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# An inter-district variation analysis of farmers' adaptations towards climate change in Kosi region of Bihar using post-hoc Tukey's HSD tests

[1]Deepak Kumar Patel, [2]Arun Kumar Paswan and [3]Sudhanand Prasad Lal

[1]Ph.D. Research Scholar, Department of Agricultural Extension Education, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

[2]Associate Professor cum-Senior Scientist, Department of Agricultural Extension Education, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

[3]Assistant Professor cum-Scientist & Co-PI AICRP-WIA, Department of Agricultural Extension Education, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

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**Corresponding Author:** Sudhanand Prasad Lal

**Abstract**

A climate change adaptation is the solution of preventing the impacts of climate change on agriculture. The Kosi River is also known as the sorrow of Bihar in India. Based on an exploratory research design, this study, purposively selected in the flood-affected region of Bihar, examines their adaptive behavior towards climate change in the Araria, Katihar, Kishanganj, and Purnea districts. A total of 400 respondents were randomly selected from two blocks in each district, two clusters villages from each blocks and 50 respondents in each cluster villages. A well structured and prior tested interview schedule was used to interview the respondents. The main objective of the study was to compare the adaptive behaviour of farmers towards climate change in Kosi region of Bihar through suitable statistical method. Post Hoc Tukey's Honestly Significant Difference (HSD) test was used to compare the adaptive behavior of farmers among the district. According to the results, Purnea ($\bar{x}$=97.83) had the highest adaptive behaviour capacity of farmers towards climate change, followed by Katihar ($\bar{x}$=90.73), Araria ($\bar{x}$=83.06) and Kishanganj ($\bar{x}$=79.77). Thus, through Post Hoc test making 6 districts for pair of comparison. Based on a hypothesis that farmers in the Kosi region of Bihar are not differently adaptive to climate change, post-hoc Tukey's HSD test was used to test this hypothesis. Tukey's HSD test, Purnea (3) has the maximum number of stark and significant differences with all three districts, i.e., significant at the 1% level with Katihar, Araria and Kishanganj when it is used as a reference category. As a result of this study, farmers of Kishanganj district has least adaptive behavior capacity towards climate change, which suggests that climate change training and awareness programmes are needed for the improvement in adaptive behaviour of farmers.

**Keywords:** Adaptive behaviour, climate change, honestly significant difference (HSD), impact assessment and post hoc test

## Introduction

Climate change refers to a long-term change in temperature and weather patterns, which can have a significant effect on agricultural production. Climate change impacts crop yields and agricultural productivity significantly. It is believed that climate change will result in lower crop yields because the rainfall patterns will change, and extreme weather events like droughts and floods will also affect crop yields [1]. Most recent research endorsed that due to increased global warming, the world is witnessing climate change and it is a major threat to declined agricultural productivity [13]. A change in climate caused by human activity or natural variability is considered climate change by the [7]. Agriculture faces unique challenges due to climate change, as the FAO Report 2021 states that drought and floods cost USD 37 billion and USD 21 billion, respectively. India has a large population that depends heavily on livelihoods that are vulnerable to climate fluctuations as well as frequent fluctuations in agricultural productivity and income [3, 4]. Climate change poses a number of challenges for Bihar. Agriculture has been the primary source of employment in Bihar for several decades. In addition to contributing 24.8 percent to the states gross domestic product, it employs 77 percent of the state's population. Bihar is highly vulnerable to hydro-meteorological natural disasters due to both floods and droughts. As a result of ten high-magnitude floods in Bihar over the past decade, the state has suffered severe losses to its economy and development (1998, 2004, 2007, 2008, 2012, 2013, 2016, 2017, 2018 and 2019). There has been extensive damage to life and property, as well as adverse effects on the economic development of the State as a result of these disasters [2].

