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Local knowledge matters: understanding the decision-making processes of communities under climate change in Suriname

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Introduction: Traditionally, local communities have relied on practical observations accumulated over extended periods to inform their decision-making. This knowledge is now recognized as a viable solution for communities to adapt to climate change effectively. The impact of climate change brings an extra layer of complexity to local communities' detection- and decision-making processes, which needs to be better comprehended.

Methodology: Our study builds on the foundation of conflict resolution and examines the knowledge systems and corresponding decision-making processes of local communities living in urban, rural, and tropical forest regions of Suriname, South America.

Results: The mixed-method study showed that the autonomous decision-making processes of these communities are guided by their knowledge systems, intertwined with values and interests. Forest communities in remote locations rely solely on their robust knowledge base for crafting adaptation solutions, while urban and rural communities near the administrative centers develop adaptation strategies primarily considering their access to social networks and relative power.

Discussion: The study highlights local knowledge as the primary determinant for the direction communities take in adaptation, with tradeoffs becoming evident as communities navigate the broader social context. The recognition and integration of this knowledge emerge as a critical factor in enhancing climate change adaptation at the local level.

KEYWORDS

local knowledge, decision-making, adaptation, communities, climate change, worldview, Suriname

1 Introduction

Local knowledge is often presented as an obvious solution for communities to adapt to the challenges posed by climate change when lacking financial or technical resources (IPCC, 2007; IPBES, 2019). This knowledge is primarily used to detect natural cycles and cultural elements that connect with the community's values and belief system (Orlove et al., 2010). The communities holding local knowledge have collected it over multiple years of place-based experimentation. Typically, they observe variations in plant phenology, animal behavior, wind circulation, rainfall shifts, and water distribution (Berkes, 2009; Jiri et al., 2015).

Extensive bodies of local knowledge are particularly evident among farmers and indigenous peoples, who rely on this knowledge for their livelihood, either entirely or partially. They apply their knowledge to implement a series of management decisions on how to cope with the detected changes (Adger et al., 2005; Adger, 2013; Blakeney, 2020). The impact of climate change introduces an added layer of complexity for these communities. This leads to a decline in the reliability of their knowledge system for detecting environmental changes, and their trust in this system is weakening (Naess, 2013; Jiri et al., 2016; Mapfumo et al., 2016).

A substantial collection of literature focuses on local communities and their knowledge systems in the context of climate change. The early studies primarily centered on assessing communities' vulnerability and how it relates to their adaptation efforts (Burton et al., 2002; Tabara et al., 2010). This research body, rooted in environmental anthropology and ethnoecology, recognized local knowledge as part of the more extensive system, including the community's values and beliefs (Vedman and Rhoades, 2001; Byg and Salick, 2009; Turner and Clifton, 2009; Hulme, 2010; Berkes, 2012). The studies assume that local communities will only take action when faced with significant environmental risks.

More recently, scholars have shifted toward investigating people's perceptions of climate change. Perception studies give valuable insights into the behavioral dynamics of communities in response to climate change and their ability to adapt to new circumstances. This research operates either from the lens of psychology (Weber, 2010; Evans et al., 2016; Takakura et al., 2021), sustainable development (Chaudhary et al., 2011; Piya et al., 2012; Stancioff et al., 2018; Leal Filho et al., 2022), human geography, or urban planning (Codjoe et al., 2014; Funatsu et al., 2019). It gives valuable information about the various factors influencing the community's perception of climate change to understand their reasoning in adaptation. However, the comprehensive process of view formation—from knowledge generation to its subsequent livelihood decision-making, remains poorly understood.

This empirical study provides a deeper understanding of the content and scale of the local knowledge systems, elucidating its role in shaping the community's decision-making process for climate adaptation. We followed an analytical framework of worldviews to capture the whole spectrum. Worldviews are "the inescapable, overarching systems of meaning and meaning-making that inform how humans interpret, enact, and co-create reality" (Hedlund-de Witt, 2013, p. 156). The worldview analytical framework allows researchers to depart from the dominating Western-oriented ontology and epistemology, and it provides an opportunity for understanding alternative ways of knowledge creation by including people, their values and beliefs, and the spiritual world (Pyhälä et al., 2016; Sanganyado et al., 2017; Rarai et al., 2021).

A lens for exploring worldviews is the discipline of conflict resolution. This emerging field systematically studies actors' views to anticipate their actions in a social setting and how interventions can lead to peaceful solutions (Folger et al., 2005). It holistically looks at the social system of actors and their environment, considering their knowledge, values, interests, power, and interaction with others (Li et al., 2012). The conflict resolution approach extends beyond solely concentrating on the community's local knowledge or perception of climate change. Instead, it adopts a broader perspective of negotiation dynamics, which involves two or more interdependent actors adjusting their interests and demands to resolve or prevent other conflicting situations (Lewicky et al., 2007). This context-specific approach can be used to analyze the community's connection between the local knowledge system and its decision-making process.

The focus of this study is on the knowledge that communities gather to address climate variability and change, and it examines how this acquired knowledge informs their decision-making processes. We present a study conducted in Suriname, South America, exploring local communities in urban, rural, and tropical forest areas. This study aims to close the existing gap in the literature on local knowledge and adaptation studies in climate change. This is especially relevant in Latin America and the Caribbean (LAC) regions, where only a few studies are available on the connection between local knowledge and adaptation, according to a recent review of the literature on knowledge and climate change actions conducted by Iwama et al. (2021). Our study aims to address this gap by answering the following research questions:

RQ1: What is the role of local knowledge in detecting and managing climate change in urban, rural, and forest communities?

RQ2: How does the community's local knowledge influence their decision-making process during climate change?

2 Local knowledge and the link with climate change adaptation

2.1 Local knowledge

Local knowledge commonly refers to knowledge and skills produced through direct environmental interaction. In the context of this paper, local knowledge includes both indigenous and local knowledge. We acknowledge that small farmer communities and indigenous people have accumulated empirical knowledge during their cultural practices to sustain their livelihood.

