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Assessing Farmers' Impediments in Climate-smart and Non-climate Smart Villages: Kendall's W Approach

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Abstract

The study was conducted from January-August, 2024 in the Samastipur (Pin code: 848101) and Darbhanga (Pin code: 846001) districts of Bihar. It investigated the constraints faced by farmers in Climate-Smart Villages (CSVs) and non-Climate Smart Villages (non-CSVs) of both Samastipur and Darbhanga districts while adopting Climate-Smart technologies and farming practices in general. Additionally, it aimed to evaluate the level of agreement among farmers regarding the severity of these constraints. A total of 20 constraints were identified and categorised into four broad groups: Technical, Economic and Labour, Social and Personal, and Animals and Pests. Farmers from both CSVs and non-CSVs ranked these constraints on a three-point scale (most severe, severe, not severe), and mean scores were calculated for each constraint. Based on these scores, both individual constraints and broader groups were ranked accordingly. To measure the level of agreement among farmers, Kendall's coefficient of concordance (W) was applied. The findings revealed that farmers in CSVs exhibited a slightly higher level of agreement (W=0.774) compared to those in non-CSVs (W=0.612), suggesting that CSV interventions may contribute to a more consistent understanding of challenges. These insights are crucial for policymakers and agricultural support systems to design targeted interventions that enhance resilience, sustainability, and overall well-being. Future research should explore how climate-smart interventions shape farmers' perceptions and long-term agricultural outcomes.

Keywords: Climate-smart agriculture, climate-smart village, constraints, Kendall's W

1. Introduction

Third-world countries face significant challenges related to water scarcity, food insecurity, and health issues, which are further exacerbated by the occurrence of natural disasters (Srinivasarao et al., 2015; Lal et al., 2016). The biophysical and socio-economic impacts of anthropogenic climate change exhibit significant geographical heterogeneity worldwide (Wiebe et al., 2015; Maiti et al., 2016; Lal et al., 2018). Although climate crises pose a global threat, countries such as India are particularly vulnerable due to the fact that over 50% of its rural population remains dependent on agriculture and related sectors for their livelihood (Reddy et al., 2016; Lal et al., 2022; Debnath and Devarani, 2023). Climate Smart Agriculture as a concept came into being from the various debates regarding the capabilities of farmers to adapt to climate change without hampering their livelihoods (Autio et al., 2021; Azadi et al., 2021; Barasa et al, 2021). CSVs, developed under the Climate-Smart Agriculture (CSA) approach, aim to enhance agricultural systems by promoting sustainable practices that increase productivity, adapt to climate change, and reduce greenhouse gas emissions (Barua et al., 2023). Climate-Smart Villages (CSVs) represent a community-based approach within CSA, where climate-resilient practices and technologies are tested and scaled up to help farmers adapt to changing environmental conditions (Aggarwal et al., 2018; Ghimire et al., 2022). This strategy has gained traction as a potential solution to mitigate climate risks, which have become more pronounced in recent years (Lipper et al., 2014). However, the effectiveness of such interventions in addressing the broad range of constraints faced by farmers, particularly in comparison to non-CSV regions, remains underexplored (Zerssa et al., 2021; Wakweya et al., 2023). Farmers are subject to various constraints that can be broadly categorized into technical, economic, social, and environmental challenges (Gebrehiwot et al., 2013; Jasna et al., 2016). These constraints not only limit the ability to adopt sustainable practices but also exacerbate vulnerabilities, particularly in areas where climate variability and limited resources compound the challenges (Gbetibouo et al., 2010; Lal et al., 2014). Technical challenges, such as limited access to improved agricultural practices and inadequate infrastructure, are critical barriers to sustainable farming (Baumuller, 2017). Economic and labour-related constraints, including high input costs, labour shortages, and market access issues, further complicate the adoption of adaptive practices (Barrett et al., 2017). Social and personal constraints, such as gender inequalities and lack of education, significantly influence the ability of farmers to adopt new technologies (Meinzen-Dick et al., 2017). Environmental factors, particularly those related to pests and animal diseases, also remain persistent threats to productivity, especially in climate-vulnerable areas (Adhikari et al., 2015). Understanding the nature and severity of these constraints is critical for developing targeted interventions that can support farmers' adaptive capacity and improve their livelihoods. This study aims to investigate and rank the constraints faced by farmers in both CSV and non-CSV contexts, across four broad categories: Technical, Economic and Labour, Social and Personal, and Animals and Pests constraints. By ranking the severity of these constraints and applying Kendall's coefficient of concordance (W), we assess the level of agreement among farmers within each group. Previous studies have employed Kendall's W to evaluate consensus in ranking exercises, particularly in the agricultural and environmental sciences (Legendre, 2005; Mallick et al., 2023). The results of this study offer valuable insights into how CSV and non-CSV farmers perceive the challenges they face and the degree to which their experiences align, providing a basis for tailored policy interventions (Memarbashi et al., 2022). By comparing the experiences of farmers in CSVs and non-CSVs, this research contributes to the growing body of literature on climate-smart agriculture and rural resilience, while also offering practical insights for enhancing the effectiveness of agricultural support systems.