Several studies around the world have indicated that India is particularly vulnerable to the effects of climate change, which have a severe impact on crops, food supplies, and human health over the next few decades, as well as cattle populations. Climate resilient and smart interventions are needed most in Zone-II of Haryana and Southwestern zone of Punjab [12]. The 14 districts of Bihar are among the most vulnerable to climate change among the 50 most vulnerable districts in India [6]. With a median score of 2.27, farmers were ranked I because of "unavailability of appropriate crop/variety" and "delay in timely availability of inputs such as crop variety, insecticides, and pesticides". As a means to improve adaptation activities, training courses, land management, and water input control have been suggested [23]. In the past, adverse weather events have affected adaptation and mitigation practices due to uncertainty in rainfall patterns and Changes in climate are changing farming patterns. Agriculture and related activities are directly affected by climate variability, and it is urgent that more risk be identified, methods and strategies developed to overcome and strengthen farmers' ability to withstand adverse situations [15]. According to [9], last 30 years have seen the most floods in north Bihar. There has also been an increase in flood-affected areas. Several smaller rivers drain north Bihar, including the Kosi and Gandak, and several other major rivers. There has been a significant loss of life and property in the north Bihar plains during the past several decades [19]. Farmers adopt climate smart agriculture technologies to mitigate climate change rather than improving productivity and resilience of the ecosystem [14]. Since most people do not understand the causes and impacts of climate change, as well as how to mitigate it, this study did in the Kosi region of Bihar. Thus realizing the importance of problem, with the study entitled Comparative Assessment of different district in terms of adaptive capacity in Bihar: An Inter-district Variation Analysis Using Post Hoc Tukey's HSD Test.

## Materials and Methods

The study was conducted in four districts of Kosi region in Bihar, namely Araria, Katihar Purnea and Kishanganj. In order to select blocks, villages, and respondents, a multistage sampling technique was used. Two blocks selected from each district purposively and from each block two villages selected purposively. As a sample, 50 respondents were selected randomly from each village [21], resulting in a total of 400 respondents. A scientifically validated interview schedule was used to collect data on how climate change impacts farmers' socioeconomic conditions and adaptive capacity. In this study, the main challenge was to compare the assessments of different districts in terms of adaptability to climate change across all four districts using a suitable statistical method. A post hoc Tukey's Honestly Significant Difference (HSD) test was used to analyze this impact comparison [16, 11, 12]. These 4 selected districts, Araria, Katihar, Purnea and Kishanganj were most affected with flood in Bihar. As part of the analysis, SPSS software version 27.0.1.0 was used to score, compile, tabulate, and analyze the collected data, including mean, standard errors, standard deviations, frequencies, one-way ANOVA, and Tukey's HSD. It is widely recognized that the Post-Hoc Tukey's HSD test is the best method for a wide range of cases [16, 11, 12].

## Results and Discussion

A descriptive statistic summarizes the structure of a data set and provides insight into its characteristics. The Wilcoxon Signed Paired Rank test is one that uses descriptive statistics to estimate data distributions. Based on the information provided in Table 1, Purnea (x=97.83) was the district with the greatest impact on farmers' adaptive capacity, followed by Katihar (x=90.73), Araria (x=83.06), and Kishanganj (x=79.77); consequently, the mean impact of the district was 87.85. As seen in Fig. 1, the mean value of impact.

**Table 1:** Descriptive Statistics of adaptive behaviour among different districts

| | | N | Mean | SD | SE | 99% CI for Mean | | Minimum | Maximum | BCV |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | LB | UB | | | |
| 1 | | 100 | 83.06 | 7.532 | .753 | 81.08 | 85.04 | 71 | 95 | |
| 2 | | 100 | 90.73 | 5.537 | .554 | 89.28 | 92.18 | 71 | 99 | |
| 3 | | 100 | 97.83 | 6.893 | .689 | 96.02 | 99.64 | 78 | 110 | |
| 4 | | 100 | 79.77 | 8.233 | .823 | 77.61 | 81.93 | 62 | 99 | |
| Total | | 400 | 87.85 | 9.972 | .499 | 86.56 | 89.14 | 62 | 110 | |
| Model | FE | | | 7.118 | .356 | 86.93 | 88.77 | | | |
| | RE | | | | 4.043 | 64.23 | 111.46 | | | 64.868 |

