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# SOCIETAL RESPONSES TO CLIMATE EXTREMES: IMPLICATIONS FOR ENVIRONMENTAL RISK PERCEPTION AND SUSTAINABLE DEVELOPMENT

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## ABSTRACT

*Climate extremes and long-term environmental stress have historically influenced ecological stability, societal vulnerability, and adaptive capacity. Understanding in what way societies perceive climate risks, governance effectiveness, sustainability, and environmental education remains critical for advancing environmental protection and sustainable development. A cross-sectional, questionnaire-based study was conducted among 200 adult participants from diverse demographic and disciplinary backgrounds. A structured 20-item Likert-scale instrument assessed five dimensions: climate extremes awareness, environmental risk perception, environmental governance, sustainability and adaptive capacity, and environmental education and policy relevance. Descriptive statistics, non-parametric group comparisons, and Spearman rank correlation analyses were applied. The findings indicated moderate and balanced perceptions across all environmental dimensions. Sustainability and adaptive capacity, along with environmental education and policy relevance, received comparatively higher endorsement, while perceptions of environmental governance were more cautious. Gender-based variation emerged only for environmental education and policy relevance, whereas perceptions remained consistent across age groups, education levels, and fields of study. Associations among perception dimensions were weak and non-significant, highlighting their multidimensional and independent nature. Strengthening environmental education, improving governance credibility, and promoting integrated sustainability strategies remain essential for enhancing societal responses to climate-related environmental stress.*

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**KEYWORDS:** Climate extremes, environmental risk perception, environmental governance, sustainability, environmental education

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## 1. INTRODUCTION

Extreme climatic conditions and long-term climatic change have over and over again influenced environmental conditions, stability in ecology and human livelihood. Scholarship on the topic indicates that environmental stresses as a result of climate affected the productivity of agriculture, settlement, and supply of resources, making society more vulnerable, and, at the same time, initiating adaptive responses in some situations.<sup>1,2</sup> The trends in long-term cooling had impact on the reliability of harvests and labor productivity forming quantifiable economic effects continuing in successive generations.<sup>3</sup> Climatic studies therefore play a role in the modern environmental studies by uncovering in what way long-term exposure to climate stress altered the ecosystems and whether the governance and adaptation systems in place were sufficient or not.<sup>4</sup> The ecological changes, including the instability of ecosystems and changes in land-use patterns, depict the initial signs of climate-induced ecological stress.<sup>5</sup> Placing current issues into a long-term perspective can help in understanding environmental strengths and weaknesses.<sup>6</sup> In the case of climatic instability, recognition of environmental change was not always met with effective adaptation, since the response was often mediated through cultural beliefs, social norms and institutional constraints.<sup>7</sup> The perception of environmental risk is a very important area in deciding whether societies remain taking adaptive strategies or maladaptive responses. Studies about previous climatic events reveal that ignorance in the perception of environmental signs may make vulnerability worse instead of reducing it.<sup>8</sup> Historical climatic change is studied with emphasis on in what way little scientific knowledge restricted the capacity of the societies to project the environmental stress on the climatic drivers, frequently leading to disjointed or inefficient responses.<sup>9</sup> These tendencies remain relevant to the modern issues in which risk perception still affects the general population in relation to climate adaptation and mitigation measures.<sup>10</sup> In addition to historical contexts, empirical studies on contemporary populations prove that the perception of a climate risk differs between social, political, and cultural contexts.<sup>11</sup> The regional comparative research demonstrates that both the experiential exposure and institutional trust define the societal reactions towards the environmental stress, which supports the necessity to consider risk perception as a fundamental element of studying the environment.<sup>12</sup>

