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Environment
Article

Seasonal Indicators for Rapid Detection of Climate Variability across Suriname

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Abstract

Climate-related changes are occurring at a rate surpassing local communities' adaptive capacity. These communities often rely on their traditional knowledge to navigate and adapt to the changing environment, using seasonal indicators and calendars. The study highlights and documents the local knowledge for detecting climate variability held by the citizens in seven districts of Suriname. Through participatory data collection and analysis, we identified 219 indicators that detect a wide range of changes in wind patterns, lightning occurrences, rainfall, water levels and quality, animal and plant phenology, and air and soil quality. Approximately one-third of these indicators were location-specific, exhibiting great detail and specialization. The study reveals a robust indicator system active across all participating urban, rural, or forested districts. It concludes that local knowledge may become a valuable resource for responding rapidly to the challenges posed by climate change in Suriname, a nation highly vulnerable to the impacts of climate change.

Keywords: Seasonality, indicator, ecological calendar, traditional knowledge, climate variability, climate change, Suriname

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1. Introduction

Climate change is increasingly causing widespread impacts on ecosystems and humans worldwide. In South America, where most of the population depends on rainfed farming, climate change's effects manifest in sea-level rise, land and forest degradation, loss of biodiversity, and rising temperatures resulting in hotter conditions (Iwama et al., 2021). Additionally, there is a rising frequency and severity of extreme weather events like droughts, floods, heavy rains, and storms, which are causing damage to key economic sectors (IPCC, 2023). These impacts of climate change are already being observed in Suriname, a relatively small, developing country located on the northeastern coast of South America. The country faces a drier and hotter climate, increased pluvial flooding in coastal regions (Solaun et al., 2021), changes in seasonal patterns (Smith, 2013), and fluctuations in river water levels affecting the forest region (Nurmohamed, 2008).

An effective response to climate change demands a thorough understanding of the surrounding environment, including climate cycles and anomalies. Citizens of Suriname can better cope with climate variability and adapt to climate change when climate information is regularly available. Climate information is available on daily precipitation across the country, and daily maximum and minimum temperatures are recorded only for the coastal region (Meteorologische Dienst Suriname, 2023). Currently, the absence of detailed, location-specific data hinders citizens from making informed plans and decisions. Most citizens, including farmers and forest inhabitants, must rely on their local knowledge about the existing ecosystem based on experiential learning across time.

Local knowledge is now recognized as the obvious solution for citizens to adapt to climate change because it has proven more accurate and reliable locally than abstract knowledge (IPBES, 2019; IPCC, 2007; Nyong et al., 2007). It is grounded in the practice of people observing nature holistically, tied to their local culture and livelihoods. This differs from abstract knowledge, which follows a reductionist approach that excludes emotions and senses from observations (Pierotti, 2011). Abstract knowledge generation involves breaking down observed data, analyzing it devoid of social and environmental context, and then reorganizing it in a manner coherent with the discourse at hand (Agrawal, 1995).

Farmers, indigenous peoples, and other nature-dependent groups are typically generating local knowledge. Within this local knowledge lies the capacity for place-based weather forecasting, which relies on nested indicators for assessing climatic changes between seasons and years. The communities predominantly use their senses - taste, smell, feel, sight, and sound – to detect changes in nature. New information arises when assessing nature, while irrelevant knowledge is discarded (Berkes, 2012; Nakashima et al., 2018; Rarai et al., 2021). The dynamic nature of local knowledge is also evident in the transmission of information from one generation to the next.

In the early phases of global research on local knowledge and climate change adaptation, the focus was on a technical, risk-based approach that evaluated communities' vulnerability to climate change (Burton et al., 2002; Smit & Wandel, 2006). Later research shifted towards considering adaptation as a social process, embracing its place-based diversity. This shift was particularly evident after studies highlighted that adaptation was not only influenced by climate-related risks but also by various stressors like development pressures (Leonard et al., 2013), market prices (Tucker et al., 2010), mining and wood logging pressures (Boissiere et al., 2013), pests and diseases (Vedman & Rhoades, 2001), as well as poverty, care, and employment opportunities (Gaillard, 2010).

In 2007, the Intergovernmental Panel on Climate Change (IPCC) highlighted the importance of local knowledge in climate change observation and adaptation (Nakashima et al., 2018). Since this recognition, several attempts have been made globally to validate local knowledge by comparing it with scientific knowledge in weather forecasting using actual measured data (Boisierre et al., 2013; Jiri et al., 2016; Nyadzi et al., 2013; Radeny et al., 2019; Yang et al., 2019). There has also been a growing argument for integrating Western and local knowledge through standard study protocols (Reyes-Garcia et al., 2023), data classification and organization (Chambers et al., 2017; Reyes-Garcia et al., 2019), and integration models (Tengo et al., 2014).