Farmers who have worked at the exact location for over a decade possess a substantial body of knowledge about rainfall, temperature, wind, and plant- and animal phenology (Vedman and Rhoades, 2001; Jiri et al., 2015, 2016; Blakeney, 2020; Hatfield et al., 2020). Indigenous peoples tend to have a more collective approach to knowledge generation because it is embedded in their lifestyle and passed down from generation to generation (IPCC, 2023).

Local knowledge has proved more accurate and reliable than scientific knowledge when applied locally (Nyong et al., 2007). Communities rely on this knowledge to navigate the daily challenges of natural cycles and anomalies. Knowledge generated through lived experiences of communities is dynamic, constantly evolving as new information is gathered and obsolete knowledge is removed from the knowledge base (Berkes, 2012; Nakashima et al., 2018; Rarai et al., 2021). The knowledge base is often quite detailed, as it gives information about the flowering of plants, the behavior of animals, and migration- and mating patterns of species. Various functional groups in the community use this interconnected knowledge system, including elders, farmers, hunters, fishers, gatherers, and healers (Wolf and Moser, 2011; Berkes, 2012; Savo et al., 2016).

Local knowledge articulates the connection between the community and its environment: the human-to-nature connection. This connection is defined by numerous community indicators (or early-warning alert signs) that identify climate variability, encompassing temperature and precipitation fluctuations over interannual and interdecadal periods (IPCC, 2012). Indicators can expand over the whole ecosystem, or they only assess the interaction between its elements (Chisholm Hatfield et al., 2018; Hatfield et al., 2020), serving as the community's primary tools for discerning variations in meteorological, biological, environmental, and astronomical data across seasons or longer time frames (Granderson, 2017). The continual and consistent use of such indicators provides valuable insights into the community's interaction with the environment and its role in decision-making.

When climate change is detected, a local community becomes aware of this shift by comparing the new information with existing information in the knowledge base (Weber, 2010). This comparison allows the community to recognize and comprehend the extent of the transformation. The community now faces the challenge of navigating through the chaos and evaluating the new information. It then actively explains the event, seeking to understand and make sense of it. This "meaning-making" process occurs before the community designs adaptation strategies to establish a new coexistence with the changing environment (Lewin, 1947; Smith and Bastidas, 2017).

Meaning-making research typically investigates values since these offer insights into the context within which the community's meaning-making process unfolds (O'Brien, 2009). Values serve as the foundation for the community's view and can be best explained as standards by which "we judge events and people's behavior and by which people decide what is worthy of support and what deserves condemnation" (Carpenter and Kennedy, 2001, p. 197). The community's values directly influence the adaptation measures it will take. To illustrate, traditional values held by forest communities guide collective actions based on local knowledge for supporting group identity and livelihood. In comparison, modern values in urban areas prioritize adaptive efforts driven by economic profit and individual growth (O'Brien, 2009).

Another factor integral to constructing meaning is the community's interest. Deeply rooted in values, interests can be best described as the goals and the development direction communities aspire to pursue (Lewicky et al., 2007). Communities may have multiple interests that drive negotiations, extending beyond the scope of climate change. Research reveals that community decision-making can be influenced by mining and wood logging (Boissière et al., 2013), market prices (Tucker et al., 2010), pests and diseases (Vedman and Rhoades, 2001), poverty, crime, and job opportunities (Gaillard, 2010), and religion (Granderson, 2017), can influence the community Thus, the ultimate decisions made by the communities are dependent on various contextual factors that are currently poorly understood.

Two studies thoroughly examine the community's decision-making process, illustrating the importance of values and interests. Leonard et al. (2013) conducted a study among Miriwoong indigenous peoples living in East Kimberley, Northern Australia. They showed that this community's view depends on a descriptive set of indicators organized into a seasonal calendar in the traditional knowledge base. The study further illustrated that community decisions not only centered on indicators but included various contextual factors, such as development pressures (dams and irrigated agriculture), extreme weather events (floods), and values concerning spiritual punishment.

A similar result was obtained from scholars in the field of conflict resolution. Smith and Bastidas (2017) deconstructed the Trio indigenous community's worldview in response to South Suriname's climate change from 2008–2013. The deconstruction process of the community view focused on three aspects: (1) evaluating the new climate information against their values, (2) making sense of the new information, and (3) making decisions while considering the surrounding environment. With a case study utilizing quantitative and qualitative data, the scholars showed that the Trio peoples rely on local knowledge to adapt to climate change to ensure food security and livelihood. However, they observed that values precede the decision-making process: the community had paused taking action because they believed climate change was part of a future apocalypse.

2.2 Decision-making for climate change adaptation

Adaptation refers to the community's "adjustment in ecological, social and economic systems in response to actual or expected climate stimuli and their effects or impacts" (Smit et al., 2001, p. 881). Scholars focus their studies on cognitive analysis to identify the drivers of adaptation. Together these studies show that worldview construction (Adger, 2013; McNeeley and Lazrus, 2014), climate change awareness, communication, and socio-political factors (Blennow et al., 2012; Myers et al., 2013; McNamara and Buggy, 2016) shape the community's adaptation efforts. Conversely, scholars examining the barriers to adaptation come to a similar conclusion (Adger et al., 2009; O'Brien, 2009; Biesbroek et al., 2013; Eisenack et al., 2014; Evans et al., 2016).

These studies demonstrate that decision-making research focuses primarily on examining the drivers and barriers to adaptation. Gorddard et al. (2016) take an advanced approach and argue that decision-making needs to be viewed from a broader societal perspective. They study the decision-making process with an interconnected framework of knowledge, values, and rules. Although this framework considers the entire social system, it assumes that restrictions on this system guide the decision-making. Our study deviates from this traditional "drivers and barriers" discourse, recognizing that the community's decision-making process occurs in a space where trade-offs between various interests exist. These interests include both tangible (goods, profits) and intangible interests (emotions, relationships) (Folger et al., 2005). The constant tension between such interests is a fundamental premise within conflict resolution.

