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Exploring Community Resilience Strategies in the Face of Escalating Heat Waves: a Comprehensive Study of Giyani, South Africa

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1 ABSTRACT

The escalating frequency and severity of heat waves due to climate change pose a significant threat globally. Giyani, a rural township in South Africa, is no exception to this concerning trend, as revealed by the data collected from Meteoblue which indicates a rise in mean temperature from 22.0 °C in 2021 to 22.5 °C in 2022. Previous studies have documented the manifestation and multifaceted effects of escalating heat waves on local communities worldwide. However, what remains to be known clearly are the strategies of communities in dealing with the escalating heat waves. Consequently, this paper discusses the Giyani community's resilience mechanisms in the face of escalating heat waves in the past few decades. Employing a descriptive research design and a mixed-method approach, this study utilizes random sampling to draw 15 participants, reaching the point of saturation for data collection. The questioners conducted to collect the primary data with residents structured were both open and closed ended. Content analysis is then applied to analyze the data. The findings indicate that the mean temperature at Giyani further increased from 22.8 °C in 2022 to 23.0 °C in 2023. The health of community members, especially street vendors and individuals above 50 years old, is increasingly at risk. Moreover, the heat wave exacerbates water shortages, impacting both residents and the agricultural sector. Several mechanisms to deal with the escalating heat waves include healthcare support, urban planning and green spaces, climate- resilient agriculture and water management. Such strategies that enhance community resilience need to be facilitated and promoted to enhance sustainable practices in the face of the changing climate conditions in Giyani. Adverse effects of heat waves need to be mitigated, ultimately, this study contributes to the broader discourse on climate adaptation and community well-being in regions experiencing the intensification of heat waves.

Keywords: Planning, Giyani, Community resilience, Climate change, Heat wave

2 INTRODUCTION

The Mopani District, situated in Limpopo Province, has undergone substantial climatic shifts, marked by an alarming increase in heat episodes and a consequential decline in rainfall, rendering it increasingly unreliable (Adebanji, 2017). These transformations not only mirror the evolving face of the local climate but are indicative of broader regional climate scenarios (Hannaford and Nash, 2016). The gravity of these changes has been underscored in the Mopani District's Integrated Development Plan, where explicit acknowledgment is given to the shifting climate patterns and the attendant threats they pose. These threats, encompassing challenges to access potable water, food security, and the health impacts on impoverished communities, emphasize the urgent need for proactive measures to address the escalating climate crisis (Ullah and Akhtar, 2023).

The ramifications of this climatic challenge extend beyond the borders of the Mopani District to encompass the Greater Giyani Municipality, which falls within the district (Jimoh et al, 2021). This municipality, too, is characterized by climate sensitivity and water stress, amplifying the complexity of the issue. The manifestation of climatic changes is not confined to the district alone but resonates throughout the broader Limpopo Province, signalling potential direct impacts such as droughts, floods, and wildfires (Sithole, 2023). These environmental upheavals, in turn, give rise to ancillary consequences, affecting both health and social systems.

The health implications of these climatic changes are profound, with an increased occurrence of climate-prone diseases such as malaria, measles, typhoid fever, cholera, and diarrhoea. Poverty-stricken communities are particularly vulnerable, exacerbating existing challenges (Li et al, 2021). The interconnectedness of these factors underscores the need for a comprehensive understanding and targeted interventions to mitigate the adverse impacts on both the environment and the well-being of communities.

This study seeks to delve into the multifaceted challenges arising from climatic changes in the Mopani District and the Greater Giyani Municipality. By examining the direct impacts on environmental stability, health, and social systems, the research aims to contribute valuable insights toward the formulation of effective strategies for climate adaptation and resilience-building in these vulnerable regions.

3 THE GROWING THREAT OF HEAT WAVES

Heat waves are becoming a looming threat to the globe. Characterized by excessively high temperatures and humidity, they are becoming increasingly frequent, intense, and prolonged. A heat wave is generally defined as a prolonged period of excessively hot weather, which may be accompanied by high humidity (Rafferty, 2024). The exact definition can vary regionally and is often based on specific temperature thresholds relative to the local climate. In meteorology, a common definition involves temperatures that exceed the historical average for a given period, typically several days to weeks (Department of Health, 2021). Heat waves can have significant impacts on human health, ecosystems, and various socio-economic sectors.

