in periphery landscapes (Bas *et al*., 2024). According to the perception-oriented structure of this research, the hypotheses were formulated in terms of approval pattern among the stakeholders, other than the causal impact of the environment:

- **H1:** Stakeholder approval ratings differ across buffer types**.**
- **H2:** Stakeholder approval ratings differ across buffer conditions (no, basic, extensive).
- **H3:** Stakeholder approval ratings differ between stakeholder groups (farmers, residents, academics).
- **H0 (for all):** No differences exist.

The null hypotheses associated with this are that there are no significant differences in the approval rating of buffer types, buffer conditions, or stakeholder groups.

2.2. Stakeholder Perceptions and the Social Dynamics of Buffer Provision

The attitude of stakeholders towards the agricultural buffers is different based on socioeconomic interests, land ownership, and the perceived opportunity cost (Ihemezie & Dallimer, 2021). Studies indicate that the residents prioritize aesthetics, shade, and recreation as the most important qualities of buffers, whereas farmers consider land loss and maintenance (Maitlo *et al*., 2023). Regardless of the incentive or payment, farmers are not always willing to put land under buffer installation.

The same trend is observed in the peri-urban planning studies in Pakistan. Central to the Taluka Khairpur case, more than half of the sampled migrants and landowners wanted to transform agricultural lands into residential lands due to the perceived returns (Rehman & Khan, 2022). In Peshawar district, at the same time, the residents supported green buffer belts and open spaces as a measure to reduce environmental degradation, but farmers did not agree because the fields were fragmented, and their profitability was decreasing (Iqbal *et al*., 2025). A study on conservation practices in Punjab has also been conducted to further establish that the willingness of farmers to employ ecological practices only rose when subsidy or government-support systems were provided (Nadeem *et al*., 2024).

These studies reveal that the implementation of buffers is greatly influenced by the stakeholder motives and preferences as well as the perceived tradeoffs. When farmers, residents, and planners have different opinions, the viability of the establishment is undermined despite the ecological value.

2.3. Fringe Development Processes and Space Dynamics

The rural-urban fringes of the developing nations are often subjected to uncontrolled and sudden land conversion. Analysis of Sargodha, Lahore, and Larkana using GIS reports 130-250% of increase in built-up area between 2000 and 2020, which was accompanied by a corresponding loss in farmland (Nadeem *et al*., 2021; Rahman *et al*., 2023). The characteristic development of the peri-urban areas in Pakistan is in a leapfrog fashion, which leaves behind patches of farmland surrounded by residential estates, roads, and business strip areas (Rahman *et al*., 2023). This fragmented structure enhances land-use conflict and the demand for protective buffers to isolate incompatible uses.

The spatial data also demonstrate that the absence of buffers is also a factor of environmental degradation: LST swells, riparian vegetation is lost, decreasing infiltration, and localized flooding are found (Majumdar & Avishek, 2025). On the other hand, cities with vegetated belts or riparian buffers have better thermal comfort and biodiversity (Schmidt & Walz, 2021).

2.4. Buffer Loss Environmental and Socioeconomic Consequences.

The disappearance of agricultural buffers along the periphery enhances the degradation of the soil, water pollution, and ecological imbalance (Wu *et al*., 2023). Research in Peshawar and Multan indicates that fringe conversion is associated with 15-20% reductions in soil organic matter, augmented loads of dust, and loss of native tree cover (Rehman & Khan, 2022). By contrast, small-scale changes like agroforestry buffers that were implemented in peri-urban Islamabad enhanced local biodiversity by 20-35%, which proves that it is possible to provide significant benefits using simple interventions (Dal Borgo *et al*., 2025).

3. METHODOLOGY

3.1. Research Design

A quantitative research design was used in the study to determine the stakeholder approval of agricultural buffers in the rural-urban fringe of Deh 202, Taluka Jhuddo, District Mirpurkhas. The design was suitable since it facilitated a methodical comparison of the opinions of various stakeholder groups and enabled statistical testing of how the type of buffer and the strength of the buffer had an impact on the approval of the people. The primary tool was a structured photo-questionnaire, which was chosen due to its ability to visually standardize the situations with the buffers and minimize confusion among the respondents with different literacy or technical backgrounds. The strategy provided the respondents with the same visual conditions to enhance response validity and consistency by offering real photographic simulations.