In the conflict resolution approach, we explore decision-making within the broader interaction between communities and their physical and social environment. The communities operate within a social system that involves various actors upon whom they depend and they may perceive incompatibility and interference from these actors in their interactions due to differences in status, power, resources, values, or interests (Folger et al., 2005; Li et al., 2012). When confronted with the impacts of climate change, the social system can undergo disorganization and require time to stabilize, during which adaptation strategies are devised (Maani, 2013). Conflict researchers examine the entire system, presuming that communities make decisions based on the opportunities available to them. The ultimate goal of this approach is to achieve a state that fosters balance.

Thus, conflict can be studied as a unique perception of communities' reality. Following this constructivist paradigm, Nudler (1993) has developed a conflict analysis framework elucidating the dynamics influencing the community view and decision-making process along five dimensions: 1) the makeup of reality (ontology), 2) how reality is understood (epistemology), 3) the value placed on aspects of reality (axiology), 4) how reality is organized (logic), and 5) how one should act in response to reality (ethic). While the first four questions describe the local view about nature, the ethically-framed question explores the actor's decision-making process. Nudller's theoretical framework has guided our study.

Nudler's inquiries are relevant to researchers who aim to comprehensively assess the social system within which the community operates. This system consists of three essential components: the community itself, its relationship with nature, and its interactions with the social environment. The first component, the community, consists of diverse groups with varying characteristics and evolved power dynamics. The level of social cohesion among these groups plays a crucial role in determining the strength of the decision-making structure. According to Triandis et al. (2001), a community that operates collectively has shared interests and values and is more likely to possess a more robust decision-making structure than a community with an individualistic orientation. Nevertheless, the decision-making process may take longer due to problem-solving and consensus-building among the subgroups to uphold the community's collective nature.

The second component, the human-to-nature interaction, focuses on the community's relationship with nature. It consists of the community's drive to secure food and maintain health and wellbeing. For instance, nature-dependent communities have a strong need for survival and use their rich traditional knowledge base to navigate within the natural cycles. Here, the binding agent is the knowledge exchange across generations and genders within the community, enabling collective action and management strategies. In contrast, less nature-dependent communities do not rely heavily on traditional knowledge for decision-making, as they have alternative means of sourcing food and meeting other human survival needs (O'Brien and Lechenko, 2009).

The third component, the human-to-human interaction, involves the push and pull factors in the social environment that impact the community's decision-making ability and choices. Communities usually make trade-offs when negotiating with various stakeholders, such as other communities, donors, supporters, and the Government. These trade-offs depend on the power structures between the community and others. The community can gather power from its (recognized) expertise, available financial resources, authority within the national governance system, and cooperation with others (Lewicky et al., 2007).

The role of power has been emphasized as a significant determinant for communities participating in negotiations over nature (Smith et al., 2023). In the LAC region, the influence of colonial power structures is still evident (Iwama et al., 2021), and this is particularly noticeable in Suriname, where a significant power divide exists between the more influential coastal region and the forest region (Collins, 2023). Therefore, the decisions made by communities in response to climate change may be significantly influenced by the power they possess (Naess, 2013) and the power derived from the social networks they utilize (Spires et al., 2014).

The dependence on external actors will determine whether a community retains full or partial responsibility for adapting to climate change or transfers this responsibility to national institutions (Giller et al., 2008). Communities can be categorized as "full participants" when fully integrated into society, or with partial interactions, they become "conscientious observers." Communities can also become "nearly absent" when isolated from the social arena. Within this place, they engage in a negotiation process in which people "confer, ponder exchange views consider evidence, reflect on mutual interest, negotiate and attempt to persuade each other" (Robinson and Berkes, 2011, p. 1186). Once negotiations are concluded, the community will present its final adaptation decision. This "continuous negotiation with the surrounding environment" provides valuable insights into the community's decision-making process during adaptation and will be further explored in this paper.

3 Materials and methods

3.1 Site description

Suriname is located in the northeastern part of South America, covers a total land area of 163,820 km^{2,} and has a comparatively small population of 616,500 (ABS, 2023). The study focused on three distinct regions: urban, rural, and forest regions (Figure 1), with each area represented by various administrative districts (Table 1).

The densely populated urban region accommodates 66% of the country's population (ABS, 2023). This region is located in the low-lying coastal zone and encompasses the capital city named Paramaribo. Primarily utilized as a residential area, the urban region is also home to numerous businesses and industries. The urban area serves as the country's administrative center and attracts people from other parts, visiting temporarily for business purposes (Planning Office Suriname, 2015).

Situated within the coastal zone, the rural region is characterized by lowlands with secondary vegetation, resulting from removing the primary tropical rainforest vegetation. Most land use is large-scale farming of rice and bananas, with the remaining area mainly including small-sized farms (<10 hectares) focused on cultivating fruits and vegetables. Uninhabited areas accommodate significant crude oil extraction operations near the