2. Materials and Methods

2.1. Background of the study locale

The Climate Smart Agriculture Project entitled 'Scaling up Climate-Smart Agriculture through Mainstreaming Climate-Smart Villages' was headed by the Bihar government and executed in collaboration with international and national institutes like CIMMYT, BISA, ICAR, BAU and RPCAU. The project was approved for implementation with the recommendation to establish four corridors, each representing a distinct Agro-climatic zone, to promote climate-resilient technologies. The first designated corridor was the Samastipur-Darbhanga State Highway, which was comprised of 25 villages across the Samastipur and Darbhanga districts. This was the only corridor that fell under the purview of RPCAU and hence blocks and villages were selected from this corridor as the study locale.

2.2. Selection of the study locale and sampling plan

The study was carried out in 2 purposively selected districts Samastipur (25.8560° N, 85.7868° E) and Darbhanga (26.1542° N, 85.8918° E) as the project was implemented in these two districts only from the first corridor. Under Smastipur district, the project was implemented in only one block i.e. Kalyanpur, and Under the Darbhanga district, there were two blocks namely Hanumannagar and Bahadurpur where the project was implemented. All the 3 blocks of the 2 districts were considered in the study.

In the Kalyanpur block, the project was implemented across 15 different villages. From this group, two Climate Smart Villages-Mirzapur and Birsingpur-were randomly selected, along with two corresponding non-Climate Smart Villages, Harpur Zakhra and Malipur. In Darbhanga district, a Climate Smart Village, Dihlahi, and a non-Climate Smart Village, Nayanagar, from Hanumannagar block, as well as a Climate Smart Village, Taralahi, and a non-Climate Smart Village, Ahila, from Bahadurpur block were selected through random selection.

A random sampling approach was used to pick the respondents. There were 25 respondents each from the 8 villages, totalling out to be 200 respondents, i.e., 100 respondents from Climate Smart Villages (CSVs) and 100 respondents from non-Climate Smart Villages (non-CSVs).

2.3. Statistical tools used for the analysis of the data

Mean score ranking method was applied to prioritise the broad group of constraints and the individual constraints and Kendall's coefficient of concordance was deployed to establish the level of agreement among the respondents. Twenty constraints were divided into four broad groups viz. Technical, Economic and Labour, Social and Personal and Animals and Pests. The respondents were asked to rank the severity of the individual constraints on a 3-point continuum, 'Most severe, Severe and Not Severe'. On the basis of the mean score derived from each broad group, ranks were determined. Moreover, the specific study employed the formula of Kendall's coefficient of concordance method to compare several broad constraints (Kendall and Smith, 1939; Kendall, 1948; Legendre, 2005; Mallick et al., 2023).

$W=12S/(m^2 (n^3-n)-mT)$

Where,

n=The total number of objects

m=The total number of individuals

$$S=n \sum_{\{i=1\}}^{\{n\}} (R_{\{i\}}-\{\bar{R}\})^{\{2\}}$$

T=Correction factors for tied ranks

So,

$$W=\frac{12\sum_{i=1}^{n}(R_i^2)-3m^2n(n+1)^2}{m^2n(n^2-1)-mT}$$

Kendall's coefficient of concordance is a statistical metric employed to assess the level of consensus or concurrence among two or more judges or respondents on specific matters. The coefficient is a value ranging from 0 to 1, where 0 indicates no consensus among the judges and 1 specifies full consensus.