Acronyms & coding elucidation: 1=Araria; 2= Katihar; 3=Purnea; 4= Kishanganj; N = No. of respondents, CI= Confidence Interval; x̄=Mean; LB=Lower Bound; UB= Upper Bound; BCV=Between- Component Variance; FE= Fixed Effects; RE= Random Effects

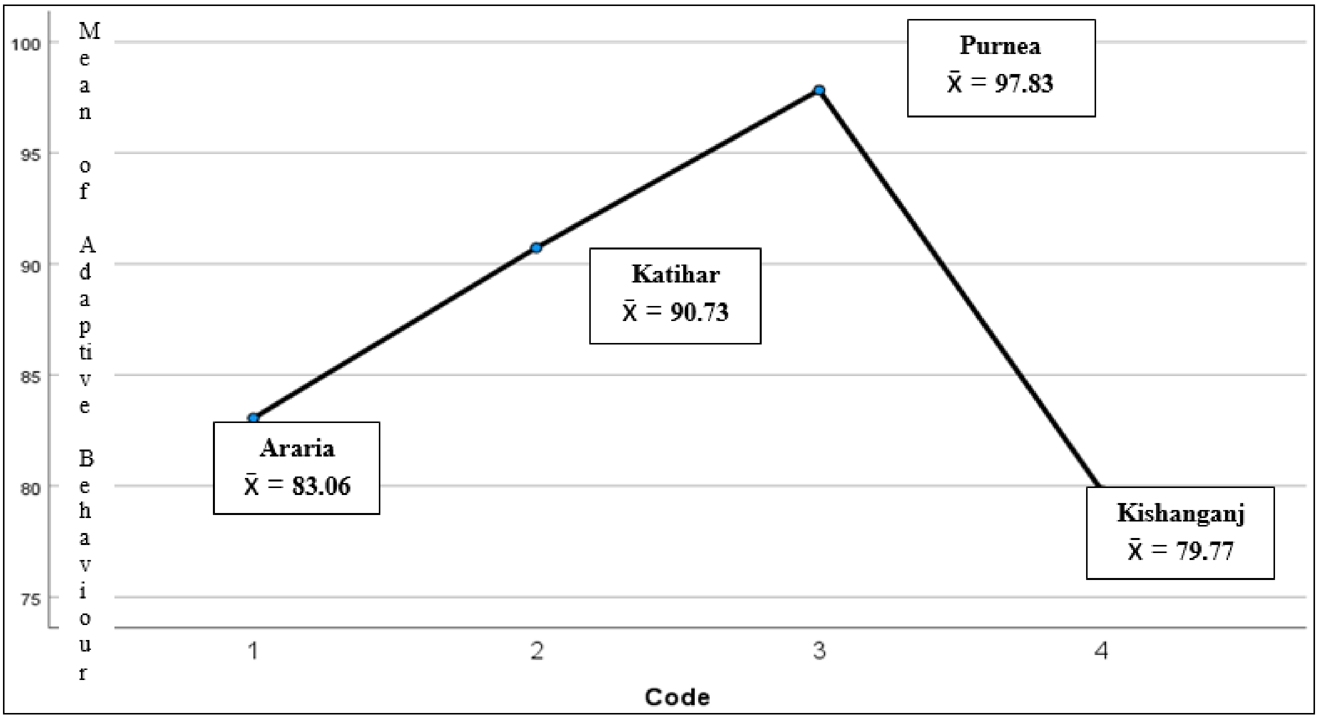


**Fig 1:** The mean value of adaptive behaviour among different district

From Table 2, shown in the illustration of the Test of Homogeneity of Variances, all the test statistic values are significant (at both 1% levels of significance), indicating that the variances for all the study variables are homogeneous.

**Table 2:** Test of Homogeneity of Variance

| Adaptive Behaviour | | Levene Statistic | df1 | df2 | Significance |
|---|---|---|---|---|---|
| | Based on x̄ | 5.558 | 3 | 396 | .001 |
| | Based on Median | 6.220 | 3 | 396 | .000 |
| | Based on Median and with adjusted df | 6.220 | 3 | 382.718 | .000 |
| | Based on trimmed x̄ | 5.866 | 3 | 396 | .001 |

ANOVA test results are presented in Table 3; it is obvious that the test statistic for ANOVA test is significant (at 1% significance levels) which indicates significant differences among all variables [18, 5].