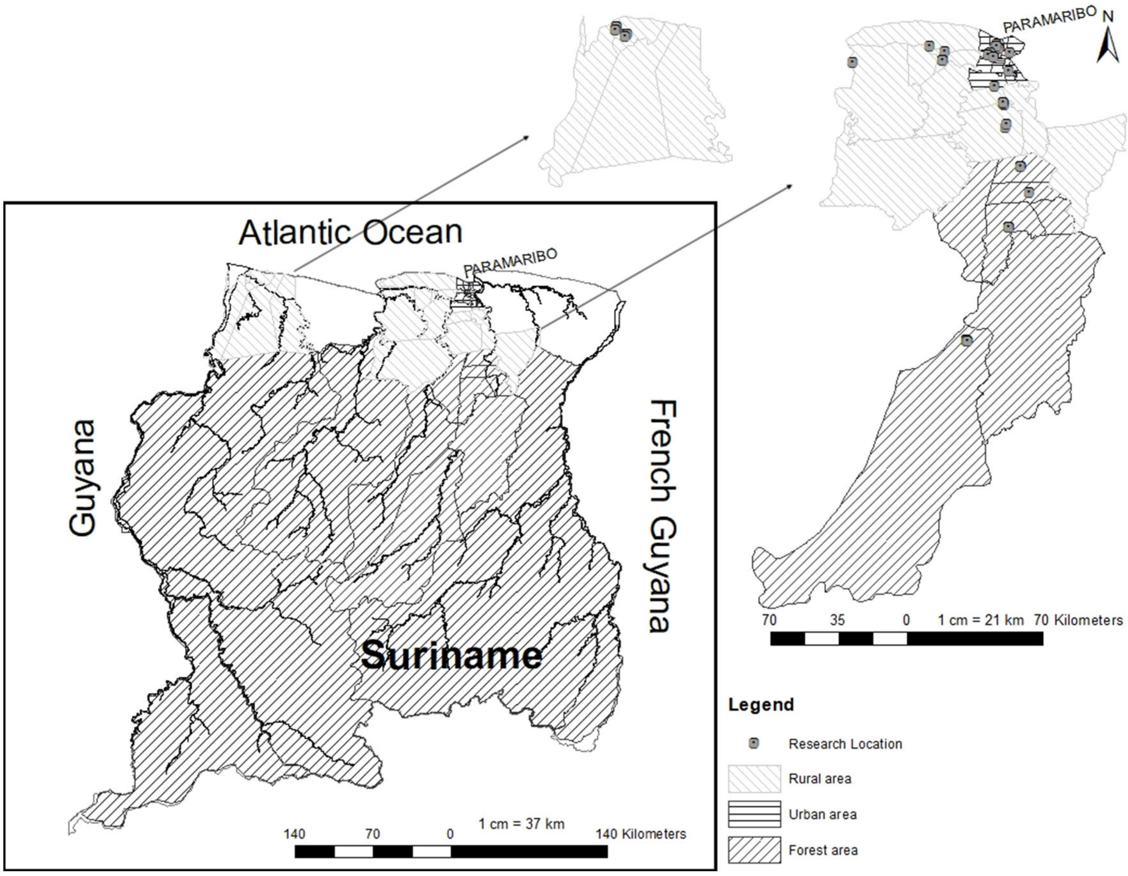

FIGURE 1
Location of the study sites in Suriname.

TABLE 1 Characteristics of the various study sites.

Region	Name district	Estimated population[a]	Area (km^2)	National multidimensional poverty index[b]	Average educational level[c]	Employment deprivation[d]
Urban	Paramaribo Wanica	374,421	625	3%	Secondary education	8%
Rural	Para Saramacca Nickerie	79,137	14,382	4%	Secondary education	8%
Forest	Brokopondo Sipaliwini	51,733	137,931	32%	Primary education	30%

[a]Demographic data 2021 (ABS, 2023). [b]Latest Census Data 2012 (Sobhie and Kisoensingh, 2023). The National Multidimensional Poverty Index shows the proportion of deprivation experienced of the poor people in the country to the total possible deprivation that would be experienced if every person in society were poor and deprived over the health, education, social economic security indicators. [c]Latest Census Data 2012 (Sobhie and Kisoensingh, 2023). The average educational level is estimated based on student attendance rates for primary and secondary school. [d]Latest Census Data 2012 (Sobhie and Kisoensingh, 2023). Employment deprivation estimated by percentage of the households.

coastline and fishing and eco-tourism activities (Planning Office Suriname, 2015).

In the southern part lies the forest region primarily covered by pristine tropical rainforests with rich biodiversity. Inhabitants of this area, comprised of Indigenous and Afro-descendent communities ranging from 50 to 5,000 people, largely depend on subsistence farming and gathering forest resources to sustain their livelihoods. Since 2011, local mineral deposits have led to increased gold mining activities, offering employment opportunities for many residents. The forest region can only be accessed through one road, lengthy canoe trips on water, and small airplane flights (World Wildlife Fund, 2016).

Suriname has a warm tropical climate with average temperatures between 25 C−28 C throughout the year and abundant rainfall between 1,500 mm in coastal areas and 3,000 mm in forest regions, with an annual average of 2,200 mm. In the context of climate change, Suriname expects a potential sea-level rise of 0.25–1 meter in the coastal zone by the end of the century,

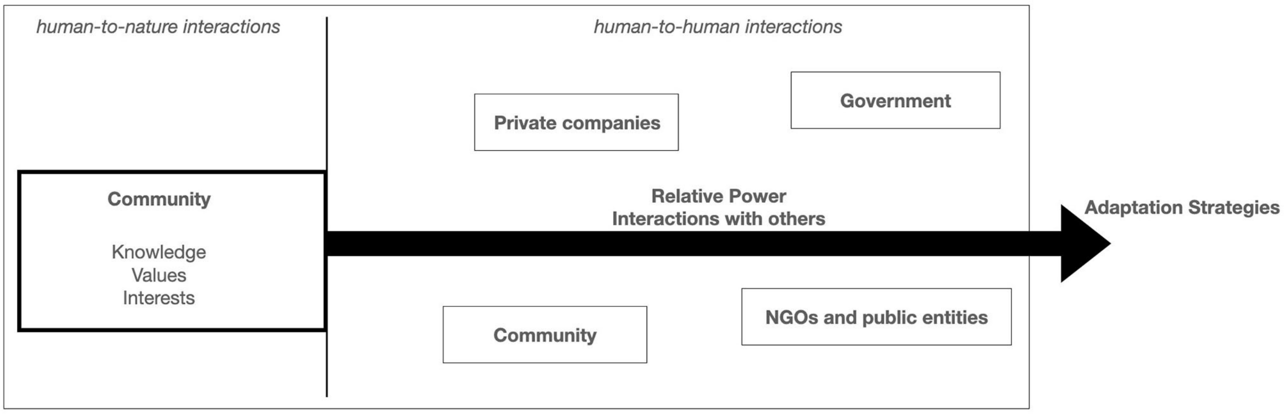

FIGURE 2
The social system of local communities adapting to climate change from a conflict resolution perspective.

affecting approximately 7% of the population, and is expected to a 6.4% decline in the country's GDP (Solaun et al., 2021; Government of the Republic Suriname, 2023). This area, including urban and rural study sites, is highly susceptible to pluvial flooding. It is about to experience a decrease in rainfall of about 10%, resulting in hotter and drier conditions (Solaun et al., 2021).