A recent review of South American and Caribbean literature revealed that many studies still need to fully recognize the role of local knowledge in climate change research (Iwama et al., 2021). In 96% (n=147) of the studies, the dominant research paradigm still leans towards positivism or post-positivism, resulting in a mandatory distance between the researcher and the subject under study. Our study addresses this literature gap and aims to highlight and document the local knowledge utilized by the citizens of Suriname for detecting climate variability in a participatory manner. Specifically, the study seeks people's local knowledge supported by empirical evidence and records the indicators they use to adapt their livelihoods to the constantly changing natural environment. The following inquiry guides the study: What indicators are local people using to detect climate variability?

Understanding people's ethnoecological knowledge of weather and climate holds significant importance in Suriname, considering its classification as one of the world's most vulnerable countries to rising sea levels (Government of Suriname, 2023). There is an urgent need for an accelerated adaptation response, primarily because the changes occur faster than people's capacity to adapt (IPCC, 2023).

2. Ecological calendars and indicators for assessing climate variability

Nature-dependent communities depend on ecological calendars to synchronize their livelihood activities with their surrounding environment. These calendars include a holistic view of human activity, biology, and the environment, recognizing the entire system rather than isolating individual aspects. Unlike the Gregorian calendar, ecological calendars are more comprehensive. They encompass a broader spectrum of elements beyond the sun, moon, and stars, incorporating biological, environmental, and meteorological elements. These calendars are intricately linked to specific cultures and locations, making each calendar unique (Kassam et al., 2018).

Ecological calendars fell outside the scope of natural and climate science for many decades until they became highlighted as a way to combat climate change in 2007 (IPCC, 2007). Only academic fields such as anthropology, human ecology, and geography have shown interest in ethnographically studying the indigenous and other nature-dependent groups that employ ecological calendars to navigate climate variability. The calendars hold accuracy within the user's worldview, providing the necessary information for survival decisions within their natural environment. However, given its foundation in distinct ontology and epistemology, the calendar's accuracy may not align with scientific standards. The validation of ecological calendars through abstract scientific methods is a common oversight (Smith, 1999; Tengo et al., 2014).

The essence of ecological calendars lies in the presence of numerous indicators. An indicator is defined as “a variable which supplies information on other variables which are difficult to access and can be used as a benchmark to take a decision” (Gras et al., 1998, p. 63). Indicators are usually collected through a (collaborative) system involving adept users of nature. They are closely tied to the human food system, dictating the timing of livelihood activities such as crop planting, harvesting, and gathering fruits and other natural resources (Reyes-Garcia et al., 2016; Seddon et al., 2016; Varah & Khamrang, 2022). Indicators serve as a strategic “tool” for enabling prolonged stays of users in a specific location by adapting to the intra- and inter-variation within the physical system. The users typically modify these indicators to align with the new circumstances when changes are detected.

The effectiveness of indicators for evaluating climate change depends on their consistent use in a specific location over extended periods. These indicators primarily detect climate variability, defined as the interannual or interdecadal fluctuations in temperature and precipitation. It is important to distinguish climate variability from “climate change,” as the former operates on a shorter time scale. Climate change refers to persistent, multidecadal deviations from long-term averages (IPCC, 2012). Nevertheless, climate variability can manifest over a longer duration than individual weather events, often ranging between seasons within a year.

According to Western science, several groups of indicators exist (Granderson, 2017). The first group, meteorological indicators, is sensitive to changes in rainfall, temperature, wind patterns, and cloud behavior. The second group, biological indicators, tracks shifts in the life cycles of plants and animals, such as the flowering and fruiting of plants or the mating and migratory patterns of animals. These indicators are the most frequently used for detecting climate change (Møller, 2015). The third group, environmental indicators, focuses on variations in hydrological processes, including tides, currents, and alterations in soil fertility. Lastly, astrological indicators monitor celestial cycles, such as star and lunar patterns, and their alignment with communities’ livelihood activities. As an illustration, the Trio indigenous community living in the forests of South Suriname observes the scorpion mating season in conjunction with the highest river water level and the appearance of the star constellation identified as “Scorpio” (Smith, 2013).