Studies have shown that societies without

coordinated governance have struggled to turn environmental awareness into sustainable action.<sup>13</sup> Instead, the climatic variability proved to be less resilient in contexts which were typified by adaptive institutions and resource management strategies.<sup>14</sup> Climate studies over time have emphasized that adaptation is a process which is not only technological but also an institutional and behavioral process.<sup>15</sup> The adaptive capacity relies on the governance structures that facilitate learning, flexibility and incorporation of environmental knowledge into policy frameworks.<sup>16</sup> The current studies also emphasize that the effectiveness of governance depends on the level, both local and national, which affects the manner in which the risks of the environment remain managed.<sup>17</sup> The experiences of past climate episodes have led to the lesson that sustainable development is based on proactive governance that can detect the environmental change early enough rather than responding to the crisis conditions.<sup>18</sup>

Environmental education is an essential component used in the development of the perception of risk, popular participation, and policy acceptance. Studies have shown that the better the society is armed with environmental information, the better it is to understand climate cues and reinforce adaptive mechanisms.<sup>19</sup> Empirical research indicates that values and perceptions play a significant role in in what way the population reacts to climate change, both the skepticism and policy intervention support.<sup>20</sup>

### Objectives of the study

1. To evaluate societal perceptions of climate extremes, environmental risk, governance, sustainability, and environmental education.
2. To examine demographic variations and relationships among key environmental perception dimensions.

## 2. MATERIALS AND METHODS

### 2.1 Study Design

The research design used in the study was a cross-sectional study based on a questionnaire to investigate the social perception concerning climate extremes, environmental risk, the government, sustainability, and environmental education. The method was suitable in exploratory social-environmental research, especially when the measurement of attitudes and awareness was to be done on ordinal measurement scales. Design enabled descriptive, comparative, and association-based statistical analysis, which could enable the study to answer its objectives without the implication of temporal bias or experimental control.

## 2.2 Study Population and Sampling

The research sample used was 200 adults who were randomly selected based on various educational and work experiences. The sampling strategy followed is the non-probability convenience sampling as it is based on the issue of accessibility and the research is exploratory in nature. The inclusion criteria involved the participants having minimal literacy levels and being in a position to give informed responses to environmental problems. The size of the sample was deemed sufficient to conduct descriptive statistics, non-parametric group comparisons, and correlation analysis that remain normally used in environmental research that focuses on perception.

## 2.3 Questionnaire Development

The data were gathered via a structured questionnaire containing 20 items which included Likert scale of five, that is, strongly disagree, slightly disagree, slightly agree, mostly agree and strongly agree. The tool was intended to measure five of the main dimensions, including climate extremes awareness, environmental risk perception, environmental governance, sustainability and adaptive capacity, and environmental education and policy relevance. The questionnaire was not technical in nature so that its interpretation is easy among various disciplinary backgrounds. Demographic factors, such as age group, gender, education level and field of study were incorporated so that the subgroup analysis could be done.

## 2.4 Data Collection Procedure

The self-administered survey provided the format of the data collection. The purpose of the study was explained to the participants who were assured of anonymity and confidentiality before participating. The responses were also collected electronically to increase access and reduced errors in data entry. All the questionnaires that were returned were vetted against completeness and no responses that were not completed were established. The completed dataset was coded and arranged in a spreadsheet format in order to carry out statistical analysis.

## 2.5 Measurement Structure and Scale Properties

The responses to the items were ordinal data, and in line with the Likert-scale measurement. To obtain construct-level scores, the average response of the items in each thematic dimension was calculated to analyze them. It was deemed suitable with this multidimensional format since the exploratory goal was to study the unique so far related perceptions of

environmental awareness, governance, sustainability and education related perceptions.

## 2.6 Statistical Analysis

Descriptive and non-parametric inferential statistics were applied to conduct the statistical analysis. Kruskal-Wallis tests were used to test group differences across demographic categories and the Mann-Whitney U tests were used to test and have Bonferonni corrections at the end of the test to do pairwise comparisons where necessary. The Spearman rank correlation coefficients were applied to determine the association between the environmental perception dimensions. This was evaluated using a standard significance level of  $p < 0.05$  and multiple comparisons were adjusted.

