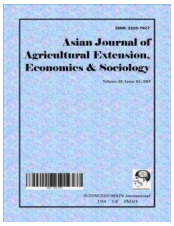

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# A Scale to Measure Farmers' Risk Perceptions about Climate Change and Its Impact on Agriculture

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## ABSTRACT

Climate change has emerged as one of the key determinants of agricultural productivity. Risks perceptions of farmers' towards climate change and its impact on agriculture are said to be a strong predictor of their behavioural intentions to climate change mitigation and adaptation strategies. Consequently, measuring farmers' perception about risks associated with climate change is of paramount importance and needs to be studied so that appropriate adaptation measures could be undertaken to mitigate the productivity losses. The present study was an attempt to develop a scale to measure the farmers risk perception about climate change which could be used by researchers. Likert's summated rating technique was followed for the construction of perception scale. The process started with selection of 30 statements on the bases of Mean Relevancy Weightage (MRW) scores; and the statements were given to 30 farmers in four purposively selected villages (based on their degree of vulnerability to climate change as determined by a State government Report) in Kumaon division Uttarakhand, a North Himalayan state of India which is perennially susceptible to climate change risks and uncertainties. The scale developed finally consisted of 20 statements. The

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reliability and validity of the scale was computed to find out the precision and consistency of the results. This scale will be useful for researchers and academicians studying farmers' perceptions towards climate change and its impact on agriculture. It would also be useful for policy makers for developing risk management strategies.

*Keywords: Farmers' risk perception scale; climate change risks; farmers' perception; climate change in Indian Himalayas; climate change adaptation, etc.*

## 1. INTRODUCTION

Agriculture is said to be the principal engine of economic growth in India as well as in many developing countries. Climate change presents a significant threat to the future of Indian agriculture [1]. It affects agriculture in terms of productivity, agricultural practices, environmental effects, and rural livelihoods. Vulnerability of agricultural sector to climate change also undermines the efforts of reducing hunger, malnutrition and poverty alleviation; it negatively impacts on prevailing food security scenario in India as well as globally [2,3]. Besides, climate change is perceived to be one of the greatest existential threats to human life on earth; however, risk judgments of global climate change vary greatly from one individual to another [4]. However, public denial of climate change is related to education and knowledge, and scepticism about climate risks and uncertainties is strongly determined by environmental and mass media messages [5].

Climate change is therefore recognised as the leading challenge to the performance of agricultural sector threatening global food security, and we need to generate suitable climate smart agricultural technology along with appropriate adaptation strategies by the farmers to mitigate the adverse impact of climate change. In this regard, perceptions of farmers about climate change related risks and uncertainties are of paramount importance as perceptions drive behavioural intentions. So, it is important to find out what farmers know about and understand the importance of changing climatic conditions, and how well they perceives its consequences (risks). Sjöberg [6] observed that perception of risk is a mental construct. It is critical in farmers' understanding of adaptation strategies and their adoption behaviour. So, to develop the location-specific and need-based effective adaptation and mitigation strategies for farmers, it is important to measure the risk perception of farmers about climate change. In this study, Climate change risk perception is conceptualised as farmers' understanding of the likelihood of dangers or negative consequences related with climate change. For this purpose, the study was designed with the objective to develop a scale on farmers risk perception about climate change and its impact on agriculture.

## 2. METHODOLOGY

A number of scaling techniques are used by social scientists/ researchers to measure socio-psychological constructs (such as attitude, perceptions, etc) in social sciences including extension education. In this study, a scale was developed by using the method of summated ratings as suggested by Likert [7] and Edwards [8]. A Summated rating scale consists of a set of statements, all of which are considered of approximately equal value, and to each of which subjects respond with degrees of agreement or disagreement carrying different scores. This method was used for the study, because the use of single statement to represent a concept is avoided and instead several statements as indicators, all representing different dimensions of the concept to obtain a better rounded perspective can be used.

### 2.1 Steps in Construction of Farmers Risk Perception about Climate Change Scale

The following steps were followed for construction of scale:

**(i). Items collection-** A set of items and statements were collected on the different risk associated with climate change from available literature in books, journals, magazines, newspaper, internet, etc. A tentative list of 75 statements was prepared after consulting with the researchers, extension experts and farmers.

