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Modeling Impacts of Climate Change

Vihaan P*

Department of Political Science, Conservation Ecology Center, Sweden

Abstract

Building community resilience and adaptation ability becomes a crucial and necessary component of local planning in the face of climate change uncertainty. But fundamental social elements that support the efficient construction and upkeep of urban resilience are poorly understood. Regarding planning methods and actions related to mitigation and adaptation strategies, as well as in relation to social features that are thought to enhance adaptive capacity and resilience to climate change, two groups of US cities that have very different commitments to addressing climate change are contrasted. When it comes to preventing and adapting to climate change, the first group has shown a strong dedication, whereas the second group has shown little to no such commitment [1-5]. The level of social capital, the prevalence of alternative thinking, and the degree of cultural variety are only a few notable social characteristics that are compared between these locations. In order for communities to be able to adapt to the effects of climate change, it is hypothesised that they must possess certain qualities. The goal is to ascertain whether there is any correlation between social or cultural structures and urban commitment to and preparation for climate change that could distinguish between metropolitan areas that are climate change resilient and those that are not. One of the most well-known endangered animals in the world is the giant panda [6-10]. The primary risks to giant pandas are habitat loss and fragmentation, and climate change may have a substantial impact on their survival. To forecast the geographic distribution and habitat fragmentation of giant pandas in the future, we combined information on giant panda habitat with broad climate models. The findings are consistent with a significant general forecast of climate change—a shift in habitats towards higher elevations and higher latitudes. According to our projections, over the next 70 years, climate change may result in a 60% reduction in giant panda habitat. Although many of these sites are distant from the giant panda's present range and just 15% are included in the current protected area system, new areas may become viable outside the giant panda's current geographic range.

Keywords: Adaptation; Fragmentation

Introduction

Local governments worldwide are tackling the issue of climate change mitigation and adaptation as part of their efforts to advance sustainability since climate change-related disturbances have the potential to significantly alter the character of communities. It is obvious that no comprehensive strategy promoting sustainability ought to downplay the effects of climate change. The ability of systems to endure and change in the face of substantial disturbances while still supplying the ecosystem services necessary to support life is strongly related to sustainability. Holling defines sustainability as "the capability to produce, test, and maintain adaptive capacity" and contends that societies must improve this capacity in order to achieve sustainable development. Urban decision-makers must use adaptive management, learn to deal with uncertainty, and encourage change without sacrificing possibilities to build a sustainable future if they are to successfully address climate change. One of the biggest sources of uncertainty currently facing all levels of government is climate change [11-16]. Wilson argued for proactive approaches to deal with climate change across Boston's many infrastructure systems, saying that doing so "allows early action, which should be more cost-effective than responding to changes as they happen or retrospectively."

The challenges posed by climate change are being addressed by urban systems all across the world in a variety of ways. Through initiatives like Cities for Climate Protection, which mandates the creation of a Climate Action Plan, the International Council on Local Environmental Initiatives has supported several of these initiatives. Cities that actively participate in CCP are encouraged to use adaptive management through a continuous process of learning, monitoring and assessing progress, sharing lessons learned, identifying knowledge gaps, and promoting community involvement. However, success in constructing community resilience to climate change will also require cultural transformations, as the implementation of adaptive management faces significant obstacles brought on by inertia, and the inability of many people to accept change. The first step in taking responsible action is making a commitment to combating climate change; however, the real challenge lies in putting that commitment into practise through effective concrete measures, as many physical, social, and political factors affect the success of any effort to promote sustainability. Because people are what drive institutions, networks, and the dynamics of social-ecological systems, changes in planning to increase resilience cannot be sustained without corresponding cultural changes. Sustainability and climate change adaptation are intimately tied to social capital issues, acceptance of unorthodox thinking, and diversity. In a collection of roughly fifty significant US cities, it discovered a direct correlation between social capital and urban sustainability. The ability of communities to adapt to change, restructure, and even use events to their advantage to stimulate adaptive transformations determines how successfully climate change-related planning initiatives are carried out in response to climatic disturbances. Concrete activities, such as those taken to reduce the community's carbon footprint and those taken to prepare for unforeseen disaster events brought on by climate change, should demonstrate the community's ability to adapt to change. In light of this, examining actual climate change anticipatory

***Corresponding author:** Vihaan P, Department of Political Science, Conservation Ecology Center, Sweden, E-mail: vihaneco@p.gmail.com

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efforts that have been performed is an excellent approach to gauge how well urban regions can adapt to climate change.