## 3. RESULTS

### 3.1 Respondent demographics

Table 1 presents a summary of the demographic information with respect to the 200 participants involved in the study. The age distribution showed a wide representation with the highest percentage of 24.5 and 24.0 in the 46-55 years and above 55 years bracket respectively, then 18.0, 17.0 and 16.5 in the bracket 18-25 years, 36-45 years and 26-35 years respectively. The percentage of gender representation was quite equal with males representing 37.0 of the sample, females 32.0, and 31.0 stating other or not disclosed. The level of education was also high as postgraduate (35.0) and doctoral (35.5) education were the most common ones compared to undergraduate degrees (29.5). The respondents were diverse in the field of their study with the highest percentage of 28.0 being engineers, 27.5 environmental sciences, 24.5 humanities/other whereas 20.0 social sciences.

**Table 1. Demographic profile of respondents (n = 200)**

| Variable        | Category                | n  | %    |
|-----------------|-------------------------|----|------|
| Age group       | 18-25                   | 36 | 18.0 |
|                 | 26-35                   | 33 | 16.5 |
|                 | 36-45                   | 34 | 17.0 |
|                 | 46-55                   | 49 | 24.5 |
|                 | Above 55                | 48 | 24.0 |
| Gender          | Male                    | 74 | 37.0 |
|                 | Female                  | 64 | 32.0 |
|                 | Other/Prefer not to say | 62 | 31.0 |
| Education level | Undergraduate           | 59 | 29.5 |
|                 | Postgraduate            | 70 | 35.0 |
|                 | Doctoral                | 71 | 35.5 |
| Field of study  | Environmental Sciences  | 55 | 27.5 |
|                 | Social Sciences         | 40 | 20.0 |
|                 | Engineering             | 56 | 28.0 |
|                 | Humanities/Other        | 49 | 24.5 |

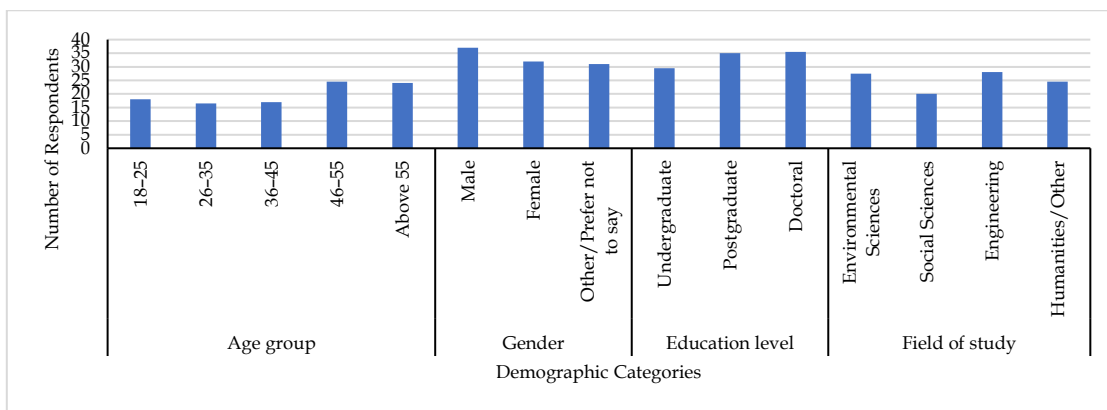


Figure 1. Distribution of respondents across demographic categories

Figure 1 shows the demographics of the sample in the study according to age, gender, education, and major. The distribution itself represents a heterogeneous profile of respondents and includes the vision of various stages of life and different academic backgrounds. This diversity increases the strength of the perception-based analysis by minimizing the concentration of the demographics and aiding the inclusion of wider explanation of climate, environmental danger, governance, sustainability and education-related reaction in the study populace.