3.2. Study Population and Sampling Technique

The research population comprised three main groups, which included farmers who were in the rural-urban fringe, people who inhabited the settlements on the outskirts, and academicians or planning experts based in Mehran University of Engineering and Technology (MUET), Jamshoro. In order to include these groups in an appropriate proportion, a stratified random sampling process was applied. 200 questionnaires were also sent to the three strata, 164 of them were returned in a usable format, with a response rate of 82%, which is deemed to be strong in field-based research of environmental perceptions. The sample size was justified using the Cochran formula of determining the sample at 95% confidence and a 5 to 7% margin of error, which proved that the sample was appropriate to conduct the proposed ANOVA tests. The stratification was used to have a balanced representation and reduce bias since each category of the stakeholders represented the proportion of the final dataset. The demographic details of the participants are presented in Table **1**.

3.3. Study Instrument

The photo-questionnaire included descriptions and diagrams that explained the advantages of buffers, simulated color photographs of buffer scenarios and corresponding questions, and space for participants to share their views about buffers on the site. Information in the questionnaire communicated the types of buffers and the different scenario-based availability of the services and infrastructure. Six types of buffers were described: grass buffers at streams, odor buffers, grass waterways, wetlands, windbreaks, and tree buffers. On the same page, two diagrams compared a “basic” and an “extensive” buffer, illustrating composition, approximate dimensions, and environmental functions of each. Accompanying the text and diagrams for each buffer type were pairs of color photo simulations showing the three buffer conditions: no buffer, basic buffer, and extensive buffer. The three pairs of images included some of the surrounding landscape, with the buffer design identical in type, but changing in size. The buffers were proposed in conjunction with a recreational trail that was illustrated along buffers that are typically found at the edge of a farm (*e.g.*, windbreak), but not along grass waterways that more typically are found within a farm field. Although the photo-questionnaire technique helped to increase the understanding and provided the same visual reference

Table 1: Demographic Details of the Participants

Variable	Category	Frequency (n)	Percentage (%)
Stakeholder Group	Farmers	68	41.5
	Residents	50	30.5
	Academics/Experts	46	28.0
Gender	Male	121	73.8
	Female	43	26.2
Age Group	20–30 years	28	17.1
	31–40 years	61	37.2
	41–50 years	49	29.9
	Above 50	26	15.8
Years of Association with Fringe Area	Less than 5 years	33	20.1
	5–10 years	48	29.3
	11–20 years	54	32.9
	More than 20 years	29	17.7

among the respondents, it also has its limitations. Image composition, perception of maintenance levels, or previous personal experience determine visual preferences and are not alone functional performance. In order to reduce such bias, all pictures were standardised in terms of viewpoint, scale, and contextual background; it is not possible to totally reduce the effects of perceptual framing during visual-elicitation experiments.

Participants were asked two questions regarding each type of buffer. First, "To what extent do you suggest this (buffer name) buffer at the Study Area?" They responded to each of the three buffer conditions (no buffer, basic buffer, and extensive buffer). The answers were noted on a 5-point Likert scale, where 1 = very much and 5 = not at all, so that a lower mean score gives a higher approval and the reverse. The second question was, "Which buffer is the best option for private farmers?" Participants answered by choosing between no buffer, basic buffer, and extensive buffer (Sullivan *et al*., 2004). The answers were noted on a 5-point Likert scale, with the lower points of this scale denoting a high degree of agreement or preference and the higher points denoting a low level of support. Therefore, the lower the mean score, the more approval the buffer scenarios have. This was a coding scheme that was consistent throughout the conditions of all the buffers.

3.4. Validity and Reliability Testing

To promote content validity, the instrument was forwarded to a group of experts on environmental planning and agricultural extension who determined the clarity of the items, relevancy, and cultural appropriateness of the items. A pretest of twenty respondents was done to correct wording and order. Cronbach's Alpha was used to determine reliability with a result of 0.87, 0.82, and 0.85, respectively, as a coefficient in the overall instrument, buffer-condition, and buffer-type items. The values of all are above the recommended value of 0.70, which suggests that the values were strongly correlated and that the instrument was reliable to be used in the general survey.

3.5. Ethical Considerations

The study was accepted by the Departmental Research Review Committee (DRRC). Each of the participants was made aware of the objectives of the study, the voluntary nature of participation, the confidentiality of their answers, and their right to exit at any point. The research was based on the principles of ethics when working with human subjects and did not indicate any human identifiable data, which guaranteed the anonymity and privacy of all participants during the study process.