**Table 3:** ANOVA value representing the appropriateness of Post Hoc test

| Adaptive Behaviour | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 19612.528 | 3 | 6537.509 | 129.022 | .000 |
| Within Groups | 20065.170 | 396 | 50.670 | | |
| Total | 39677.698 | 399 | | | |

According to Table 4, the Robust tests of equality of means are asymptotically significant, indicating that the means of the variables are significantly different.

**Table 4:** Robustness test of equality of means

| Adaptive Behaviour | Statistic[a] | df1 | df2 | Sig. |
|---|---|---|---|---|
| Welch | 119.849 | 3 | 217.594 | .000 |
| Brown-Forsythe | 129.022 | 3 | 369.403 | .000 |

a. Asymptotically F distributed.

It is necessary to code all four districts from 1 to 4 in order to apply Tukey's HSD test. Reference codes are (I) Codes, whereas comparison codes are (J) Codes. The mean difference between Araria (1) and Purnea (3) was found to be significant at a 1% level [83.06-97.83 = -14.77). Purnea was ranked first and Araria was ranked third in terms of adaptive behavior of farmers towards climate change, but even then, these 2 districts displayed significant differences. Purnea (3) was also highly significant at a 1% level when compared to Katihar (2), and when compared to Kishanganj (4), it was highly significant at a 1% level, but weakly significant when compared to Katihar (2) and Araria (1). As a reference category, Purnea (3) has a maximum number of stark and significant differences from the other 3 districts, namely, significant at 1% level with Araria, Katihar and Kishanganj. In light of this, Purnea in the Kosi region of Bihar has the best adaptive behavior capacity of farmers in regards to climate change (Table 5).

**Table 5:** Inferential Statistics among different districts through multiple comparisons Tukey's HSD test

| (I) Code | (J) Code | Mean Difference (I-J) | Std. Error | Sig. | 99% CI | |
|---|---|---|---|---|---|---|
| | | | | | LB | UB |
| 1 | 2 | -7.670* | 1.007 | .000 | -10.82 | -4.52 |
| | 3 | -14.770* | 1.007 | .000 | -17.92 | -11.62 |
| | 4 | 3.290* | 1.007 | .006 | .14 | 6.44 |
| 2 | 1 | 7.670* | 1.007 | .000 | 4.52 | 10.82 |
| | 3 | -7.100* | 1.007 | .000 | -10.25 | -3.95 |
| | 4 | 10.960* | 1.007 | .000 | 7.81 | 14.11 |
| 3 | 1 | 14.770* | 1.007 | .000 | 11.62 | 17.92 |
| | 2 | 7.100* | 1.007 | .000 | 3.95 | 10.25 |
| | 4 | 18.060* | 1.007 | .000 | 14.91 | 21.21 |
| 4 | 1 | -3.290* | 1.007 | .006 | -6.44 | -.14 |
| | 2 | -10.960* | 1.007 | .000 | -14.11 | -7.81 |
| | 3 | -18.060* | 1.007 | .000 | -21.21 | -14.91 |

*. The mean difference is significant at the 0.01 level.
1 Araria, 2 Katihar, 3 Purnea, 4 Kishanganj

## Conclusions

Adapting to climate change can prevent the impact of climate change on agriculture. This study focused on comparing farmers' adaptive behaviors towards climate change in Kosi region of Bihar. By using the Post Hoc Tukey Honestly Significant Difference (HSD) test, this comparison of adaptive behavior was analyzed. The results concluded that Purnea ($\bar{x}$=97.83) had the highest adaptive behavior capacity of farmers [8] against climate change because farmers of this districts were more educated and belong to higher socio-economic status followed by Katihar ($\bar{x}$=90.73), Araria ($\bar{x}$=83.06), and Kishanganj ($\bar{x}$=79.77). Kishanganj had the least adaptive behaviour capacity of farmers towards climate change; therefore awareness and training program related to climate change are needed in this district to enhance the adaptive capacity of farmers.