**(ii). Editing the statement-** The items and statements were carefully edited according to the fourteen criteria given by Likert [7], Bird [9] and Edwards and Kilpatrick [10].

Out of total 75 statements, 60 statements were selected as they were found to be non-ambiguous and non-factual.

**(iii). Relevancy test-** It was possible that all the collected statements may not be equally relevant in measuring the risk perception of farmers about climate change. Hence, these statements were subjected to scrutiny by an expert panel to determine their relevancy and their screening for final inclusion in the scale. The judges comprised experts (scientists and researchers) from extension education disciplines of different State Agricultural Universities (SAUs), State Departments and Extension Institutes. The statements were sent to 120 judges with necessary instructions to critically evaluate each statement for its relevancy. The judges were requested to give their response on a 3 point continuum *viz.,* most relevant, relevant and least relevant, respectively. Out of 120, only 50 responded in the time span of two months, out of which five judges' responses were rejected due to incomplete and ambiguous responses. By summing up, the score given by 45 judges, the total score of all the 60 statements was calculated. From this, Relevancy Percentage (RP), Mean Relevancy Weightage (MRW) and Mean Relevancy Score (MRS) were calculated for all the 60 statements individually by using the following formulae:

a) **Relevancy Percentage (RP) -** It is the number of respondents who scored the statements as "most relevant" and "relevant", which is converted into percentage.

$$RP = \frac{FS}{\text{No. of respondents}} \times 100$$

Where FS= Frequency score of most relevant and relevant

b) **Mean Relevancy Weightage (MRW) =** It is the ratio of actual score obtained to the maximum possible scores (MPS) obtainable for each statement. It was calculated by using the following formula:

$$MRW = \frac{MRR \times 3 + RR \times 2 + LRR \times 1}{MPS}$$

**Where MPS = No. of judges responded *3(45*3=135)**

Where,

MRR= Most Relevant Response
RR= Relevant Response
LRR = Least Relevant Response
MPS= Maximum Possible Scores

c) **Mean Relevancy Score (MRS) =** It is the ratio of actual score obtained by each respondent to the number of judges responded for the variable.

$$MRS = \frac{MRR \times 3 + RR \times 2 + LRR \times 1}{\text{No. of Judges}}$$

Where,

MRR= Most Relevant Response
RR= Relevant Response
LRR = Least Relevant Response

Using this criterion the statements were screened for their relevancy. Statements having relevancy percentage >70, mean relevancy weight age >0.70 and mean relevancy score >2 were selected for final selection of statements. By this process 30 statements were selected and modified and rewritten as per the comments of the experts.