3.6. Data Analysis

SPSS Version 20 was used to analyze the data. The ANOVA procedures were implemented to test the hypothesis of whether the approval ratings varied across the stakeholder groups, buffer types, and buffer conditions. Since the study is exploratory in nature and the results do not show any significant differences between the two groups, the results will be presented in the form of the available ANOVA outputs and descriptive trends. The stakeholder group acted as a between-subjects factor, and buffer condition and buffer type acted as within-subjects factors. The dependent variable was the approval scores on a Likert scale. Before conducting the analysis, the conventional ANOVA assumptions were analyzed. The Shapiro-Wilk test and the Q-Q plots were used to test the normality, the test of homogeneity of variance was done using the Levene test, and the homogeneity of the test was conducted using Mauchly-Greenhouse-Geisser correction, where appropriate. Even though a mixed-design ANOVA framework was implemented to organise the analysis, the discussion of results in this paper is focused on the description of descriptive trends in the mean approval rating because the effects lacked statistical significance. This can be used to be able to draw practical and planning-relevant insights based on the patterns of stakeholder preferences, even in situations where the inferential thresholds have not been met. There was no priority given to the estimation of effect sizes, measurement, or the reporting of confidence intervals because the analysis focus was still on exploration and perception but not prediction and causality.

4. RESULTS

4.1. Statistical Analysis of Stakeholder Approval for Different Agricultural Buffer Types

This part of questionnaire analysis consist of the questions regarding the types of buffers namely, Grass Waterways Buffers (broad and shallow grass designed to prevent soil erosion), Riparian Grass Buffers (combination of trees, shrubs, grasses along stream or river), Wetlands Buffers (stream, river or wetland to maintain vegetation cover), Odor Buffers (to reduce odors from livestock and sewage facilities), Wind Breaks Buffers (shelterbelt plantation usually made up of one or more rows of trees or shrubs planted), Riparian Tree (large trees to provide shade and cooling for water) Buffers. The ANOVA Test was used to analyze these questions, where in two groups, three variables were kept, which included the choices of types of buffers and the group of respondents. It is necessary to point out that the values in the ANOVA table are the mean square statistics and are used to test the hypotheses and not as the direct meaning of the magnitude of preference. Descriptive mean scores are only provided to determine the relative ranking of buffer types and conditions as opposed to absolute levels of support.

Table **2** shows the results of the question, "To what extent do stakeholders suggest agricultural buffers?" To answer this question, we compared the mean approval ratings across the six types of buffers for the no buffer, basic buffer, and extensive buffer conditions.

The between-group F statistics in all six types of buffers did not show statistically significant differences between farmers, residents, and academics in terms of approval ratings ($p > .05$).

Table 2: Results of the Approval of All Six Types of Buffers at Rural-Urban Fringes

Sr.no	Questions	Group	Sum of Squares	df	Mean Square	F
1.	To what extent do you suggest the use of Grass Waterways Buffers (broad and shallow grass designed to prevent soil erosion) at rural-urban fringes?	Between	.481	2	.241	.148
		Within	262.756	161	1.632	
		Total	263.238	163		
2.	To what extent do you suggest Riparian Grass Buffers (a combination of trees, shrubs, grasses along stream or river) at rural-urban fringes?	Between	1.177	2	.588	.496
		Within	190.793	161	1.185	
		Total	191.970	163		
3.	To what extent do you suggest Wetlands Buffers (stream, river, or wetland to maintain vegetation cover) at rural-urban fringes?	Between	3.634	2	1.817	1.761
		Within	166.140	161	1.032	
		Total	169.774	163		
4.	To what extent do you suggest Odor Buffers (to reduce odors from livestock and sewage facilities) at rural-urban fringes?	Between	.547	2	.274	.322
		Within	136.843	161	.850	
		Total	137.390	163		
5.	To what extent do you suggest Wind Breaks Buffers (shelterbelt plantation usually made up of one or more rows of trees or shrubs planted) at rural-urban fringes?	Between	.301	2	.150	.218
		Within	110.919	161	.689	
		Total	111.220	163		
6.	To what extent do you suggest Riparian Tree (large trees to provide shade and cooling for water) Buffers at rural-urban fringes?	Between	.475	2	.237	.122
		Within	313.885	161	1.950	
		Total	314.360	163		

4.2. Analysis of Stakeholder Preferences for Buffer Conditions Using ANOVA

This part of questionnaire analysis consist of the questions regarding the nature and intensity of buffers as no buffers, basic buffers, extensive buffers, of the all six types of buffers namely, Grass Waterways Buffers (broad and shallow grass designed to prevent soil erosion), Riparian Grass Buffers (combination of trees, shrubs, grasses along stream or river), Wetlands Buffers (stream, river or wetland to maintain vegetation cover), Odor Buffers (to reduce odors from livestock and sewage facilities), Wind Breaks Buffers (shelterbelt plantation usually made up of one or more rows of trees or shrubs planted), Riparian Tree (large trees to provide shade and cooling for water) Buffers. ANOVA Test was used to analyze these questions, where in two groups, three variables were kept, including the three conditions of buffers and the group of respondents.