3.1 Characteristics of Heat Waves

There are certain characteristics of heat waves. These characteristics are the ones that makes a heatwave to be noticeable. Heat waves are characterized by their extended duration, typically lasting for several days to weeks (Pascal et al, 2021). The prolonged nature distinguishes them from short-term temperature spikes. In addition, there is persistence of high temperatures even during the night (Chen et al, 2020). Night-time temperatures may remain elevated, offering little relief and contributing to health-related concerns. High temperatures during a heat wave are notably more intense than usual, surpassing the normal range for the region. Intensity is often measured by comparing temperatures to historical averages. Heat waves can cover vast geographical areas, affecting multiple regions simultaneously (Horton et al, 2016). The extent of the affected area contributes to the overall severity and impact of the heat wave. Changes in the frequency of heat waves over time may be indicative of climate trends. An increase in the frequency of extreme heat events is often associated with climate change.

3.2 Impacts of Heat Waves

Heat waves can have cascading effects on ecosystems, water resources, and agriculture. Drought conditions, wildfires, and stress on plant and animal populations may be exacerbated during heat waves (Sithole, 2023). Heat waves pose substantial risks to human health. Heat-related illnesses, such as heat exhaustion and heatstroke, become more prevalent during these periods (Pascal et al, 2021). Vulnerable populations, including the elderly and those with pre-existing health conditions, are particularly at risk. The socio-economic impacts of heat waves include decreased labour productivity, increased energy demand for cooling, strain on infrastructure, and potential disruptions to daily life (Smith et al, 2021).

Understanding these characteristics is crucial for developing effective strategies to mitigate the impacts of heat waves and enhance community resilience in the face of changing climatic conditions. Climate change refers to long-term changes in temperature, precipitation, wind, and other atmospheric conditions on Earth. One of the most noticeable and concerning impacts of climate change is the increase in the frequency, intensity, and duration of heat waves. Heat waves are prolonged periods of excessively hot weather, which can have widespread and severe effects on ecosystems, human health, and various sectors (Chen et al, 2020).

3.3 Keyways in Which Climate Change Contributes to the Occurrence and Impact of Heat Waves

As global temperatures increase due to the accumulation of greenhouse gases in the atmosphere, heat waves become more frequent and severe. Climate change amplifies the likelihood of extreme heat events, setting new temperature records in many regions (Masson-Delmotte et al, 2021). Climate change alters atmospheric circulation patterns, leading to shifts in weather systems. This can result in more persistent and stagnant air masses, which contribute to the prolonged duration of heat waves (Olabi and Abdelkareem, 2022).

Higher temperatures during heat waves can pose serious health risks, especially for vulnerable populations such as the elderly, infants, and individuals with pre-existing health conditions (Sithole, 2023). Heat-related illnesses, such as heatstroke and heat exhaustion, become more common during prolonged periods of extreme heat (Pascal et al, 2021).. Heat waves contribute to increased evaporation, drying out soils and water sources. This can lead to drought conditions and water scarcity, impacting agriculture, ecosystems, and

human water supplies. Heat waves contribute to the drying of vegetation, making it more susceptible to ignition. This increases the risk of wildfires, which can have devastating effects on ecosystems, air quality, and human communities (Chen et al, 2020).

Extreme heat events can harm crops and reduce agricultural yields. Heat stress during critical growth stages can affect plant development and decrease the productivity of crops, leading to food security concerns (Smith et al, 2021). Prolonged heat waves can strain energy, transportation, and water infrastructure. Increased demand for cooling systems during hot periods can overload electrical grids, leading to power outages.

Mitigating the impacts of heat waves requires global efforts to reduce greenhouse gas emissions and adapt to the changing climate (Masson-Delmotte et al, 2021). This includes developing resilient infrastructure, implementing heat action plans, and promoting sustainable practices to minimize the human and environmental impacts of extreme heat events.

3.4 Local Factors Influencing Heat Waves in Giyani

Understanding the local factors influencing heat waves in a specific area like Giyani requires considering a combination of geographical, climatic, and environmental elements. Giyani is a town located in the Limpopo Province of South Africa. Here are some local factors that can influence heat waves in Giyani:

3.4.1 Geography and Topography

Giyani is situated in a subtropical region with relatively low elevation (Mashele, 2022). Low-lying areas may experience higher temperatures, especially during heat waves, as they are more susceptible to heat accumulation.