3.2 Construct-level descriptive results

The construct-wise descriptive statistics of the responses to the questionnaires remain provided in Table 2. The findings showed that there was

moderate agreement in every dimension that was measured. The largest mean score was registered with sustainability and adaptation (3.09 + - 0.68), as there was a relatively better approval of adaptive and sustainability perspectives. There was also a fairly high mean value of environmental education (3.05 + - 0.69) and policy relevance (3.05 + - 0.69) as they demonstrated the understanding of environmental protection education and policy mechanisms. There were no differences in climate extremes awareness and environmental risk perception since they exhibited the same mean score (3.01) which indicated balanced awareness of climate effects and climate risks. The mean score of environmental governance was slightly lower (2.98 + - 0.72) which means that there were reserved views on the effectiveness of governance.

Table 2. Construct-wise scores (mean of items; 1-5 scale)

| Construct                        | Items   | Mean | SD   |
|----------------------------------|---------|------|------|
| Climate extremes awareness       | Q1-Q4   | 3.01 | 0.71 |
| Environmental risk perception    | Q5-Q8   | 3.01 | 0.67 |
| Environmental governance         | Q9-Q12  | 2.98 | 0.72 |
| Sustainability & adaptation      | Q13-Q16 | 3.09 | 0.68 |
| Environmental education & policy | Q17-Q20 | 3.05 | 0.69 |

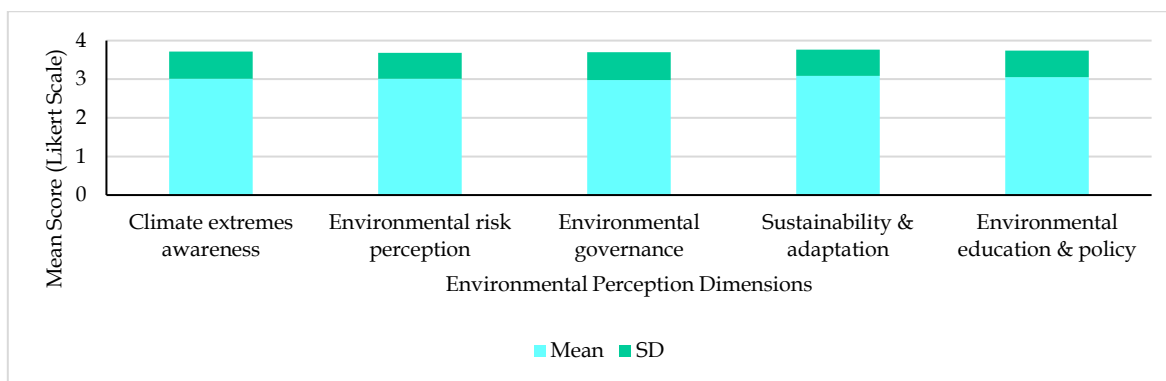


Figure 2. Comparative distribution of environmental perception dimensions

Figure 2 contains a comparative summary of the main environmental perception dimensions that

were measured in the research which remain climate extremes awareness, environmental risk perception,

environmental governance, sustainability and adaptation, and environmental education and policy relevance. Altogether, the visualization highlights a mediated image of an environmental knowledge among respondents, which indicates interrelated and independent elements of awareness, governance, adaptive capacity, and educational relevance in the larger framework of environmental protection and sustainable development.