## References


1. Annie M, Pal RK. Meta-Analysis Studies Emphasizing Activities Related to Natural Resources Management for Imparting Resilience to Dryland Agriculture. In Enhancing Resilience of Dryland Agriculture under Changing Climate: Interdisciplinary and Convergence Approaches; c2023. p. 207-218. Singapore: Springer Nature Singapore. DOI: 10.9734/ijecc/2023/v13i71906
2. Bihar Floods: A Field Report. National Institute of Disaster Management, Ministry of Home Affairs, New Delhi; c2007. ISBN: 978-93-82571-04 9.https://nidm.gov.in/PDF/pubs/Bihar%20Flood%2020 07.pdf
3. Bizikova L, Roy D, Swanson D, Venema HD, McCandless M. The water- energy-food security nexus: Towards a practical planning and decision-support framework for landscape investment and risk management 16-20 Winnipeg: International Institute for Sustainable development; c2013. https://www.researchgate.net/publication/356879079_The_Water-Energy Food_Security_Nexus_Towards_a_practical_planning_and_decisionsupport_framework_for_landscape_investment_and_risk_management_for_Sustainable_Development.
4. Brown E, Johnson TC, Scholz C, Cohen A, King JW. Abrupt change in tropical African climate linked to the bipolar seesaw over the past 55,000 years. Geophysical Research Letters. 2007;34:20. https://doi.org/10.1029/2007GL031240
5. Chithra K, Evoor S, Allolli TB, Jagadeesh SL, Cholin S. Correlation Coefficient Analysis for Yield and Yield Attributing Traits in Sponge Gourd (*Luffa cylindrica* (L.) Roem.). Biological Forum – An International Journal. 2023;15(1):419-424.https://www.researchtrend.net/bfij/pdf/Correlation-Coefficient-Analysis-for-Yield-and-Yield-Attributing-Traits-in-Sponge-Gourd-(Luffa-cylindrica-(L.)-Roem.)-Chithra-K-69.pdf
6. DST. Climate vulnerability assessment for adaption planning in India using common framework. Department of Science and Technology (Ministry of Science and Technology) Government of India, New Delhi; c2020. https://dst.gov.in/sites/default/files/Full%20Report%20%281%29.pdf
7. IPCC. Climate Change: Synthesis Report Summary for Policymakers; c2014. https://www.ipcc.ch/report/ar5/syr/
8. Jha CK, Gupta V. Farmer's perception and factors determining the adaptation decisions to cope with climate change: An evidence from rural India. Environmental and Sustainability Indicators. 2021;10:100112. https://doi.org/10.1016/j.indic.2021.100112
9. Kale VS. Flood studies in India: A brief review. Journal of the Geological Society of India. 1997;49:359-370. https://www.geosocindia.org/index.php/jgsi/issue/view/5529
10. Kumar A, Singh AK, Lal SP, Patel DK, Prakash S. An Exploratory Studyon Pattern and Factors Influencing Out Migration among COVID-19 Returned Migrants in North Bihar. Biological Forum – An International Journal. 2022;14(4a):492-498. https://www.researchtrend.net/bfij/current_issue_bfij.php?taxonomy-id=147
11. Lal SP, Jha SK, Sinha S. Detrimental bio-invasion in the green revolution Belt of India: LSD multiple comparisons post hoc analysis. Journal of Entomology and Zoology Studies. 2019;7(2):129-132. https://www.entomoljournal.com/archives/2019/vol7issue2/PartC/7-2-21-765.pdf
12. Lal SP, Jha SK, Sinha S. Climate Vagaries in Two

Green Revolution States ofIndia: An Inter-Zonal Variation Analyses Through Post Hoc Tukey's HSD Test.Journal of Community Mobilization and Sustainable Development. 2023;18(1):186-192. http://mobilization.org.in/current-journal.php