**Table 1. Selection of statements based on judge's ratings: RP, MRW and MRS**

| Sl. No | Statements | RW | MRW | MRS |
|---|---|---|---|---|
| 1. | Agriculture sector has become more vulnerable due to climate change.* | 100 | 0.89 | 2.6 |
| 2. | Climate change is not a real phenomenon. | 46.66 | 0.54 | 1.64 |
| 3. | Climate change is the most important problem now days.* | 91.11 | 0.81 | 2.44 |
| 4. | Climate change is just a matter of belief by some people. | 48.88 | 0.55 | 1.66 |
| 5. | Temperature is increasing every year due to climate change.* | 97.77 | 0.88 | 2.64 |
| 6. | There is insufficient evidence to show whether climate change is occurring or not. | 60 | 0.61 | 1.84 |
| 7. | The frequency and extent of dry spells has affected agriculture production.* | 95.55 | 0.85 | 2.57 |
| 8. | Climate change is caused by human interventions. | 62.22 | 0.61 | 1.4 |
| 9. | Livestock rearing has become vulnerable because of climate change.* | 91.11 | 0.87 | 2.62 |
| 10. | Existing temperature is decreasing gradually due to climate change. | 46.66 | 0.58 | 1.75 |
| 11. | There is increased incidence of weed and insect pest attacks nowadays.* | 97.77 | 0.79 | 2.37 |
| 12. | There is increasing incidence of crop disease now days as compared to earlier times.* | 100 | 0.88 | 2.66 |
| 13. | Changes in weather pattern are adversely affecting farm operations.* | 88.88 | 0.77 | 2.33 |
| 14. | Climate change is caused by both natural changes in environment and human activities.* | 95.55 | 0.86 | 2.6 |
| 15. | Irregularity of rainfall has become a common occurrence. | 71.11 | 0.69 | 2.08 |
| 16. | Agriculture is not adversely affected by climate change. | 44.44 | 0.51 | 1.55 |
| 17. | Climate change is caused due to changes in environment. | 51.11 | 0.59 | 1.77 |
| 18. | Climate change is a real phenomenon. | 77.77 | 0.67 | 2.02 |
| 19. | The problem of water shortage has increased due to changing climatic conditions.* | 91.11 | 0.81 | 2.44 |
| 20. | Crop production is affected by unpredictable and erratic rainfall.* | 93.33 | 0.87 | 2.62 |
| 21. | There is no crop loss due to climate change. | 48.88 | 0.55 | 1.66 |
| 22. | Climate change is not a serious issue to affect the livelihood of farmers. | 55.55 | 0.62 | 1.86 |
| 23. | There is no change in the crop varieties due to changing climatic parameters. | 55.55 | 0.61 | 1.84 |
| 24. | Climate change is not caused by human interventions. | 33.33 | 0.49 | 1.48 |
| 25. | Extreme cold weather, strong wind and heavy fog affect farming. | 95.55 | 0.8 | 2.4 |
| 26. | Heat stress due to rise in temperature is proving harmful for the crops. | 53.33 | 0.60 | 1.82 |
| 27. | Uncertainty in rainfall pattern is one of the major factors that affect the crop production.* | 93.33 | 0.84 | 2.53 |
| 28. | The productivity of different crops has changed due to climate change. | 97.77 | 0.87 | 2.62 |
| 29. | Extreme weather events in the last few years have affected the adaptation and mitigation practices.* | 95.55 | 0.86 | 2.6 |
| 30. | Cultivation of crops has become difficult due to decreasing ground water table.* | 91.11 | 0.80 | 2.42 |
| 31. | Crop production has not affected due to climate change. | 40 | 0.52 | 1.57 |

| Sl. No | Statements | RW | MRW | MRS |
|---|---|---|---|---|
| 32. | There is greater loss of nutrients into waterways due to extreme weather events. | 75.55 | 0.65 | 1.97 |
| 33. | Farming community is not aware of the consequences of climate change.* | 95.55 | 0.8 | 2.4 |
| 34. | Deforestation has become more severe due to climate change. | 68.88 | 0.68 | 2.06 |
| 35. | Farmers are adopting different adaptation & mitigation strategies to cope up with the adverse impacts of climate change.* | 86.66 | 0.77 | 2.31 |
| 36. | Livelihood patterns of farmers are changing because of changing climatic conditions.* | 88.88 | 0.8 | 2.4 |
| 37. | People are migrating from more vulnerable to less vulnerable places. | 52.22 | 0.51 | 1.55 |
| 38. | Life of farmers has become more difficult due to climate change. | 57.77 | 0.58 | 1.75 |
| 39. | Rise in temperature is not dangerous for crops. | 62.22 | 0.60 | 1.82 |
| 40. | Climate change threatens the biodiversity in hills.* | 95.55 | 0.78 | 2.35 |
| 41. | Land use pattern in hills is changing due to changing climatic conditions.* | 93.33 | 0.82 | 2.46 |
| 42. | It has become difficult to determine when to begin sowing and harvesting operations due to climate change.* | 97.77 | 0.84 | 2.53 |
| 43. | Many plant and animal species have become extinct due to changing climatic conditions.* | 95.55 | 0.82 | 2.46 |
| 44. | Land use pattern of farmers in not affected by climate change. | 73.33 | 0.64 | 1.93 |
| 45. | Food habits of the communities are changing due to impact of climate change. | 71.11 | 0.67 | 2.02 |
| 46. | There is enough community awareness about adverse impact of climate change. | 51.11 | 0.59 | 1.77 |
| 47. | Marketing behaviour of farmers has been adversely affected due to climate change. | 55.55 | 0.54 | 1.64 |
| 48. | Climate change is the biggest threat to food security. | 57.77 | 0.62 | 1.86 |
| 49. | Productive capacity of livestock is adversely affected due to extreme climate conditions.* | 91.11 | 0.81 | 2.44 |
| 50. | Forest cover has decreased in the hilly region due to climate change.* | 77.77 | 0.74 | 2.22 |
| 51. | Transportation of agricultural produce has not been affected due to climate change. | 73.33 | 0.67 | 2.02 |
| 52. | Soil erosion is increasing day by day due to heavy rainfall.* | 86.66 | 0.74 | 2.24 |
| 53. | There is change in crop seasons and cropping practices of the farmers due to climate change.* | 95.55 | 0.78 | 2.35 |
| 54. | There is no change in the crop varieties due to changing climatic parameters.* | 88.88 | 0.74 | 2.24 |
| 55. | Agricultural production is not affected due to temperature fluctuations.* | 82.22 | 0.74 | 2.24 |
| 56. | Farmers do not use local knowledge to cope and adapt to climate change. | 48.88 | 0.54 | 1.64 |
| 57. | Climate change related disasters have increased the people's belief in God. | 62.22 | 0.62 | 1.86 |
| 58. | Climate change induced losses widen the gap between rich and poor farmers. | 77.77 | 0.67 | 2.02 |
| 59. | Mortality rate among animals has increased due to climate change impacts. | 46.66 | 0.56 | 1.68 |
| 60. | Deforestation has become more severe due to climate change.* | 91.11 | 0.81 | 2.44 |