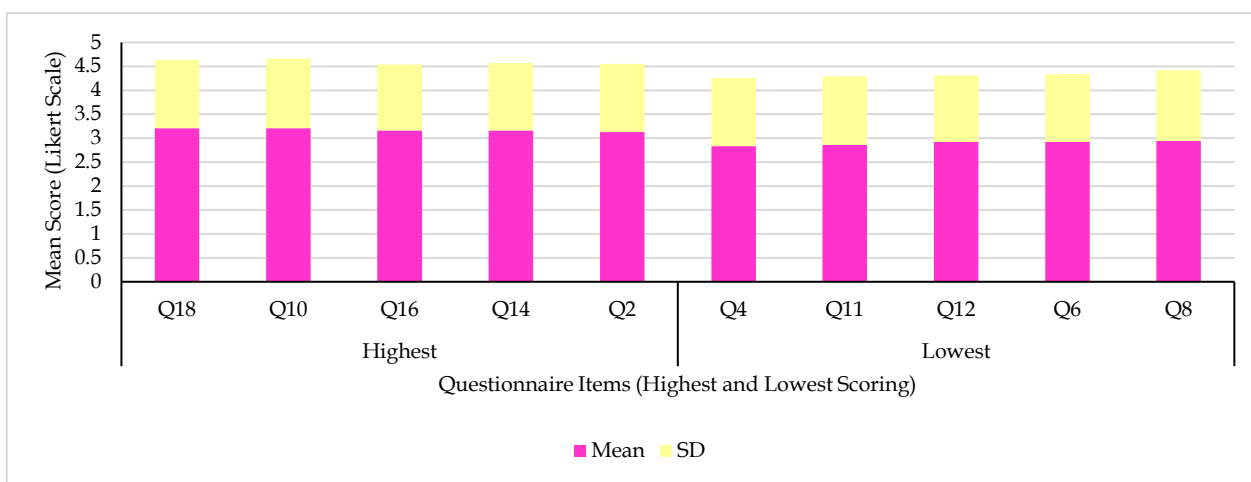
**3.3 Item-level highlights**

Table 3 identifies the most and least scoring questionnaire items to demonstrate the major tendencies in responses of the respondents. The mean score of items Q18 and Q10 (mean = 3.23) was the highest showing a comparatively strong agreement with the statements regarding the environmental education, policy relevance, and views on governance. Questions Q16 and Q14 (mean = 3.16 each) also indicated positive attitudes to sustainability and adaptive capacity, whereas

question Q2 (mean = 3.13) indicated the realization of the environmental effects of climate. Contrary to this, the lowest average scores were obtained at Q4 (2.83), Q11 (2.86), and Q12 (2.92) indicating the relatively lower agreement on the certain aspects of climate-resource linkage and governance performance. Questions C6 and C8 were also less endorsed, which means that there were different perceptions on in what way to interpret environmental risk.

*Table 3. Highest- and lowest-scoring questionnaire items (selected)*

| Group   | Item | Mean | SD   |
|---------|------|------|------|
| Highest | Q18  | 3.21 | 1.43 |
|         | Q10  | 3.21 | 1.45 |
|         | Q16  | 3.16 | 1.38 |
|         | Q14  | 3.16 | 1.41 |
|         | Q2   | 3.13 | 1.42 |
| Lowest  | Q4   | 2.83 | 1.43 |
|         | Q11  | 2.86 | 1.43 |
|         | Q12  | 2.92 | 1.39 |
|         | Q6   | 2.92 | 1.42 |
|         | Q8   | 2.94 | 1.48 |



*Figure 3. Comparison of highest and lowest scoring questionnaire items*

Figure 3 provides a comparison of the selected items in questionnaires that were awarded the highest and the lowest rates of agreement among the respondents. The visualization pinpoints the items linked to environmental education, relevance to policy, and sustainability as well as governance that received comparatively greater endorsement which indicates positive dispositions to adaptive and knowledge-based environmental solutions. This comparison gives a picture on the areas of priority when it comes to enhancing environmental communication and policy participation.

**3.4 Scale reliability**

Cronbach alpha was used to measure the consistency of the questionnaire internally to

determine the compatibility of the measured items. The internal consistency in the entire 20-item scale was low and had a Cronbachs alpha value of 0.02, which means that there is not much homogeneity between the items. Equally, construct-level analyses showed that alpha values were low 0.12 to 0.04. Such findings indicated that the questionnaire had several and comparatively distinct domains of environmental perception as opposed to one underlying latent construct, which was in line with the multidimensional and exploratory characteristics of the research.