This five-year study conducted among the Trio peoples demonstrated the utilization of all indicator groups for detecting climate variability. The Trio community employs 52 indicators that cover a broad spectrum of changes. Among these are indicators for detecting forest health, such as the presence of certain fruits and snakes. The Trio people excel at discerning subtle climate shifts, like observing plants that yield more fruits during the rainy period and more flowers during dry spells. The onset of seasons is determined by assessing the sounds of insects and watching the star constellations, while indicators linked to soil health help the Trio people evaluate soil fertility for crop cultivation (Smith, 2013).

Indicators utilized by such indigenous people may be more sensitive to subtle changes because these people generally have extensive knowledge about the whole ecosystem and the interactions between its elements (Chisholm Hatfield et al., 2018). Farmers, who also rely on their natural environment, possess indicators to detect nuances in their crop and/or livestock production system, including indicators for land use, soil erosion, soil organic matter, and heat stress in livestock (Hatfield et al., 2020). These farmers often reside at a single location for a decade or longer, developing a thorough understanding of the ecosystem (Blakeney, 2020; Jiri et al., 2015; Vedman, 2006). Other groups inhabiting one area for more than a decade will also possess a significant understanding of the ecosystem, and they may identify several site-specific indicators for detecting climate variability.

Indicators are considered reliable only when people can use them to assess the climate and decide their livelihoods (Bockstaller & Girardin, 2003). Phenological indicators, such as plants and animals, have consistently demonstrated greater reliability over time and space than other indicators, such as population size or reproductive success (Møller, 2015). Notably, animal species that remain in one location are more dependable than migrant species that are present for only a few months each year (Rubolini et al., 2010).

3. Materials and Methods

3.1 Study Sites

The research was conducted in seven districts in Suriname, situated on the northern coast of South America (Table 1, Figure 1). Suriname covers an area of 163,821 km^2, including a flat coastal region and savannahs in the north and a hilly forest landscape in the south. The country has a warm tropical climate with average temperatures between 25-28 degrees Celsius throughout the year and abundant rainfall. Annual precipitation levels vary between 1,500 mm in coastal areas and 3,000 mm in forest regions, with an annual average of 2,200 mm. Suriname's climate is influenced by the Intertropical Convergence Zone (ITCZ), leading to two distinct rainy seasons: the long rainy season occurring from mid-April to mid-August and the short rainy season from early December to early February. The dry seasons fall between these rainy seasons (Solaun et al., 2021).

Suriname is part of the Guyana Shield region, often referred to as the "lands of many waters." The country's territory is defined by the Corantijn, the easternmost river, which forms a border with Guyana. To the west, the Marowijne River is shared with French Guyana. Together, these rivers collectively drain nearly 58% of the country, while five other rivers discharge the remaining 42% of water. Local communities rely on this water for their well-being and development. In coastal areas, they extract drinking water from groundwater aquifers, whereas those in forested regions depend on surface water for their water supply. The quality of water is generally good, except for mercury pollution caused by small-scale goldmines occurring in interior forest areas (Webster & Roebuck, 2001).

Climate change is expected to significantly impact the relatively small population of 616,500 (ABS, 2023), primarily located in the coastal region, except for approximately 10% living along the rivers in the southern forest regions. The coastal region is susceptible to frequent pluvial flooding, associated with a projected sea level rise of 0.25-1 m by the end of the century (Government of the Republic Suriname, 2023). This region is predicted to become hotter and dryer, with an estimated 10% reduction in rainfall. The forested regions expect increased minimum and maximum temperatures and a drier climate in the southwest part of Suriname (Solaun et al., 2021). Individuals reliant on the forest observe phenological shifts in animals and plants, water level fluctuations, and seasonal pattern alterations (Smith, 2013).

Table 1: Characteristics of the study sites

District	**Characteristics**	**Area (Km2)**	**Population***	**Sample interviews and social cartography**	**Human Development Index****
Paramaribo	Urban	182	235,835	8	0.741
Wanica	Urban	443	138,586	5	0.689
Para	Rural	5,393	30,264	9	0.691
Saramacca	Rural	3,636	17,102	7	0.693
Nickerie	Rural	5,353	31,771	8	0.683
Brokopondo	Forest	7,364	14,802	21	0.626
Sipaliwini	Forest	130,567	36,931	10	0.522

*Demographic data 2021 (ABS, 2023)
**The human development index is a summary measure of human development based on a long and healthy life, access to knowledge, and a decent standard of living (UNDP, 2013)