3.4.2 Vegetation Cover

The type and extent of vegetation in and around Giyani can impact local temperatures. Vegetation provides shade and helps cool the environment through evapotranspiration. Greater Giyani has the abundance of Mopani and Marula trees (Mashele, 2022). It is mainly grassland which is often overgrazed due to overstocking. Changes in land use and vegetation cover can influence heat wave dynamics.

3.4.3 Water Bodies

The presence of water bodies, such as oceans, rivers or lakes, can have a moderating effect on temperatures (Munyai et al, 2021). They may contribute to local cooling, and changes in their availability or temperature can influence the severity of heat waves. However, Giyani is not surrounded by any oceans. it is surrounded by perennial rivers, Letaba Dam is among them, situated 40 kilometres to the west of Giyani (Khwashaba, 2018).

3.4.4 Local Weather Patterns and Climate Zone

The interaction of local weather patterns, such as the movement of air masses, prevailing winds, and the presence of weather systems, can influence temperature extremes (Smith et al, 2021). Stagnant air masses can contribute to the persistence of high temperatures during heat waves. Giyani experiences a subtropical climate, characterized by hot summers and mild winters (Maluleke and Mokwena, 2017). The region is prone to high temperatures, which can contribute to the occurrence of heat waves.

Understanding these local factors is crucial for developing effective strategies to manage and adapt to heat waves in Giyani. Local authorities and communities can use this information to implement measures such as urban planning, water conservation, and public health initiatives to mitigate the impacts of extreme heat events. Additionally, raising awareness about climate change and its local implications can foster community resilience.

4 EXISTING POLICIES AND STRATEGIES IN SOUTH AFRICA THAT ADDRESS THE IMPACTS OF HEAT WAVES AND CLIMATE CHANGE

South Africa has implemented various policies and strategies to address the impacts of heat waves and climate change. some aspects of existing policies and strategies in South Africa related to heat waves are outlined below.

Name of Policy	Description
National Climate Change Response Policy (NCCRP):	The NCCRP is a comprehensive policy framework that outlines South Africa's approach to addressing climate change, including adaptation and mitigation strategies. It recognizes the importance of addressing extreme weather events, including heat waves, and emphasizes the need for resilience in various sectors.
National Adaptation Strategy (NAS):	The NAS provides a roadmap for adapting to the impacts of climate change in South Africa. It includes measures to enhance resilience in sectors such as agriculture, water resources, health, and human settlements. Specific actions may be outlined to address heat waves and extreme heat events within the broader context of climate adaptation.
Disaster Management Framework:	South Africa has a National Disaster Management Framework that includes guidelines for managing and responding to disasters, including those triggered by extreme weather events such as heat waves. This framework may involve coordination among various government departments, local authorities, and other stakeholders in responding to and mitigating the impacts of heat waves.
Health Sector Strategies:	The Department of Health in South Africa may have specific strategies addressing the health impacts of extreme heat events. This could include public health campaigns, early warning systems, and measures to protect vulnerable populations.
Water Resource Management:	Given the importance of water resources in mitigating heat stress, South Africa likely has strategies for sustainable water resource management to ensure water availability during periods of high temperature.
Urban Planning and Infrastructure Development:	Urban planning and infrastructure development policies may incorporate measures to reduce the urban heat island effect, enhance green spaces, and promote sustainable building practices to mitigate the impacts of heat waves in urban areas.

Table 1: South African policies and strategies addressing heat waves and climate change impacts (Source: Authors 2024)

A potential gap might exist in the effective implementation and enforcement of existing policies. Ensuring that strategies are translated into concrete actions on the ground is crucial. Furthermore, there may be gaps in public awareness and education about the risks and impacts of heat waves. Strengthening public awareness campaigns can enhance community resilience. Ongoing research and the collection of local data on heat wave patterns, vulnerabilities, and impacts are essential for refining strategies. There might be gaps in the availability of up-to-date and comprehensive data.