**3.5 Variation in Environmental Perceptions across Demographic Groups**

The differences in the environmental perceptions

were studied between the demographic categories through non-parametric tests that apply to ordinal data. The only statistically significant difference was found in the environmental education and policy relevance among the gender groups, which implies the differences in the importance of education and policy role in the field of environmental protection. This difference was mostly due to the differences between female respondents and the ones who described themselves as other or those who did not want to reveal their gender. Moreover, the results of the perceptions did not vary greatly among age groups, education, and the subject areas, which means that there is overall uniformity among the demographics.

### **3.6 Associations between Environmental Perception Variables**

Analysis of Spearman rank correlation revealed a weak and non-significant correlation between climate extremes awareness and environmental risk perception, environmental governance, sustainability and adaptive capacity and environmental education and policy relevance (all  $r < 0.11$ ,  $p > 0.05$ ). These findings revealed that climate extremes awareness was not strongly co-varying with risk perceptions, governance performance, sustainability behaviour, or the contribution of environmental education implying that these dimensions of environmental knowledge were operating as independent variables in the study population.

## **4. DISCUSSION**

The findings showed that the respondents exhibited moderate and comparatively equal perceptions in all of the appraised dimensions of the environment such as climate extremes awareness, environmental risk perception, environmental governance, sustainability and adaptive capacity, environmental education and policy relevance. This moderation is indicative of the complexity of the environmental issues, in which there is awareness which is not directly reflected in certainty or decisive attitudes. The response tendencies of climate extremes awareness and environmental risk perception were also similar, which means that the notion of climatic stressors was also accompanied by the perception of environmental risks. The attitudes towards environmental governance were not very optimistic as the confidence in the efficacy of the institutional and policy tools was not high. This finding implies that the respondents recognized the significance of governance but doubted its

effectiveness in practical terms to deal with environmental issues. Conversely, such aspects as sustainability and adaptive capacity were perceived more positively, which means more effective conviction in the long-term planning, adaptive strategies, and sustainable management of resources.

The results have a significant implication on environmental safety and sustainability. Moderate awareness and perception level show that there is the opportunity to enhance the interaction with the environment with the help of the reform of governance, education and communication tools. The comparative studies in different settings have proved that the impacts of climate change on social well-being occur in complex environmental, informational, and policy channels, which support the necessity of the holistic approach.<sup>21</sup> Adaptation can be assisted by technological and informational tools, but their usefulness is limited to the ability to govern and social acceptance.<sup>22</sup> Moreover, environmental stress affects various areas of human well-being, not only with ecological effects but social and psychological aspects as well.<sup>23</sup> It has been demonstrated historically and currently that societies with powerful adaptive knowledge systems are better able to adapt to change brought about by the environment as has been seen in indigenous and resource-dependent societies.<sup>24</sup> Equally, challenges that remain ecosystem based like fisheries and coastal systems demonstrate in what way environmental pressure triggers diverse responses to society based on governance and education systems.<sup>25</sup>

## **5. CONCLUSION**

This study explored in what way the society perceived extreme weather conditions, environmental risk, governance, sustainability and environmental education by use of a structured questionnaire-based research methodology. The results showed that there were moderation and fairly equal perceptions of all measured dimensions, which meant that the respondents had a grounded knowledge of climate- and environment-related issues that were not highly polarized and had no univocal confidence. The environmental governance perceptions were characterized by cautious confidence, implying that the importance of policies is perceived but the effectiveness of the institutions is doubtful. Sustainability and adaptive capacity, in contrast, were perceived positively, which demonstrated a greater confidence in planning over the long-term, adaptability in strategies, and sustainable management of resources. The relevance

of environmental education and policy-related factors appeared to be of paramount importance, with the perceived role of knowledge dissemination, historical learning, and popular awareness being relevant in enhancing environmental protection. In general, the research adds empirical knowledge about the distribution of the environmental perceptions through social groups and thematic areas. The results illuminate the significance of

investing more effort in environmental education, improving the efficiency of governance, and advancing the practice of sustainability to enhance in what way the society reacts to environmental stress caused by climate. These joint initiatives remain needed to develop environmental conservation and sustainable development amidst growing climate fluctuating.

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