3. Results and Discussion

3.1. Prioritisation of constraints faced by farmers of both CSVs and non-CSVs

3.1.1. Technical constraints

The ranking of technical constraints revealed critical challenges faced by both CSV and non-CSV farmers in the adoption of climate-smart practices. The top-ranked constraint, "Unavailability of necessary inputs," underscored a fundamental barrier where farmers may struggle to access the necessary resources to implement climate-smart technologies effectively. The slightly higher mean scores for non-CSV farmers across several constraints, such as the "Lack of timely information related to climate-resilient technologies" and " Limited availability of farming machinery," suggested that farmers in non-CSV regions faced greater informational and awareness gaps compared to their CSV counterparts. This reflected the benefits of the CSV approach in providing better access to information and raising awareness about climate resilience. These results contrast with those reported by Mishra et al. (2024), who examined 120 paddy farmers from the eastern climatic zone of Haryana. Their study identified key technical barriers-namely, limited awareness of climate-smart agricultural practices, insufficient training, and the perceived complexity of these practices-as the primary factors hindering the adoption of climate-smart agriculture in non-climate-smart villages (Table 1).

3.1.2. Economic and labour constraints

The ranking of economic and labour constraints among CSV and non-CSV farmers highlighted the critical issues that needed to be addressed for improving agricultural productivity and sustainability. The top-ranking issue, " Insufficient reserve of owned resources," highlighted the widespread challenges faced by farmers in both groups regarding access to necessary resources, which limited their ability to maximise agricultural output. The slight variation in the ranking of "Higher investment cost on farm machinery and land development" suggested that non-CSV farmers may have experienced slightly more financial pressure in this area compared to CSV farmers, possibly due to the differences in resource availability or external support. These findings diverged from those of Mishra et al. (2024), who conducted a study involving 120 paddy farmers from the eastern climatic zone of Haryana. Their research revealed that in climate-smart villages, the most significant challenges were economic in nature, including the rising cost of paddy production, substantial initial investment requirements for inputs, and reduced paddy yields (Table 2).

Table 1: Ranks of all the technical constraints

Technical constraints	Ranks		
	CSVs	Non-CSVs	Pooled
1. Lack of awareness about climate change	VI	VI	VI
2. Unavailability of necessary inputs	I	II	I
3. Poor availability and accessibility of flood tolerant crop varieties	II	I	II
4. Limited availability of farming machinery	IV	IV	IV
5. Lack of timely information related to climate resilient technologies	III	III	III
6. Lack of proper drainage system	V	V	V

Table 2: Ranks of all the economic and labour

Economic and labour constraints	Ranks		
	CSVs	Non-CSVs	Pooled
1. Inadequate financial assistance	III	III	III
2. Higher investment cost on farm machinery and land development	IV	IV	IV
3. Longer gestation period	V	V	V
4. Labour scarcity	II	II	II
5. Insufficient reserve of owned resources	I	I	I

3.1.3. Social and personal constraints

The ranking of social and personal constraints among CSV and non-CSV farmers revealed key challenges that influenced the adoption of Climate Smart technologies and other innovative practices. The top-ranked constraint, "Requirement of longer period to get positive responses from the social system," highlighted the farmers' concerns about the time it takes for the social system to respond positively to changes, which may have hindered their willingness to make such changes. The prominence of "Criticism from various social groups" and "Resistance to change the conventional practices" indicated that social pressures and reluctance to deviate from established methods are significant barriers to innovation. These findings underlined the need for targeted interventions that address these social and personal barriers to ensure a more supportive environment for the adoption of innovative farming techniques. These findings show a slight deviation from those reported by Jasna et al. (2016), who conducted their study in the Tumkur district of Karnataka and the Gumla district of Jharkhand. The study concluded that "resistance to changing conventional practices" was perceived as the most critical social and personal constraint by both farmers (mean rank=3.99) and agricultural officials (mean rank=4.05) (Table 3).

Table 3: Ranks of all the social and personal constraints

Social and personal constraints	Ranks		
	CSVs	Non-CSVs	Pooled
1. Criticism from various social groups	II	III	II
2. Resistance to change the conventional practices	III	II	III
3. The belief that 'It is better to follow conventional farming today and let tomorrow take care of it'	V	V	V
4. Requirement of longer period to get positive responses from the social system	I	I	I
5. Lack of proper community action for the promotion of Climate-smart technologies	IV	IV	IV

3.1.4. Animals and pests constraints

The ranking of animal and pest constraints among CSV and non-CSV farmers revealed notable patterns. The consistent identification of "Interference by Nilgai (Indian antelope)" as the most severe issue highlighted its significant impact on farmers across both groups. This issue, characterised by high mean scores, reflected the widespread challenges posed by Nilgai, which likely affects crop yields and farming operations extensively. The close ranking of "Interference by rats" and "Interference by wild boars" highlighted their importance as well, though slightly less severe than Nilgai interference. Overall, these rankings provided valuable insights into the differing challenges faced by farmers in CSV and non-CSV settings, which can inform targeted interventions and resource allocation for managing animal and pest-related issues.