In the last decade, the forested regions have experienced notable changes, including increased minimum and maximum temperatures and a drier climate in southwest Suriname. Forest users have observed animal and plant phenology shifts, river water level fluctuations, and seasonal pattern alterations (Smith, 2013). These changes pose significant risks to the forest communities, mainly due to their reliance on vulnerable subsistence agriculture, limited accessibility, and inadequate infrastructure (Solaun et al., 2021).

3.2 Data collection and analysis

Between April 2022 and 2023, single households ($n = 68$) were selected for semi-structured interviews in the forest, rural, and urban areas dispersed throughout the country. These households resided at their current location for 10 years or more and were selected through non-probability snowball sampling. The selection of a 10-year time frame was motivated by people's inability to recall events accurately over more extended periods (Boillat and Berkes, 2013). Respondents ranged between 21 and 79 years, averaging 47 years. The male/female gender ratio of the sample was 0.94.

The researchers visited the selected households and conducted face-to-face interviews with household members on their premises. This survey aimed to determine whether individuals perceived climatic changes as seasonal and long-term and what adaptation strategies they adopted. The questionnaire used for these interviews assessed 42 indicators for detecting changes in wind, lightning, rainfall, drought, animal phenology, plant phenology, air, and soil. The questionnaire was validated in earlier research (Smith, 2013). The survey questionnaire is included in Annex 1.

Data was collected using Kobo Toolbox, an open data kit to collect data on phones and tablets (Kobo Organization, 2023). The number of responses for each climate indicator was tallied and converted into scores between 0 (lowest) and 1 (highest). The collected data was downloaded and analyzed with SPSS, version 24. The homogeneity of variance was examined using Levene's test. The consistency of the scores across different regions was assessed using the Kruskal-Wallis test with *post hoc* analysis.

Subsequently, the researchers approached the same households to engage in a social mapping exercise to understand better climate change indicators and their influence on individuals' motivation to undertake adaptive actions. Social mapping served as a platform for initiating a dialogue between the researchers and the community members, which included men, women, elders, and youth. This qualitative data was organized by themes and provided substantial detail on the broader context of the specific region in which the household was located. Other relevant secondary sources were also included in the study.

All data were analyzed using Nudler (1993)'s worldview analysis framework adapted to local communities facing climate change (Figure 2). Initially, the community's knowledge, values, and interests were determined to describe their current reality. Subsequently, the community's decision-making process was examined by assessing their relative power, level of interaction with others, and ultimately, adaptation strategies.

4 Results and discussion

4.1 Local knowledge

Seasonal observations are essential for detecting immediate changes in natural cycles, such as the (dis)appearance of animals and plants, plant blooming and fruiting, wind speeds, lightning activity, cloud cover, river water levels, water quality, air temperature, and heat levels. Our data reveals that all researched communities possess a broad range of indicators, implying their capacity to observe the natural ecosystem, evaluate it, and take appropriate actions (Figure 3). This characteristic is often seen in communities that still maintain a close connection to nature, according to Chisholm Hatfield et al. (2018).

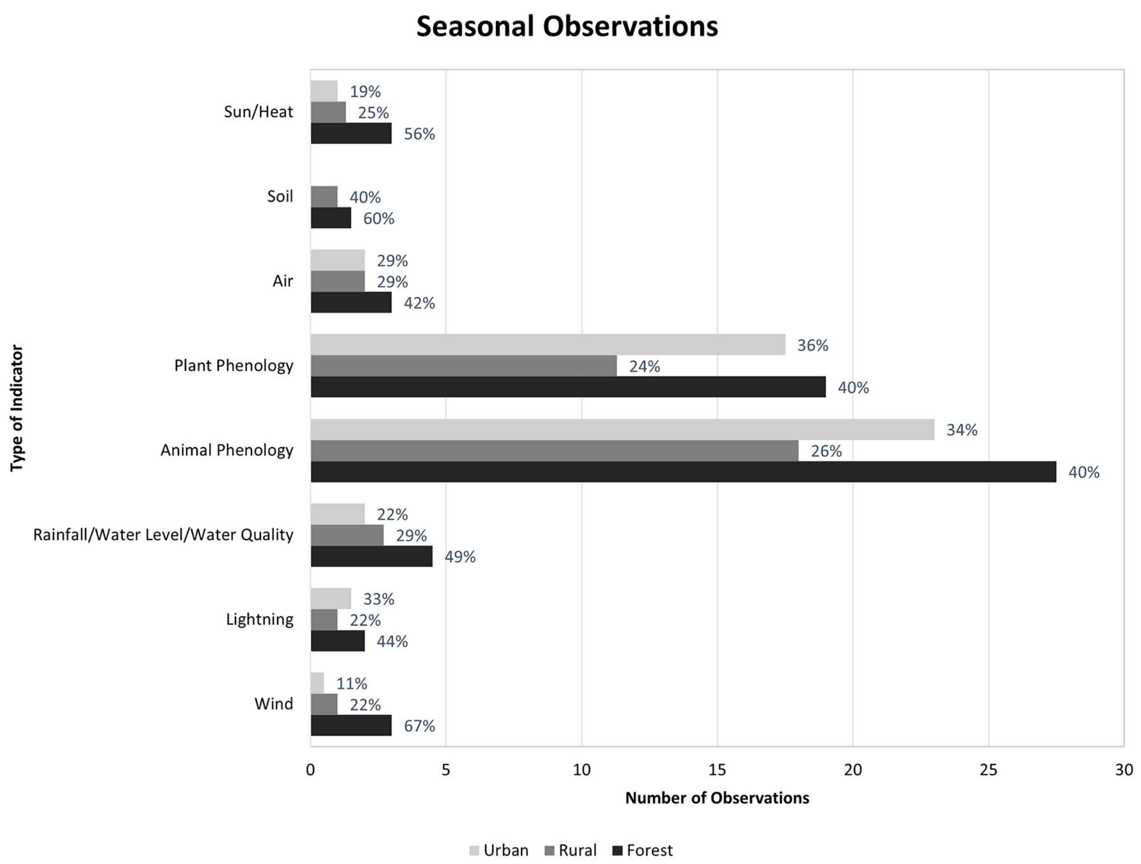

FIGURE 3
Seasonal observations made by urban, rural, and forest communities. Percentages of observations are shown per indicator.