The ANOVA results of the conditions between buffers also revealed the lack of any statistically significant differences between the stakeholder groups (all $p > .05$).

For each of the six buffer types, the no buffer condition earned the lowest approval rating, and the basic and extensive conditions earned considerably higher ratings. For the three buffer types without trees (grass waterway, riparian grass buffer, and wetland), ratings of the basic and extensive conditions were not significantly different from each other. Conversely, for the three buffer types with trees (odor buffer, windbreak, and riparian tree buffer), the extensive condition was rated slightly, but significantly, higher than the basic condition.

Therefore, according to the quantitative analysis, the following hypotheses have been accepted:

According to the ANOVA data (all $p >.05$), the null hypotheses were not disproved at the level of differences in the approval ratings of the stakeholder-groups when comparing the types of buffer and when comparing the conditions of the buffers. Consequently, the research paper lacks statistical data that can validate the differences in approval patterns of stakeholder groups, whereas descriptive patterns are addressed in the research paper as planning-relevant cues.

5. DISCUSSION

The results of the research give a clear insight into the perception of various types of agricultural buffers and buffer levels by the stakeholders in the rural-urban fringe of Deh 202, Taluka Jhuddo, District Mirpurkhas. Despite the statistically insignificant differences in the ANOVA results among the groups of stakeholders in any of the buffer types or buffer conditions (all $p >.05$), the descriptive means indicate a clear and significant trend in line with the world research on vegetative buffers and landscape perception. The patterns also inform the interpretation of the hypotheses, where the null hypotheses of both H1 and H2 were accepted. Riparian tree buffers were always found to be the most popular type of buffer among the stakeholder groups.

Riparian tree buffers were the most approved of the six types of buffers with the greatest mean score, and it is therefore clear that they are highly visual and ecologically attractive in the semi-arid environment of Mirpurkhas. The next to be rated in descending order were grass waterways, riparian grass buffers, wetland buffers, odor buffers, and windbreak buffers. Although the ANOVA values of riparian tree buffers ($F = 0.122$) and the other types of buffers ($F = 0.148$ to 1.761) did not indicate any significant differences between the stakeholder groups, the uniformity of the means indicates that there is a shared perception of what is a desirable rural-urban edge.

Table 3: Results of the Condition of the Buffers at Rural-Urban Fringes

Sr.no	Questions	Group	Sum of Squares	df	Mean Square	F
1.	No Basic Buffer should be there.	Between	.141	2	.070	.390
		Within	29.054	161	.180	
		Total	29.195	163		
2.	Basic buffer should be there	Between	.244	2	.122	.488
		Within	40.262	161	.250	
		Total	40.506	163		
3.	An extensive buffer should be there	Between	.043	2	.22	.124
		Within	166.140	161	1.032	
		Total	169.774	163		

The high level of riparian tree buffers in Mirpurkhas is similar to the European, Chinese, Australian, and North American experience, where tree-dominated buffers are commonly favoured most (Dinca *et al*., 2025). According to a study, this pattern is explained by a number of reasons: trees slow down the speed of the wind, decrease the ambient temperature, increase biodiversity, and produce environmental stability (Verma, 2021). These advantages are well received in the semi-arid environment of Mirpurkhas, where dust, heat, and visual monotony are the main features. The mean score of riparian trees is high, which means that the stakeholders attach importance to vegetation that offers short-term and visible ecological and microclimatic benefits.

Wetland buffers scored moderately, which is in line with international research in Malaysia, Brazil, and Bangladesh, where wetlands are valued in terms of water purification, habitat maintenance, and cooling (Sharma & Naik, 2024). The fact that the wetland buffers and grass waterways in Mirpurkhas are different implies that the respondents distinguish between thick and structured vegetation and the grass-only buffers. The same trends have been reported in European studies, where the respondents always give high ratings to ecologically rich and visually expressive buffers compared to plain grass strips (Serée *et al*., 2023).

Windbreaks and odor buffers were the least preferred. The same happens with international work in South Africa and Spain, where visually dominant and functionally specialized buffers, in particular odor control buffers or strong structural forms, are less popular (Bokowa *et al*., 2021). The findings from the study showed that lower-rated types of buffers rated higher than the no-buffer condition in the analysis of the buffer conditions, which indicates that even in the case of the low visual attractiveness of vegetation, the stakeholders still appreciate the presence of vegetation.