5 METHODOLOGY

This research employed a descriptive research design. Qualitative data collection methods were utilized, aligning with Creswell's (2014) definition of qualitative research as a method for understanding complex social and psychological phenomena. The study focused on the population of Giyani. A non-probability sampling strategy was adopted, acknowledging that participants were not selected with equal chance. Specifically, random sampling was employed to recruit 15 participants. Both primary and secondary data sources were utilized. Primary data was collected through structured questionnaires containing open-ended and closed-ended questions. Secondary data comprised relevant academic journals, books, statistics, policies, and articles to supplement the primary data collection (Creswell, 2014). This multifaceted approach to data collection strengthens the research by drawing on various sources of information. Qualitative data analysis, specifically content analysis, was employed to analyse the collected data.

6 RESULTS FOR COMMUNITY PERCEPTIONS AND VULNERABILITIES

The study undertaken by the authors aimed to comprehensively examine the diverse challenges emanating from climatic changes within the Greater Giyani Municipality in Mopani District. The ensuing results encapsulate both the demographic composition of the respondents and the psychographic profiles specific to the Giyani region. The primary data encompasses the age, highest level of education, employment status and salary range. Furthermore, it encompasses the correlation between heat temperature and relative humidity in

Giyani, coupled with an assessment of respondents' awareness of heat waves. Furthermore, the study explores into the economic and health adversities induced by heat waves, along with an exploration of the respondents' capacity to afford cooling systems during such climatic events.

6.1 Demographics of respondents

The participants were inquired about their demographic details, including age, highest educational level, employment status, and salary range. Age inquiries aimed to determine if respondents fell within the specified age range of 18 to 65 and to identify vulnerable age groups. Information on the highest level of education helped assess which groups might possess knowledge about heat waves. Employment status and salary range data were gathered to discern groups that could potentially afford cooling systems and those who might face financial constraints in acquiring them.

6.1.1 Age of Respondents

Age is one of the demographic profiles of the respondents. However, this criterion of the study excluded respondents below 18 and above 64 since this age group was an at-risk group. There was a total of 15 respondents from Giyani who participated in the questionnaires.

Age	Number of Respondents
18 - 20	3
21 - 30	5
31 - 40	1
41 - 50	4
51 to 64	2

Table 2: Age of respondents in Giyani (Source: Authors 2024)

As far as age is concerned, the study conducted in Giyani disclosed that most respondents were between the ages of 21–30. Out of 15 respondents, 20% were between the ages of 18 – 20. A total of 33% of respondents were between the ages of 21- 30. Furthermore, respondents between the ages of 31- 40 account for 7% of the surveyed sample. In addition, respondents between the ages of 41- 50 accounted for 27% of the total surveyed sample. A total of 13% of the respondents were aged 51- 64.

6.1.2 Level of Education

Respondents were asked to indicate their highest level of education, and 15 respondents attempted this question.

Level of Education	Number of Respondents
Primary	6
Secondary	4
Bachelor's Degree	3
Master's Degree	2

Table 3:Level of education of respondents in Giyani (Source: Authors 2024)

Out of these, 40% indicated that the primary level was the highest education acquired. Furthermore, 27% indicated that the highest acquired education was secondary level while 20% acquired a bachelor's degree. In addition, 13% of the surveyed sample indicated that a Masters degree was their highest educational achievement.

6.1.3 Employment status of participants

The figure below provides a visual representation of the occupation status of the respondents, with 15 participants responding to this particular question. The inquiry into employment status was made because of the observed correlation between employment status and income levels. Typically, individuals who are employed tend to possess higher financial resources, which can impact their ability to afford air conditioners and other cooling devices.

Figure 1: Employment status of respondents in Giyani (Source: Authors 2024)

The analysis revealed that 47% were employed, 13% were trainees, 27% were self-employed, and 13% were unemployed. Employment status significantly impacts the ability to afford cooling systems like air conditioners and fans, though income level and personal responsibilities within each category likely further influence affordability. Notably, unemployed respondents face heightened challenges in acquiring such systems.

6.1.4 Household income

One of the demographic criteria included was household income, and an attempt was made to examine the income level of respondents. Data on salary ranges were collected to identify segments of the sample that could potentially afford cooling systems and those who might encounter financial challenges in acquiring them.