Our study also shows that the local knowledge system differs considerably among the three regions. Forest communities had a more significant number of observations across all indicators compared to rural and urban communities, including wind, lightning, rainfall/water levels/water quality, animal phenology, plant phenology, air, soil, and sun/heat. Variations in animal and plant phenology are most frequently observed, highlighting their importance in assessing the seasons for all communities. The widespread use of animal and plant indicators is attributed to their consistency across time and space, making them reliable (Møller, 2015).

Seasonal observations are typically gathered in response to perceived shifts in weather patterns and are intricately linked with the community's livelihood activities. The significance of these indicators lies in helping the communities prepare for site selection, plot clearing, and crop planting, as Varah and Khamrang (2022) pointed out. Our study shows a similar correlation between seasonal indicators and daily livelihood activities. The indicators gathered offer insights into the onset, peak and conclusion of the dry and rainy seasons. They are essential for planning agricultural activities and securing food production in rural and forest communities.

According to our results, urban communities lack indicators for evaluating soil changes (Figure 3). This practice could come from their limited engagement with soil-related activities, as soil indicators are typically linked to agriculture, often absent in urban areas (Hatfield et al., 2020). A similar absence of soil indicators was observed among citizens in Accra, a metropolitan city in Ghana, where they utilized fauna, astrology, and sea indicators to detect climate variability (Codjoe et al., 2014).

Regarding long-term observations of climate change, which spanned over 10 years or more, the forest communities show a robust traditional knowledge system, achieving an average observation score of 0.286. In contrast, the rural and urban communities recorded lower average scores of 0.157 and 0.185, respectively. Kruskal-Wallis test comparison among the mean observation scores of various indicators confirmed significant differences between the forest, rural and urban regions, shown in the alphabetical letters in Table 2. This table shows that forest communities have significantly higher scores across 15 indicators, encompassing all themes except drought. Urban areas recorded significantly higher scores in the drought theme, particularly in observing dryer and hotter conditions typical for cities and towns. Significantly higher scores were also observed for the indicator "soils difficult to irrigate," which may indicate their experiences with extensive flooding experiences in the coastal region.

The study showed no significant differences in long-term observations among genders, while age variances were demonstrated. For animal, plant, and soil observations, households with observers older than 40 years recorded significantly more

TABLE 2 Comparison of mean scores of various climate change indicators.

Indicator	Activity	Forest			Rural			Urban		
		Mean	SD		Mean	SD		Mean	SD	
Wind	More wind	0.258	0.080		0.208	0.085		0.385	0.140	
	More gusts	0.419	0.090		0.167	0.078		0.462	0.144	
	More turns	0.032	0.032		0.083	0.058		0.077	0.077	
	Less wind	0.194	0.072	a	0.000	0.000	b	0.000	0.000	ab
Lightning	More lightning	0.032	0.032		0.042	0.042		0.077	0.077	
	Lightning in different places	0.129	0.061		0.042	0.042		0.077	0.077	
	Harder thunder	0.226	0.076	a	0.000	0.000	b	0.077	0.077	ab
	Less lightning	0.097	0.054		0.000	0.000		0.000	0.000	
Rainfall	More rainfall	0.807	0.072		0.792	0.085		0.539	0.144	
	Rainfall more intense	0.774	0.076	a	0.333	0.098	b	0.231	0.122	bc
	Longer rainy season	0.548	0.091		0.667	0.098		0.615	0.140	
Drought	Longer dry season	0.000	0.000		0.083	0.058		0.154	0.104	
	Dryer	0.000	0.000	ab	0.083	0.058	b	0.385	0.140	a
	Hotter	0.194	0.072	b	0.125	0.069	bc	0.917	0.083	a
	Shorter dry season	0.387	0.089		0.292	0.095		0.385	0.140	
Air	Air is hotter	0.419	0.090	a	0.250	0.090	b	0.154	0.104	ab
	More clouds	0.323	0.085	a	0.042	0.042	b	0.000	0.000	bc
	Fewer clouds	0.129	0.061		0.000	0.000		0.000	0.000	
	Fewer stars	0.290	0.083	a	0.042	0.042	b	0.000	0.000	bc
	Stars moving asynchronously with nature	0.032	0.032		0.000	0.000		0.000	0.000	
Animal phenology	Fewer animals seen	0.258	0.080		0.167	0.078		0.385	0.140	
	Animals disappeared	0.194	0.072		0.083	0.058		0.077	0.077	
	Animals seen in different places	0.258	0.080		0.125	0.069		0.231	0.122	
	Animal mating different	0.194	0.072	a	0.000	0.000	b	0.000	0.000	ab
	Insect less sounds	0.387	0.089	a	0.083	0.058	b	0.077	0.077	ab
	Insects more sounds	0.000	0.000		0.065	0.045		0.000	0.000	
	Insects less activity	0.387	0.089	a	0.083	0.058	b	0.000	0.000	bc
	Fewer insects seen	0.355	0.087	a	0.167	0.078	ab	0.000	0.000	b
Plant phenology	Fewer fruits	0.516	0.091		0.333	0.098		0.308	0.133	
	Weeds grow faster	0.387	0.889		0.292	0.095		0.385	0.140	
	Early blooming	0.032	0.032		0.125	0.069		0.000	0.000	
	Late blooming	0.387	0.089	a	0.208	0.085	ab	0.000	0.000	b
	Early fruiting	0.000	0.000		0.083	0.058		0.000	0.000	
	Late fruiting	0.387	0.089	a	0.083	0.058	b	0.000	0.000	bc
	Plant withering	0.355	0.087		0.250	0.090		0.154	0.104	
	Early fruit ripening	0.032	0.032		0.125	0.069		0.000	0.000	
	Late fruit ripening	0.484	0.091	a	0.042	0.042	b	0.000	0.000	bc
	Fewer fruits	0.516	0.091	a	0.083	0.058	b	0.231	0.122	ab
Soil	Soils wetter	0.548	0.091		0.417	0.103		0.385	0.140	
	Soils less fertile	0.419	0.090		0.333	0.098		0.462	0.144	
	Soils different to burn	0.452	0.091	a	0.167	0.078	ab	0.077	0.077	b
	Soils different to irrigate	0.194	0.072	ab	0.042	0.042	b	0.462	0.144	a

According to the Kruskal-Wallis test, different letters indicate differences between indicators at a 5% significance level.

observations than those between 20–30 years at a 5% significance level. This means that younger generations exhibit lower levels of knowledge. Our age analysis contrasts with studies conducted among Amazonian indigenous peoples with robust knowledge systems across all genders and ages (Smith, 2013; Funatsu et al., 2019), suggesting a potential erosion of established traditional knowledge systems.