Social capital involves trust and conventions that enable a united community response to shared goals in addition to the connections made through social networks between individuals. Many academics contend that social capital is a prerequisite for fostering community resilience to significant upheavals. Accordingly, it is argued that "present and future vulnerabilities have strong social elements because both are a function of adaptive capacity, which is in turn dependent on social capital, institutions, and resources and their distribution." It is also asserted that the capacity of communities to adapt to climate change is determined by their capacity for collective action, which is in turn dependent on trust and social networks. Giant pandas are critically endangered, garner a lot of public curiosity, scholarly attention, and financial support for conservation. Historically, the species' range included the majority of southeastern China, northern Myanmar, and northern Vietnam. The geographic distribution of giant pandas has been drastically restricted by climate changes during the late Pleistocene, millennia of agricultural conversion, and human habitation, and populations are currently dispersed throughout six mountain ranges between the Sichuan plain and Tibetan plateau. The destruction of their environment is one of the biggest challenges to their survival. The species can only be found in highland forests of conifers and deciduous trees with bamboo understories. Giant panda habitat fell steadily and quickly throughout the 20th century. Large-scale endeavours like road building, forestry, mining, and hydropower development are the main causes of habitat loss, as well as agricultural conversion. Numerous giant panda populations are small and isolated due to habitat destruction, which has resulted in a highly fragmented range. This poses a risk of inbreeding and reduced gene flow. Giant panda survival may be seriously threatened by climate change. A 1.4-5.8 degree Celsius rise in temperature is predicted by current climate models for this century. It has been demonstrated that range shifts and contractions in plant and animal distributions are caused by past and present climatic changes. Various aspects of a species' life history determine whether it can endure changes in its environment. Limited geographic range, poor capacity to spread, low rates of reproduction, and highly specialised habitat requirements are traits that increase a species' likelihood of being badly impacted by disturbance.

Material and Methods

Area

Six mountain ranges—the Qinling, Minshan, Qionglai, Xiaoxangling, Daxiangling, and Liangshan—make up the current geographic range of giant pandas, and were included in our study. Within the giant panda distribution, habitat types change vertically as a result of elevational changes, moving from subtopical evergreen broad-leaved forests at lower elevations to evergreen and deciduous broad-leaved forests to mixed coniferous and deciduous broad-leaved forests up to subalpine coniferous forests. The distribution of giant pandas is characterised by wide variations in temperature and precipitation, as well as in soils, hydrology, slope, and aspect, all of which have led to a variety of plant and tree species. We excluded croplands, urban areas, and buffers against human disturbance since these regions do not accommodate giant pandas and do not provide sufficient habitat. We deemed places that were 1410 metres from cities and 210 metres from roadways to be unacceptable. Data on land cover was retrieved from Global Land Cover 2000. These locations were also taken out of the estimated suitable habitat since giant pandas cannot live in areas below 1,200 m in elevation due to human development. We estimated the sizes of all remaining patches after removing anthropogenic disturbance and unsuitable land cover. Using the average panda home range size as a guide, we then eliminated any areas less than 4 km2.

Selection of Cities

Three factors were used to choose the cities. The size of the city was the first factor. All cities were chosen from the group of the 50 largest cities in the USA by population in order to maintain a reasonable variety of city sizes for comparison purposes. The availability of information on the social aspects included in the Leigh Stowell Archival Dataset, namely social capital and open-mindedness, is the second requirement. Finally, the dataset of the International Council of Local Environmental Initiatives was evaluated to divide the cities into two unique categories, namely, climate change active and climate change inactive cities.

Statistical Analysis

For the two groups of cities, standardised values of the Open-Minded Thinking Index, the Social Capital Index, and the Cultural Diversity Index were combined. A statistical analysis using the Independent-Samples -test was then carried out to see whether there were any significant differences in the mean values of social features for the two groups of cities that might account for variations in adaptability to climate change. Prior to using bivariate correlations, all indices were standardised to an ascending scale, which runs from zero as the lowest value to one as the greatest value, in order to make it easier to grasp the connections between the various study variables. To analyse the relationship between the social traits, the Pearson Product Moment Correlation Coefficient was determined.