** denotes statements/ items selected for further analysis*

**(iv). Item Analysis-** Item analysis is an important step as per the Likert technique of construction of valid and reliable scale. It was essential to delineate the items based on the extent to which they can differentiate the respondents with high perception than the respondents with low perception of the risks of climate change. For this purpose, item analysis was carried out on the 30 statements selected in the first stage. A schedule consisting of 30 statements was prepared and used for personally interviewing a sample of 30 farmers' from non-sampled area. The responses for the statements were obtained on a five point continuum viz., Strongly agree, Agree, Undecided, Disagree and Strongly disagree with scores of 5, 4, 3, 2 and 1, respectively. For negative statements, the scoring pattern was reversed. The perception score of the respondent was obtained summing up the scores of all statements.

For item analysis, the respondents were arranged in ascending order based on perception score. Twenty five percent of the respondents with highest total scores and 25% with lowest total scores were selected. These two groups provided the criterion groups in terms of evaluating the individual statements as suggested by *Edwards [9]*. Thus, out of 30 farmers to whom the items were administered for the item analysis, 8 farmers with highest and 8 with lowest scores were used as a criterion group to evaluate individual item.

The critical ratio was calculated by t-test. The 't' value is a measure of the extent to which a given statement differentiates the high group from the low group. The't' value was calculated by using the formula suggested by Edwards [7,10,11].

$$t = \frac{X_H - X_L}{\sqrt{\frac{S_H^2}{n_H} + \frac{S_L^2}{n_L}}}$$

Where,

$X_H$ = the mean score on a given statement for the high group

$X_L$ = the mean score on the same statement for the low group

$S^2_H$ = the variance of the distribution of responses of high group to the statement

$S^2_L$ = the variance of the distribution of responses of low group to the statement

$n_H$ = number of subjects in the high group; $n_L$ = number of subjects in the low group

Table 2 below gives the results of analysis of statements and their respective t-values.

**(v). Selection of Statements for final scale***:* After computing "t" value for all the items, 20 statements with highest "t" value equal to or greater than 1.75 were selected. The thumb rule of rejecting the items with 't' value less than 1.75 was followed [8]. As per the thumb rule, selection of items (i.e. statements) to be retained in the scale was based on the highest discriminating values, besides eliminating those with poor discriminating ability and questionable validity.

Thus, 20 statements were retained in the final scale based on the following criteria:

i. *The 't' value should be more than 1.75*
*ii. The statement should present a new idea i.e., the idea not overlapping with that expressed with other statement*
*iii. The statement should be simply worded and brief.*

**(vi) Standardization of the scale:** The validity and reliability was ascertained for standardization of the scale. The validity was confirmed by content validity and criterion validity

a) **Validity:** The content validity of the scale was tested. The content validity is the representativeness or sampling adequacy of the content, the substance, the matter and the topics of a measuring instrument. As the content of the scale thoroughly covered the universe of climate change risk in agriculture through literature review and experts' opinion, it was assumed that present scale satisfies the content validity. Thus, scale value difference for all the statements has a high discriminating value and it seems reasonable to accept the scale as a valid measurement.