In summary, the data on local knowledge highlights a link between the extensiveness of the knowledge system and its intended purpose. Forest areas where survival relies heavily on monitoring nature exhibit a comprehensive system with numerous nested indicators. The indicators the communities use to evaluate short- and long-term climate changes here are comparable to those observed in the wider region (Bynoe and Liddel, 2013; Smith and Bastidas, 2017; Stancioff et al., 2018; Funatsu et al., 2019). In rural areas focusing on agricultural production, the communities select indicators aligned with this purpose. Urban areas, with a lower dependence on nature than forest and rural regions, possess fewer indicators.

4.2 Strategies for adaptation

Communities can benefit significantly from tapping into their local knowledge base, serving as a fundamental resource in crafting adaptation solutions. The findings include that forest communities possess a robust knowledge system centered around collective survival within the forest. These communities, situated at least 80 km from the administrative center, have few social connections other than those with neighboring communities and non-governmental organizations operating in the area. Despite these connections, the forest communities rank among the country's poorest, with relatively low educational levels and employment opportunities, further exacerbating the scarcity of development opportunities (Table 1).

Confronted with little social support and financial resources, forest communities rely heavily on their internal capabilities for adaptation. Their local knowledge system plays a central role in shaping adaptation strategies guiding the refinement of existing practices in response to reduced rainfall and more drought events (Table 3). More specifically, 76% of respondents prefer advancing the execution of events, and 43% opt for delaying livelihood activities. Another less commonly employed strategy among these communities involves planting various crops to mitigate crop deterioration, as 29% of respondents reported. Similar self-reliant adaptation measures were identified by Smith and Bastidas (2017) in their study of the isolated Trio indigenous community living in the forests of South Suriname.

Conversely, urban communities actively seek adaptation strategies from external sources. With small land parcels, typically <1,000 m^2 (0.25 acre), these communities cultivate home vegetable gardens and maintain a few fruit trees to supplement their self-sustenance. The urban knowledge base holds little significance and is primarily employed to support recreational activities amidst the vibrant urban lifestyle, such as subsistence agriculture (50% of respondents) and subsistence fishing (50% of respondents)—activities falling under the relaxation category. Social mapping analysis reveals a recurring theme of

TABLE 3 Overview of factors determining the decision-making of communities facing climate change.

Region	Climate stressor	Human-to-nature interaction			Human-to-human interaction		Adaptation strategy
		Local knowledge	Values	Interests	Relative power	Interaction with others	
Forest communities	Less rainfall and more drought, increased temperature	Traditional knowledge only. Traditional knowledge includes seasonal and long-term indicators	Collectivity. Equitable division of resources. Food security. Health of the community	Collection of Non-Timber Forest Products, followed by subsistence farming and fishing	Limited power. Marginalized communities with traditional knowledge that is poorly recognized.	Dependent on own community for support. None or limited interaction with others. Mainly absent from the negotiation arena	Adjustment of the timing of subsistence activities. Planting of multiple crops.
Rural communities	Heavy rainfall with pluvial flooding events, extreme heat and drought	Western- and traditional knowledge. Traditional knowledge includes seasonal and long-term indicators	Individual interests. Profit-driven use of nature. Family health	Commercial farming, followed by relaxation in nature and subsistence farming	Medium power. Low to middle-class communities that obtain power through expert farming knowledge and farmers' organizations	Depending on the family. Interaction with other farmers, and farmer organizations. A conscientious observer in the negotiation arena	Adjustment of production system by increasing the number of crops and livestock
Urban communities	Heavy rainfall with pluvial flooding events, extreme heat and drought	Western- and traditional knowledge. Traditional knowledge includes seasonal and long-term indicators	Individual interests. Recreational value of nature. Healthy food. Family health	Relaxation in nature, followed by subsistence farming and fishing	Medium power. Middle-class communities that obtain power through administrative governance, legal structures and media channels	Dependent on self. Mainly interaction with residents in the neighborhoods, politicians, and media. A conscientious observer in the negotiation arena	Migration to higher grounds and seeking technological solutions (irrigation improvements)

relaxation in these communities, indicating a perception of climate change that lacks a strong sense of immediate danger. This perception remains consistent regardless of the severity of the climate change event. Adger (2013) and McNeeley and Lazrus (2014) made similar observations in theoretical analysis about adaptation choices.

Urban communities strategically leverage their power and social connections, taking advantage of their proximity to the capital city of Paramaribo. In addressing climate change adaptation, they focus on securing support for relocating activities to higher ground (62% of respondents) and exploring technological solutions to improve irrigation (100% of respondents) in response to heavy rains and pluvial flooding events. This finding underscores the communities' preference for adaptation measures that align with their values and interests, particularly within the context of Western development. However, a substantial portion, accounting for 46% of urban respondents, refrain from taking specific actions in response to climate change. It shows the significant impact of communities' access to power and social networks, choosing inaction as a preferable option over tapping into their local knowledge base. This pattern demonstrates the substantial influence of human-to-human interaction in shaping the perceptions and responses of the communities.

The impact of this human-to-human interaction is also evidenced within rural communities. Most of these communities (75% of respondents) engage in permanent or semi-permanent small-scale agriculture on individual or family-owned land. Within these close-knit groups, families rely on a medium-sized local knowledge base passed down through generations of farmers. Their primary focus is on generating profit through commercial crop cultivation and livestock production, emphasizing family health significantly.