Open-Minded Thinking

Utilizing information from the Stowell dataset, the relationship between cities' resilience to climate change and openness to novel ideas was also assessed. In order to gauge how open-minded the population is, three questions were chosen. As previously stated, there are five possible answers to the statement, ranging from 1 to 5. Less commitment to the norm is also indicated by lower scores on the items, which also show a greater willingness to change. By adding the mean values of the answers to these three pertinent questions, the Open-Minded Thinking Index was created. The Open-Minded Thinking Index theoretically may range from 3 to 15. The degree of unorthodox thought was regarded as pertinent because, in order to be adaptive, persons must possess or acquire the capacity to respond to novel chances.

Climate Change Data

In contrast to B1 and B2 families, which anticipate slower economic growth by the year 2100 and more environmentally conscious societies, A1 and A2 families anticipate faster economic growth. In contrast to the A1 scenario, which assumes a more homogeneous world with varied standards of living and technological advancement across regions, the A2 family model assumes more heterogeneous future societies with regionally divergent economic growth and fragmented growth in technological changes. The A1 scenario predicts that after 9 billion people, the population would begin to drop, while the A2 scenario assumes that population will continue to rise. Based on current trends in China—where fossil fuel CO2 emissions have doubled since 2000, population has doubled since 1960, and GDP has increased by roughly 40 times since 1960—we chose the A2 scenario.

Results

The mean value of the Climate Change Index was derived for each group of cities using information on performance on climate change issues that was displayed in. For the top cities, the Climate Change Index average is 8, while for the bottom cities, it is 3.25. There is undoubtedly a significant difference between the two groupings of cities. As previously mentioned, cities that perform well in terms of climate change issues are regarded as having greater resilience than those that do not take any steps to mitigate or address the effects of climate change.

In addition to the difference in climate change resilience between the two groups of cities, there is also a statistically significant variation in social capital measured by trust. The degree of social capital is postulated to be an important factor in fostering social resilience to climate change, which is supported by the observation that more resilient cities displayed higher levels of trust. The level of trust within the cities is strongly correlated with the Climate Change Index. the relative standing of every city included in the study in terms of trust as a gauge of social capital. With an AUC of 0.752, a standard error of 0.010, and a 95% confidence interval of 0.992–1.000, our models passed the test with flying colours. According to permutation importance, the mean temperature of the warmest quarter was the most significant variable, closely followed by the seasonality of precipitation. Annual temperature range, which drops 10 percentage points to third place, is followed by annual precipitation and temperature seasonality. The permutation relevance of all other precipitation variables, including those of the driest quarter, driest month, warmest quarter, wettest month, coldest quarter, and wettest quarter, was less than 3.0%. Along with slope and aspect, the annual average temperature, the wettest quarter, and the driest quarter were all less than 3.0%.

Both climate models predict that by 2080, less than half of the giant panda distribution will be suitable. The current distribution areas expected to be appropriate in 2080 can be thought of as remaining habitat as opposed to the current distribution areas projected to be unsuitable, which can be thought of as lost habitat. Potential new habitat regions are those that are outside of the current distribution and are predicted to be suitable in 2080. The severely fragmented nature of the remaining giant panda range is demonstrated by the removal of sizable areas of both climate prediction models as a result of human interference. The baseline CGCM3 and HadCM2 models, respectively, had about 21,840 km2 and 11,690 km2 subtracted. A significant rise in fragmentation is seen in all mountain ranges when comparing fragmentation metrics between the existing giant panda distribution and the anticipated acceptable habitat area for 2080. Both models predict a greater than treble increase in the number of patches. In 2080, the MPS substantially shrinks from 505 km2 in the current distribution to 67 km2 (CGCM3) and 38 km2 (HadCM3).

Discussion

In terms of addressing climate change challenges and, in our opinion, developing adaptive ability to deal with possible climate change impacts, the two groups of cities clearly perform differently. The findings are consistent with our premise that more resilient cities have populations that are more diversified in terms of their cultural backgrounds, social capital, and open-mindedness. In this research, the communities' trust levels were higher in the more resilient cities. Weak relationships, the bridging type of social capital, are seen to be crucial for mobilising resources, communicating, and exchanging experiences in the face of significant disturbances to metropolitan communities. The distinction between bridging and bonding social capital is crucial. While the bonding type might occasionally limit opportunities for creativity and information flow, both of which are essential for resilience, the bridging kind seems to be more vital for developing adaptive ability and resilience. The bridging type and the bonding type are not distinguished by the social capital index used in this study. As opposed to less resilient cities, more resilient cities are also proactive and creative in coming up with solutions to help the city go in a more sustainable and adaptive direction. We contend that they have an advantage when dealing with the unpredictability of climate-related perturbations because of their performance on one of the most important challenges for urban planning, namely climate change.