The present findings share both similarities and differences with the conclusions drawn by Wakweya et al. (2023), who, in their research conducted in the sub-Saharan Africa on the challenges and prospects of CSA practices and technologies and their implications on food security, identified the absence of supportive policies and political commitment, limited awareness of climate-smart agriculture (CSA) technologies among smallholder farmers, institutional barriers, and financial limitations as the principal challenges to CSA adoption. Conversely, they also highlighted the presence of various resources-such as projects, programs, technologies, practices, and related applications-as key opportunities for policymakers, extension agents, and farmers (Table 4, 5 and 6).

3.2. Ranks of different groups of constraints as perceived by farmers of CSVs and non-CSVs

For farmers in CSVs, "Economic and Labour" constraints were

Table 4: Ranks of all the animals and pests constraints

Animals and pests constraints	Ranks		
	CSVs	Non-CSVs	Pooled
1. Interference by monkeys	IV	IV	IV
2. Interference by wild boars	III	III	III
3. Interference by rats	II	II	II
4. Interference by Nilgai (Indian antelope)	I	I	I

Table 5: Mean scores of the list of constraints faced by the farmers

Particulars		Mean score		
		CSVs	Non-CSVs	Pooled
Technical	1. Lack of awareness about climate change	1.14	1.23	1.14
	2. Unavailability of necessary inputs	1.42	1.45	1.42
	3. Poor availability and accessibility of flood tolerant crop varieties	1.41	1.46	1.41
	4. Limited availability of farming machinery	1.29	1.36	1.29
	5. Lack of timely information related to climate-resilient technologies	1.32	1.38	1.32
	6. Lack of proper drainage system	1.25	1.32	1.25
Economic and labour	7. Inadequate financial assistance	1.84	1.89	1.84
	8. Higher investment cost on farm machinery and land development	1.55	1.64	1.55
	9. Longer gestation period	1.4	1.47	1.4
	10. Labour scarcity	1.85	1.90	1.85
	11. Insufficient reserve of owned resources	1.86	1.91	1.86
Social and Personal	12. Criticism from various social groups	0.81	0.84	0.81
	13. Resistance to change the conventional practices	0.80	0.86	0.80
	14. The belief that 'It is better to follow conventional farming today and let tomorrow take care of it'	0.55	0.63	0.55

Figure 5: Continue...

Particulars		Mean score		
		CSVs	Non-CSVs	Pooled
	15. Requirement of longer period to get positive responses from the social system	1.09	1.12	1.09
	16. Lack of proper community action for the promotion of Climate smart technologies	0.72	0.79	0.72
Animals and pest interferences	17. Interference by Monkeys	0.11	0.15	0.11
	18. Interference by wild boars	1.18	1.23	1.18
	19. Interference by rats	1.32	1.36	1.32
	20. Interference by Nilgai (Indian antelope)	1.74	1.78	1.74

Table 6: Overall ranks of all the constraints combined are shown after comparing the mean score values of each constraint

Particulars		Overall ranks		
		CSVs	Non-CSVs	Pooled
Technical	1. Lack of awareness about climate change	XIV	XIII	XIV
	2. Unavailability of necessary inputs	VI	VIII	VI
	3. Poor availability and accessibility of flood tolerant crop varieties	VII	VII	VII
	4. Limited availability of farming machinery	XI	X	XI
	5. Lack of timely information related to climate-resilient technologies	IX	IX	IX
	6. Lack of proper drainage system	XII	XII	XII
Economic and Labour	7. Inadequate financial assistance	III	III	III
	8. Higher investment cost on farm machinery and land development	V	V	V
	9. Longer gestation period	VIII	VI	VIII
	10. Labour scarcity	II	II	II
	11. Insufficient reserve of owned resources	I	I	I
Social and personal	12. Criticism from various social groups	XVI	XVII	XVI
	13. Resistance to change the conventional practices	XVII	XVI	XVII
	14. The belief that ‘It is better to follow conventional farming today and let tomorrow take care of it’	XIX	XIX	XIX
	15. Requirement of a longer period to get positive responses from the social system	XV	XV	XV
	16. Lack of proper community action for the promotion of Climate-smart technologies	XVIII	XVIII	XVIII
Animals and pest interferences	17. Interference by Monkeys	XX	XX	XX
	18. Interference by wild boars	XIII	XIII	XIII
	19. Interference by rats	IX	X	IX
	20. Interference by Nilgai (Indian antelope)	IV	IV	IV

identified as the most severe, holding the top rank with a mean score of 3.92. This was followed by “Technical,” “Animals and Pests,” and “Personal and Social” constraints, with mean scores of 2.76, 2.05, and 1.28, respectively. Similarly, for non-CSV farmers, “Economic and Labour” constraints also ranked the highest, with a mean score of 3.55. They were followed by “Technical,” “Personal and Social,” and “Animals and Pests” constraints, with mean scores of 2.93, 2.31, and 1.21, respectively (Figure 1 and Table 7 and Table 8).