Income Level	Number of Respondents
Less Than R5000	6
R5000 – R15 000	6
R15 000 – R25 000	2
R25 000 – R35 000	1

Table 4: Income Level of respondents in Giyani (Source: Authors 2024)

Out of 15 required respondents, only 10 attempted the question. Of the respondents, 5 were not comfortable disclosing their salary range and hence were excluded. Out of the 10 respondents, 60 % earned less than R5000, another 60% earned between R5000 to R15000, and 20% earned between R15000 to R25000. Furthermore, 10% of the respondents earned between R25000 to R35000.

6.2 Psychographic Profile

6.2.1 Heat wave awareness: Have you heard of heat waves?

Respondents from Giyani were asked if they ever heard of heat waves Out of the 15 respondents, 67% indicated that they are aware of the term “heat waves” while 33% indicated that they are not aware of it. As indicated from figure 2 that 4 respondents have primary level of education, 3 respondents have secondary level, 2 respondents have a bachelor's degree, and 1 respondent has a master’s degree. It might be possible that individuals with higher education levels are more likely to be aware of heat waves due to their exposure to information, either through formal education or other sources. There seems to be a correlation between education levels and awareness of heat waves. Respondents with higher education levels (bachelor's and master's degrees) make up 30% of the sample, and it's possible that they are more likely to be aware due to their exposure to information. The data suggests that there might be a link between higher education levels and awareness of heat waves.

6.2.2 Heat Temperature vs Relative Humidity in Giyani

The graph shows the average monthly temperature and relative humidity in Giyani, South Africa, over the course of a year, from January 1, 2023, to December 31, 2023. The x-axis of the graph shows the months of

the year, and the y-axis on the left shows the temperature in degrees Celsius (°C). The y-axis on the right shows the relative humidity as a percentage (%).

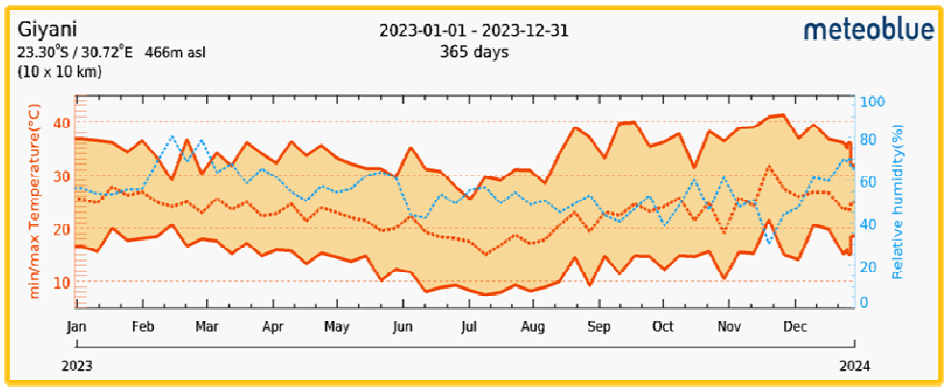

Figure 2: average monthly temperature and relative humidity in Giyani (Source: Meteoblue 2024)

According to the above 2 figure, between September and October, the temperature in Giyani went as high as 40 °C. Furthermore, the heat temperature between November and December was about 41°C.The relative humidity is generally higher in the warmer months and lower in the cooler months. However, there is some variation in this pattern, with the relative humidity being relatively high in May and June despite these months being relatively cool.

The driest months of the year are July and August, with an average relative humidity of around 40%. The wettest months of the year are December to February, with an average relative humidity of around 70%.

The figure below shows an estimate of the mean annual temperature for the larger region of Giyani. The dashed blue line is the linear climate change trend.

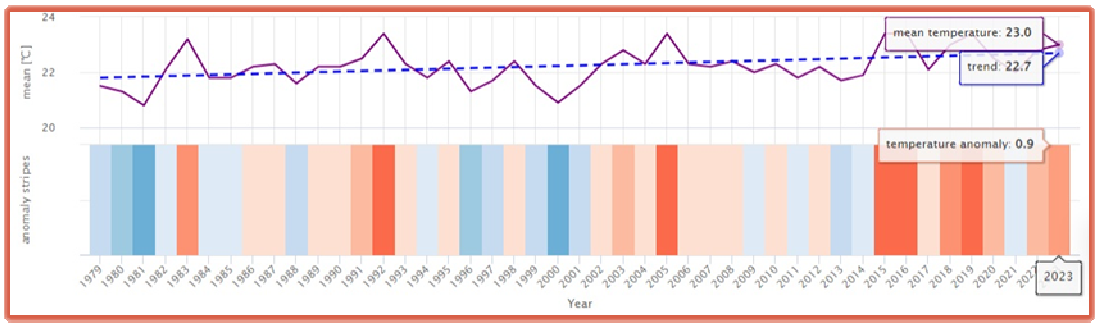

Figure 3: The mean annual temperature in Giyani from 1979 - 2023 (Source: Meteoblue 2024)