13. Lal SP, Shukla G, Jha RK. Perceived Impediments faced by farmer's vis-à-vis adoption of Zero tillage machine for sowing of field crops in Indo-Gangetic plain of India: PCA based Construct Validation. Agricultural Mechanization in Asia, Africa and Latin America. 2022;53(6):7909-7918. https://www.shin-norinco.com/article/perceived-impediments-faced-by-farmers-vis-a-vis-adoption-of-zero-tillage-machine-in-indo-gangetic-plain-of-india-pca-based-construct-validation
14. Madhumitha GS, Murugan PP, Janaki Rani A, Dheebakaran GA, Ganapathi PS, Devi NM, *et al*. Assessing and identifying the factors influencing utilization of CSA technologies among farmers of agro-climatic zones of Tamil Nadu. Int. J Agric. Extension Social Dev. 2024;7(2):248-252. https://doi.org/10.33545/26180723.2024.v7.i2d.350
15. Namdeo S, Gupta S. Communicational and psychological determinants of risk perception of farmers towards climate change in Madhya Pradesh.Journalof community mobilization and sustainable development. 2024;19:329-335. http://dx.doi.org/10.5958/2231-6736.2024.00089.9
16. Schlegel A. Tukey's Test for Post-Hoc Analysis. Published on 07 September. Retrieved from; c2018: https://aaronschlegel.me/tukeys-test-post-hoc-analysis.html
17. Shukla G, Ansari MN, Lal SP, Bandhavya M. Information seeking behaviour of farmers through mobile: An innovative ICT tool. Biological Forum–An International Journal. 2022;14(1):586-590. http://dx.doi.org/10.13140/RG.2.2.27632.53765
18. Shukla P, Lal SP, Baruah B. An Exploration on Feminization of Agriculture and their Involvement in Agricultural Workforce: Perceptivity Analysis on unseen Partners. International Journal of Theoretical & Applied Sciences. 2022;14(1):48-52. https://researchtrend.net/ijtas/pdf/10%20An%20Exploration%20on%20Feminization%20of%20Agriculture%20and%20their%20Involvement%20in%20Agricultural%20Workforce%20Perceptivity%20Analysis%20on%20unseen%20Partners%20Sudhanand%20Prasad%20Lal.pdf
19. Sinha R, Jain V. Flood hazards of north Bihar rivers, Indo-Gangetic plains. In: Kale, V. S. (Ed) Flood Studies in India, Memoir Geological Society of India. 1998;41:27-52. https://link.springer.com/article/10.1007/s12524-008-0034-y
20. Srivastava D, Kumari A, Lal SP. Relational Analysis of Awareness Regarding Health and Hygiene Apropos Menstruation among Women in Bihar. Biological Forum – An International Journal. 2023;15(2):1003-1007. https://www.researchtrend.net/bfij/pdf/Relational-Analysis-of-Awareness-Regarding-Health-and-Hygiene-Apropos-Menstruation-among-Women-in-Bihar-Sudhanand-Prasad-Lal-156.pdf
21. Srivastava D, Kumari A, Lal SP. Factors Determining Awareness and Role of Community Moblization vis-à-vis Bio- degradable Jan Aushadhi Suvidha Sanitary Napkins among Women in India. Journal of Community Mobilization and Sustainable Development. 2024;19(2):1-7.
22. Srivastava RK, Lal SP. Relational Analysis of Food grains and its Seed Production in India: Current Scenario and Future Prospects. Biological Forum – An International Journal. 2021;13(2):726-731. https://www.researchtrend.net/bfij/pdf/106%20Relational%20Analysis%20of%20Foodgrains%20and%20its%20Seed%20Production%20in%20India%20Current%20Scenario%20and%20Future%20Prospects%20SUDHANAND%20PRASAD%20LAL.pdf
23. Suryawanshi D, Gupta S, Mishra YD. Study on adaptation strategies adopted by farmer and factors influencing regarding adaptation strategies to climate change in Satpura range agro climatic zone of Madhya Pradesh. Journalof community mobilization and sustainable development. 2023;18(4):1107-1112. http://dx.doi.org/10.5958/2231-6736.2023.00098.4