Rural communities implement adaptation strategies that mitigate reduced rainfall and pluvial flooding. These strategies include keeping additional animals (73% of respondents) and planting multiple crops (53% of respondents), demonstrating that they prefer to tap into family and farmer networks rather than depending solely on local knowledge to mitigate climate change-related risks. This intriguing finding suggests that the communities prioritize solutions based on human-to-human interaction, even when a local knowledge base is sufficiently available. Nevertheless, the local knowledge base remains valuable, utilized to support subsistence farming activities to meet the communities' nutritional needs (42% of respondents), aligning with the value placed on family health.

The finding that rural communities favor support networks over their knowledge base shows the complexity of the adaptation process. These communities made a tradeoff between these two options, made possible by their involvement in the negotiation arena, where they hold low-to-medium power. A similar observation was made by coffee farmers in Guatemala, Honduras, and Mexico, who prioritized crop selling prices over other options when making adaptation decisions (Tucker et al., 2010). Both study outcomes illustrate that communities make a cost-benefit analysis when dealing with adaptation, showing that the process involves evaluating the available options. Clearly outlining these options, as demonstrated in our study, is thus crucial for analyzing decision-making on adaptation.

5 Conclusion

Our study highlights the pivotal role of local knowledge in shaping how communities approach climate change adaptation. We found that local knowledge's role in decision-making is not independent but interwoven with the community's values and interests. These factors collaboratively guide the autonomous decision-making process of communities, delineating a specific direction for decision-making. We demonstrated that local knowledge is the primary resource for adapting to climate change in forest communities. In urban and rural communities closer to the administrative centers, local knowledge serves a secondary purpose aligned with their values and interests of fostering relaxation in nature and ensuring family food supply, respectively.

The size and comprehensiveness of the local knowledge base emerge as a precursor in decision-making. Communities with a relatively small knowledge base, such as urban communities, can easily leverage their influence and seek outside assistance for adaptation. A medium-sized knowledge base, as seen in rural communities, may fall short of providing comprehensive adaptation solutions when communities have strong support networks. In comparison, forest communities rely on their robust knowledge to undertake self-reliant adaptation, an essential activity in developing countries like Suriname, where resources for technological solutions are limited. Our results could assist researchers in identifying the ideal scale of local knowledge necessary for self-reliant adaptation, especially in forest communities where local knowledge still remains prevalent in South America, Asia, and Africa.

Similar to other research (Gaillard, 2010; Tucker et al., 2010; Granderson, 2017), our study shows that contextual factors play an important role in autonomous decisions in adaptation. The impact of "relative power" and "social interaction" should not be underestimated as communities consider these factors when navigating through available adaptation options irrespective of the existing climate conditions. The study findings demonstrate that rural and urban communities seriously consider these factors when exploring adaptation solutions. It also shows that in the case of rural communities with a medium-sized local knowledge base, tradeoffs are made between utilizing the internal knowledge system and seeking external support. Meanwhile, remotely located forest communities opt for solutions solely from their local knowledge base because they have no other available options.

Thus, two essential dimensions in community decision-making have been highlighted in our study: the interaction between the community and nature and the interaction between the community and other human actors. The research indicates the significance of both dimensions in analyzing decisions made by the community. The first dimension, which involves human-to-nature interaction, defines how the knowledge base (including their values and interests) guides the direction of community decisions. The second dimension, focused on human-to-human interactions, enables the community to balance their interests with other available resources. A more profound integration into the social system will provide the community with a broader range of options.

Applying a conflict resolution approach allowed us to assess the entire decision-making system and research the interconnectedness of its components. By structuring our data within the conflict analysis framework (Figure 2), we could analyze each component's distinct roles and observe their collective contributions to the decision-making process. Considering local knowledge alongside values and interests seems essential for researchers to understand the "human-to-nature" interaction. Also, the researcher can integrate the "human-to-human interaction" into their analysis, which may offer them insights into the, often underestimated, influence of the social system on decision-making processes.

However, due to time and resource constraints, our study limits exploring the meaning-making process in depth. Gaining a more profound understanding of the meaning-making process requires ethnographic research, which demands significant time investment. For example, the Trio community study took 5 years to comprehensively understand the meaning-making process in climate change. Further studies should build on this study's foundational information to unravel the community's information selection process, as this will give more insight into the factors that influence decision-making.

The study left us uncertain whether the adaptations actions recorded were short-term responses or long-term strategies. This distinction is significant because communities may implement these measures as immediate reactions to climate change while exploring more sustainable options. For example, Funatsu et al. (2019) illustrates how local farmers in North-East Brazil resort to short-term alternatives when facing technological and cultural limitations. Similarly, in our research, we interpret the adaptation strategies as reactions to imminent climate threats. Further research is necessary to differentiate between immediate response and long-term strategies.

Our study offers a practical case study for evidence-based policymaking. Local knowledge represents a valuable resource that should be recognized and systematically integrated into national adaptation plans, a practice rarely seen worldwide. We encourage policymakers to utilize the study's insights to design policies to support communities in taking self-driven adaptation measures, which will be the obvious solution to climate change challenges in developing countries like Suriname with limited resources. This study has the potential to refine national adaptation plans and offer a set of indicators that ordinary citizens can utilize to detect early indications of climate variability and change. Then, nations can establish a location-specific citizen science network that could facilitate the integration of valuable traditional knowledge into the national climate change decision-making process.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval for the studies involving human subjects was not obtained because Suriname lacks a national committee on social science research. The studies were conducted in accordance with local legislation and institutional requirements. Written informed consent for participation of the participants or the participant's legal guardians/next of kin was not obtained because not all participants could read and/or write, and therefore verbal informed consent was obtained in this research.

Author contributions

GS: Conceptualization, Formal analysis, Methodology, Supervision, Visualization, Writing – original draft. MC: Data curation, Investigation, Writing – review & editing. JK: Data curation, Investigation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fclim.2023.1294271/full#supplementary-material

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