The trend line is going up from left to right; therefore, this indicates that the temperature trend is positive and that it is getting warmer in Giyani due to climate change. This is made visible by the increase in the mean temperature. In 2022, the recorded mean temperature was 22.8 °C, which increased to 23.0 °C in 2023. The lower part of the graph illustrates the warming stripes. Each coloured stripe represents the average temperature for a year. The blue colour represents colder years, and red represents warmer years. In 2022, the red colour was lighter as compared to the year 2023, which was becoming darker. This also indicated that it was becoming warmer in Giyani.

6.2.3 Impacts of heat waves: Economic and health negative impacts experienced from heat waves.

Respondents from Giyani were further asked an open-ended question if they have personally experienced health and economic impacts from heat waves. Out of the 15 respondents, 40% indicated that they have experienced economic impacts from heat waves. They further indicated that due to the excessive heat they experience a decline in productivity and work hours. The remaining 60% percent indicated that heat wave affects their health. This 60% percent has an average age group between 31 to 64. It was highlighted that the extreme heat leads to worker fatigue, heat stress, and even heatstroke. It was also indicated that the heat waves cause the increasing risk of waterborne diseases like diarrhoea and some respondents have difficulty managing heat due to age-related health conditions.

6.2.4 Affordability to cooling systems during heat waves.

Out of the 10 respondents, 60 % earned less than R5000, another 60% earned between R5000 to R15000, and 20% earned between R15000 to R25000. Furthermore, 10% of the respondents earned between R25000 to R35000 (see figure 4). Lower income levels earning less than R5000 faced challenges in affording cooling systems during heat waves. Those earning between R5000 to R15000 also found it to be challenging to allocate resources for cooling systems, although to a lesser extent than the lower income group. Respondents earning between R15000 to R35000 had more financial flexibility, however, individual circumstances and priorities can vary. The data suggests that a significant portion of respondents (50%) may have limited financial capacity to afford cooling systems during heat waves. It is important to consider that affordability is not the only factor influencing the use of cooling systems; awareness, perceived need, and priorities also play a role.

7 CONCLUSION

The study highlights the vulnerability of the Giyani community to escalating heat waves, particularly for low-income residents and those with limited access to cooling resources and healthcare. The majority of respondents were aged 21-30, with varying levels of education and employment. Income levels ranged from below R5000 to R35000. While 67% of respondents were aware of heat waves, a significant portion lacked knowledge about the associated risks and impacts. Giyani experiences high temperatures, particularly between September and December, with relative humidity also increasing during these warmer months. Data indicates a rising mean annual temperature over the past few years. Heat waves negatively affect the community's health and economic well-being. Respondents reported experiencing decreased productivity, worker fatigue, heat stress, and increased risk of waterborne diseases. Lower income groups face significant challenges in affording cooling systems like air conditioners and fans during heat waves. The findings emphasize the need for:

- Community resilience: Building resilience can help individuals and families stay cool and healthy during heat waves. By enhancing resilience, communities can minimize these economic disruptions and ensure a more stable livelihood. Furthermore, it lays the groundwork for a future where Giyani can thrive despite these challenges.
- Community engagement and education: Communities can advocate for long-term policy changes that address systemic issues like affordable housing, access to cooling technologies, and equitable distribution of resources, contributing to broader heat resilience measures. Communities can develop heat mitigation strategies like planting trees, creating shade structures, promoting energy-efficient buildings, and advocating for urban green spaces.
- Targeted interventions: Addressing the specific needs of vulnerable populations through social support systems and affordable cooling solutions.
- Collaboration: Fostering collaboration between communities, policymakers, and stakeholders to develop effective heat wave action plans

Conducting further research, including qualitative interviews or surveys, can provide deeper insights into the specific challenges faced by different income groups in affording cooling systems.

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