**Reliability:** The split-half method for testing reliability was used. The scale was split into two halves on the basis of odd and even number of statements and administered to 30 respondents. Thus, the two sets of scores were obtained.

The Karl Pearson product moment correlation coefficient was calculated between the two sets of scores obtained by using the following formula:

$$r_{oe} = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{[N\Sigma X^2 - (\Sigma X)^2][N\Sigma Y^2 - (\Sigma Y)^2]}$$

Where,

N= Number of respondents
X= Value of odd numbered items score
Y= Value of even numbered items score

The value of correlation coefficient was 0.58 and this was further corrected by using Spearman's

**Table 2. Farmers risk perception about climate change statements analysis and their respective 't' values**

| Sl. No | Statements | 't' values |
|---|---|---|
| | Agriculture sector has become more vulnerable due to climate change. | 3.52* |
| | Climate change is the most important problem now days. | 3.13* |
| | Temperature is increasing every year due to climate change. | 3.26* |
| | The frequency and extent of dry spells has affected agriculture production | 4.24* |
| | Livestock rearing has become vulnerable because of climate change. | 3.54* |
| | There is increased incidence of weed and insect pest attacks nowadays. | 3.22* |
| | There is increasing incidence of crop disease now days as compared to earlier times. | 1.67 |
| | Changes in weather pattern are adversely affecting farm operations | 0.42 |
| | Climate change is caused by both natural changes in environment and human activities. | 2.16* |
| | The problem of water shortage has increased due to changing climatic conditions | 1.21 |
| | Crop production is affected by unpredictable and erratic rainfall. | 0.24 |
| | Extreme cold weather, strong wind and heavy fog affects farming | 1.88* |
| | Uncertainty in rainfall pattern is one of the major factors that affects the crop production | 2.96* |
| | The productivity of different crops has changed due to climate change. | 2.23* |
| | Extreme weather events in the last few years have affected the adaptation and mitigation practices | 1.87* |
| | Cultivation of crops has become difficult due to decreasing ground water table | 1.67 |
| | Farming community is not aware of the consequences of climate change. | 0.31 |
| | Farmers are adopting different adaptation & mitigation strategies to cope up with the adverse impacts of climate change | 1.68 |
| | Livelihood patterns of farmers are changing because of changing climatic conditions. | 2.64* |
| | Climate change threatens the biodiversity in hills | 2.72* |
| | Land use pattern in hills is changing due to changing climatic conditions. | 1.87* |
| | It has become difficult to determine when to begin sowing and harvesting operations due to climate change. | 1.98* |
| | Many plant and animal species have become extinct due to changing climatic conditions | 2.43* |
| | Productive capacity of livestock is adversely affected due to extreme climate conditions. | 4.27* |
| | Forest cover has decreased in the hilly region due to climate change. | 0.38 |
| | Soil erosion is increasing day by day due to heavy rainfall. | 3.86* |
| | There is change in crop seasons and cropping practices of the farmers due to climate change | 2.82* |
| | There is no change in the crop varieties due to changing climatic parameters. | 1.62 |
| | Agricultural production is not affected due to temperature fluctuations. | 1.35 |
| | Deforestation has become more severe due to climate change. | 3.52* |

** denotes statements/items having 't' values equal to/greater than 1.75*

Brown formula and obtained the reliability coefficient of whole set. The formula used was:

$$r_{tt} = \frac{2\, r_{oe}}{1+ r_{oe}}$$

The r value for scale was 0.73, which was significant at one percent level of significance, indicating the high reliability of the instrument. It may be said that, the test is reliable to measure the perception of farmers about climate change.

**(Vii). Final Administration –** The finally selected statements of the scale were randomly arranged and incorporated in the final format of the interview schedule for the farmers.