Particularly vulnerable to changing vegetation regimes may be giant pandas. Despite the existence of additional bamboo species, they not only specialise in eating bamboo but may only consume two or three varieties, depending on their area. At this time, it is impossible to anticipate how climate change will affect different species of bamboo or whether they will remain at lower elevations, move upslope, or do both. However, it's probable that some of the higher elevation locations are unsuitable for vegetation because of stony cover. In this case, we assume that all future potential habitat will be usable. The Chinese government has already taken significant actions that rank first on any list of giant panda adaptation techniques. In recent decades, they have significantly increased the quantity of protected territory in addition to the restoration efforts that are currently in motion. There were just 12 giant panda protected areas in 1980; by the year 2000, there were 33; and as of right now, there are more than 59. However, just 60% of giant pandas are now found in protected regions. Our findings indicate that there is significant potential for extending protected status to regions that have been determined to be suitable, as well as for enhancing connectivity within ranges to aid in the mobility of small populations. According to both of our models, even in the case of diverse climate change scenarios, the Qinling Mountains will retain the majority of its habitat and will see very little fragmentation. Even though only 15% of the Qinling Mountains' suitable habitat is predicted to be protected by 2080, this might lead to a significant increase in the Qinling population. By expanding protection to further places. However, it is anticipated that the Minshan and the Qionglai will lose more than half of their existing acceptable habitat. There will likely be a sizable number of new, appropriate sites that emerge in both mountain ranges, but with little protection. In the extreme south and northwest of the Minshan Mountains, both of our models depict suitable habitat insulating already-existing protected zones.

Conclusion

Climate change will significantly impact the habitat of giant pandas and the efficacy of safeguarding this habitat. We offer crucial direction for creating adaption plans, planning upcoming surveys, and establishing the importance of protecting giant panda habitat using well-established modelling techniques. Our findings are in line with other research on how climate change is affecting species in montane habitats. Our analysis offers convincing justification for expanding protected area development in the northern and central ranges of the current giant panda distribution, as well as for guaranteeing enhanced connectivity between currently existing and prospective future appropriate regions. Because of the effects of climate change, there is a good chance that the dynamics of urban systems will be significantly disrupted, and how well we are able to deal with these disturbances relies on how well our communities can encourage change. This capability should be represented in practical activities like those meant to reduce the community's carbon footprint and those meant to increase the capacity to tolerate unfavourable effects brought on by climate change. Similarly, the ability of urban areas to adapt to changing conditions is probably influenced by some of their social characteristics; in this regard, openness to change, cultural diversity, and urban settlers' capacity for adaptation and the ability to share information and resources in collective action stand out as essential components of resilience.

Our examination of two sets of cities has shown evidence that, in comparison to cities that are now less active on climate change issues, those cities likely to have populations that exhibit higher levels of openness to new ideas, higher levels of social capital, and greater cultural diversity. This supports the hypothesis that cities with better levels of adaptive capacity to face climate change challenges tend to have populations with these characteristics. Diversity is well known to be a crucial factor in resilience development. In our study, cities with greater cultural diversity—as indicated by the existence and representation of various ethnic groups—were also cities with higher levels of resilience. Higher degrees of variety can boost resilience because the new fusion of ideas may foster more of the innovation and creativity that are crucial to resilience. In spite of the fact that this study has shown a strong and substantial association between the social components proposed to foster urban resilience, much more research is required to improve our comprehension of urban environments from a resilience perspective. Urban social dynamics are so complicated that further research is needed to fully understand how social and cultural characteristics of cities affect something as crucial as developing the ability to adapt to climate change. Other pertinent factors include the complex problems of social equality in addition to social capital, unconventional attitude, and cultural variety.

The study's concentration on a restricted number of cities and just large metropolitan areas is one of its shortcomings. Research on the urgent topic of urban climate resilience is being advanced.

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Conflicts of Interest

The author has no known conflicts of interested associated with this paper.

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