Another finding is in relation to the buffer intensity (no buffer, basic buffer, extensive buffer). The descriptive means show a definite pattern: both basic and extensive vegetative buffers were rated higher than the no-buffer one. Similar studies in Canada, Finland, and Japan have demonstrated that any vegetation improves the perception of a landscape in transitional rural-urban environments (Arslan *et al*., 2021; Mahajan *et al*., 2024; Zerbe, 2022). This fact is confirmed by the Mirpurkhas data: even the presence of the slightest vegetation is perceived in a more positive way than bare edges.

In most Western nations, farmers have a lower rating of buffers than residents due to land loss issues (Liu *et al*., 2023; Nchanji *et al*., 2023). Conversely, farmers, residents, and academics in this study were subject to the same hierarchy of preference. This consistency probably represents environmental pressures that are common to all, which include heat, dust storms, and the loss of vegetation cover that render large trees and thick vegetation a necessity and not a luxury. Shade and cooling are of great functional importance in this context, and this is one of the reasons behind the high popularity of riparian tree buffers.

Also, contrary to wetter areas, where wetland vegetation is the dominant type of vegetation in community preferences, Mirpurkhas respondents showed a stronger preference for tree-based buffers. This can be attributed to the irregular canal irrigation patterns of Sindh, where the tree cover is more reliable and manageable than the wetland vegetation, which needs a constant water supply (Zaidi *et al*., 2022).

Although the statistically significant effects are not present, the numerical trends give a logical and environmentally based image of the perception of the types and intensities of buffers. The patterns of description, which are backed by the international results, demonstrate a high level of preference for dense, tree-based vegetative buffers, which are determined by the global ecological logic as well as by the local climate conditions of Mirpurkhas (Visscher *et al*., 2023).

5.1. Planning and Implementation Implications for Deh 202

The preference trends that have been found in this research propose that the rural-urban fringe planning strategies of Deh 202 must focus on tree-dominated buffer structures, especially along the canals, streams, and settlement boundaries where microclimatic stress is most significant. Considering the land fragmentation and semi-arid conditions, simple buffers can be a feasible solution of minimum intervention, with a gradual shift to larger buffers in pressure areas. Grass waterways and riparian grass buffers can be incorporated in cultivated lands where trees cannot be planted easily, whereas riparian tree buffers should be considered where irrigation can be made available to enable viability in the long run. These results endorse a more graded buffer strategy that is commensurate with local environmental and land-use conditions and provides planners with an opportunity to have a socially justifiable framework for the integration of buffers in the control of peri-urban development.

6. LIMITATIONS AND FUTURE RESEARCH

The strength of this study is that it employed photo-elicitation, which enabled the respondents to evaluate the types of buffers using clear visual images that enhanced comprehension among different literacy levels. The presence of various stakeholder groups, such as farmers, residents, and academics, provided rich and varied data, which provided a complete picture of perceptions in the rural-urban fringe of Mirpurkhas. The reliability of the findings is also improved by the stratified sampling method and high response rate. One of the limitations is that the study was conducted on one rural-urban fringe area, which limits the geographic generalization of the findings. The perceptions in Mirpurkhas are not similar to other districts that have various climatic, cultural, or agricultural environments. The other weaknesses of the research are that the simulation of photo buffers is done, and this captures the perceived preferences but not the actual implementation behaviour. Respondents are also able to value visual density, shade, or aesthetic order and undervalue land, water, or maintenance restrictions. Consequently, the conclusion drawn should be taken as a pointer to the relative preferences of the stakeholders as opposed to an absolute recommendation of buffer performance.

Future studies need to be extended to other areas to compare and contrast and to use mixed methods, *i.e.*, a combination of perception surveys and on-ground ecological measurements, to reinforce the relationship between stakeholder attitudes and actual buffer performance.

CONCLUSION

The research examined the perception of various types of agricultural buffers and buffer conditions in the rural-urban fringe of Mirpurkhas by the stakeholders through the photo-questionnaire method. In general, vegetated buffers were favored by the respondents over those that had no buffer at all. Buffers that included trees, particularly those that offered shade and high visual density, were more positively rated than grass-only or low vegetation buffers. Wetland and grass waterways were also appreciated, although to a lesser extent. The general trend in all stakeholder groups was the preference for basic and broad buffer conditions over no-buffer conditions, which suggests common ground on the perceived environmental and visual advantages of vegetation in fringe landscapes. The fact that the preferences are similar implies that the local environmental pressures influence shared attitudes to landscape features despite occupation or background. Considering these results, the research recommends the further application of visually clear tree-dominated buffer designs in rural-urban transition zones to improve the quality of the environment and the acceptance of the community.

DECLARATION OF INTEREST

The authors declare no conflict of interest.

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