3.3. Kendall’s coefficient of concordance

The examination of Table 9 showed that Kendall’s coefficient of concordance (Kendall’s W) value for farmers of CSVs was 0.774, whereas for farmers of non-CSVs, it was estimated to

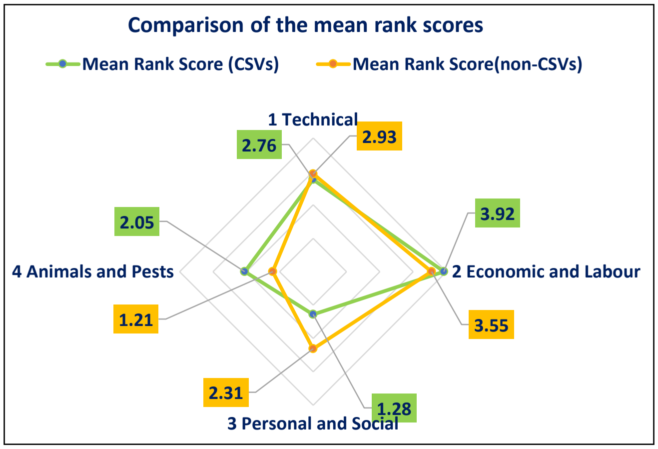

Figure 1: Comparison of the mean rank scores of the constraint groups of CSV and non-CSV farmers

Table 7: Mean rank scores and ranks of constraint groups as perceived by farmers of CSVs

Sl. No.	Constraint groups	Mean rank score	Rank
1	Technical	2.76	II
2	Economic and labour	3.92	I
3	Personal and social	1.28	IV
4	Animals and pests	2.05	III

Table 8: Mean rank scores and ranks of constraint groups as perceived by farmers of non-CSVs

Sl. No.	Constraint groups	Mean rank score	Rank
1	Technical	2.93	II
2	Economic and labour	3.55	I
3	Personal and social	2.31	III
4	Animals and pests	1.21	IV

Table: 9: Test for Kendall's coefficient of concordance (CSVs)

Test Statistics			Values
N			100
Kendall's W			0.774
Chi-Square			232.142
df			3
Asymp. Sig.			0.000
Monte Carlo Sig.	Sig.		0.000
	99% CI	LB	0.000
		UB	0.000

be 0.612. Given that Kendall's W is a numerical scale ranging from 0 to 1, scores of 0.774 and 0.612 both suggest that respondents were more in agreement among comprehensive sets of limitations. Nevertheless, the farmers of Climate Smart Villages (CSVs) have shown a somewhat higher degree of agreeableness among themselves in comparison to the farmers of non-CSVs. The asymptotic significance for both farmer groups was 0.000, indicating statistical significance (*p*<0.01). The chi-square test statistic for both groups was 232.142 and 183.664, respectively, with 3 degrees of freedom. The table unequivocally shows that the Monte Carlo result was statistically significant with a 99% confidence interval. Hence, it can be stated that there exists a substantial disparity among the four distinct broad categories of limitations encountered by the farmers of both CSVs and non-CSVs. This result shows some congruency as concluded by Mallick et al., 2023 in his study conducted in the cyclone affected regions of Odisha on 160 farmers about four broad groups of impediments where the Kendall's W value came out to be 0.588 showing significant agreeableness among the 160 farmers about the constraints faced in their respective localities (Table 10).

Table: 10: Test for Kendall's coefficient of concordance (non-CSVs)

Test Statistics			Values
N			100
Kendall's W			0.612
Chi-Square			183.664
df			3
Asymp. Sig.			0.000
Monte Carlo Sig.	Sig.		0.000
	99% CI	LB	0.000
		UB	0.000

4. Conclusion

This study analysed the constraints faced by farmers in Climate-Smart Villages (CSVs) and non-CSVs, categorised into Technical, Economic and Labour, Social and Personal, and Animals and Pests groups. Using mean rankings and Kendall's W, findings showed that CSV farmers exhibited greater agreement (W = 0.774) than non-CSV farmers (W = 0.612), suggesting CSV interventions enhanced shared experiences.

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