## 3. RESULTS

The final scale consisted of 20 statements as given in the Table 3. The statements have been categorised according to their (i) Exposure, (ii) Sensitivity, and (iii) Adaptive capacity to climate change. The responses had to be recorded on a

**Table 3. Statements selected for inclusion in the final scale**

| S.N. | Statements | SA | A | UD | DA | SDA |
|---|---|---|---|---|---|---|
| **(a). Exposure** | | | | | | |
| 1. | Agriculture sector has become more vulnerable due to climate change. | | | | | |
| 2. | Climate change is caused by both natural changes in environment and human activities. | | | | | |
| 3. | Extreme cold weather, strong wind and heavy fog affect farming. | | | | | |
| 4. | Climate change is the most important problem now days. | | | | | |
| 5. | Temperature is increasing every year due to climate change. | | | | | |
| 6. | Uncertainty in rainfall pattern is one of the major factors that affect the crop production. | | | | | |
| 7. | Extreme weather events in the last few years have affected the adaptation and mitigation practices | | | | | |
| 8. | Climate change threatens the biodiversity in hills. | | | | | |
| 9. | The frequency and extent of dry spells has affected agriculture production | | | | | |
| **(B). Sensitivity** | | | | | | |
| 10. | There is increased incidence of weed and insect pest attacks nowadays as compare to earlier times. | | | | | |
| 11. | The productivity of different crops has changed due to climate change. | | | | | |
| 12. | Deforestation has become more severe due to climate change. | | | | | |
| 13. | Soil erosion is increasing day by day due to heavy rainfall. | | | | | |
| 14. | Many plant and animal species have become extinct due to changing climatic conditions | | | | | |
| 15. | Livestock rearing has become vulnerable because of climate change. | | | | | |
| 16. | Productive capacity of livestock is adversely affected due to extreme climate conditions. | | | | | |
| **(C). Adaptive capacity** | | | | | | |
| 17. | There is change in crop seasons and cropping practices of the farmers due to climate change | | | | | |
| 18. | Livelihood patterns of farmers are changing because of changing climatic conditions. | | | | | |
| 19. | It has become difficult to determine when to begin sowing and harvesting operations due to climate change. | | | | | |
| 20. | Land use pattern in hills is changing due to changing climatic conditions. | | | | | |

*SA: Strongly agree A: Agree UN: Undecided DA: Disagree SDA: Strongly disagree*

five point continuum representing strongly agree, agree, undecided, disagree and strongly disagree with scores of 5, 4, 3, 2, and 1, respectively. The perception score of each respondent can be calculated by adding up the scores obtained by him/her on all the items. The perception score on this scale ranges from a minimum of 20 to a maximum of 100. Based on their scores farmers were divided into three categories viz. high, medium and low. The higher score indicates that the respondent had more risk perception about climate change and vice-versa.

## 4. DISCUSSION AND CONCLUSION

Climate change has emerged as a critical component of global (including UN) as well as nation's policy making dialogues and debates regarding sustainable development and food security scenario. Climate change induced risks and uncertainties are therefore churning intellectual discussions and development scholarship with focus on improving agricultural productivity and production efficiency. IPCC (Inter-Governmental Panel on Climate Change) [12] has observed that India is one of the most vulnerable regions to climate change and variability due to its dependence on climate. A number of scales [13,14,15] have been developed but they all are context specific. The context of the study area was deemed to be different. Hence, we need to develop specific scales/ tools for assessing the climate vulnerability and flag-out the factors which can compromise the food security scenario in the country.

However, farmers' perceptions about climate change and its adverse impact on agriculture is critical for implementing mitigations and adaptation strategies. Risk perception is social phenomena that express relationship between risk object (farmers) and the object at risk (agricultural productivity). Sound and accurate measurements of farmers' perception about the risks and uncertainties associated with climate change and its adverse impact on agriculture will therefore help in undertaking appropriate mitigation measures and adaptation strategies. But, we need reliable and valid measurement tools for correct measurements of farmers' risk perception about climate change. This scale, developed by the researcher, has been devised to assess farmer's level of risk perception towards the changing climate, and how it will have impact on farmers' vulnerability. The validity and reliability of scale indicated the high precision and consistency of the results. It will be very useful for researchers, academicians and policy makers, and can also be used beyond the study area perspective with some modifications.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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