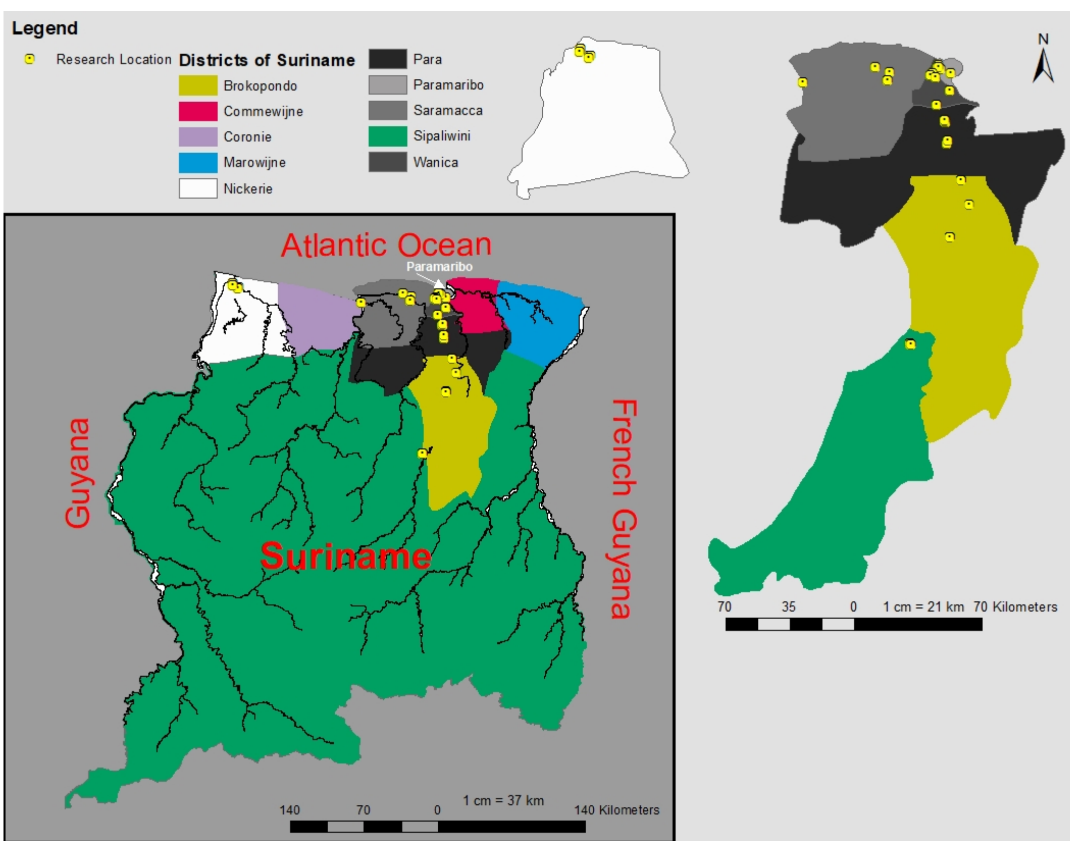

Figure 1: Location of the various study sites. Source: Melvin Uiterloo

3.2 Data Collection and Analysis

Qualitative data was collected using key informant interviews during April 2022-2023. The qualitative information collected was mainly on people's perceptions of climate change, variability, and associated indicators. Single households (n=68) were randomly selected for semi-structured interviews when they stayed at their current location for ten years or more. By adhering to the 10-year selection criterion, we were confident that respondents could recall climate events accurately and had collected indicators for effectively adapting to climatic changes (Boillat & Berkes, 2013).

The researchers visited the selected households to conduct face-to-face interviews. Respondents ranged between 21 and 79 years, averaging 47 years. The male/female gender ratio of the sample was 0.94. The questionnaire used for this study was validated in earlier research (Smith, 2013) and included questions on indicators to detect climate changes in the dry and rainy seasons.

Using questions that distinguish between dry and rainy seasons was a practical decision, as prior research revealed that local communities struggled to identify detailed indicators, particularly when attempting to convey nuances between the short and long durations of these seasons (Smith, 2013). Data was collected using KOBO Toolbox, an open data kit designed to gather data via mobile devices (KOBO Organization, 2023). The climate indicator's responses were downloaded and analyzed for each district using SPSS, version 24. The consistency of indicator means across different districts was assessed through the Kruskal-Wallis non-parametric test.

In addition, the same households were invited to participate in a social mapping exercise. This exercise aimed to gain deeper insights into the behavior of the plant and animal indicators through a dialogue between the researcher and the household members, including men, women, elders, and youth. During these discussions, maps were utilized to help guide the conversation, allowing household members to visually depict the relationship between the indicators and the surrounding environment. This exercise also corroborated the information collected during the interviews, as it aligns with the participatory approach needed for effective local knowledge research (Reyes-Garcia et al., 2022). The participatory approach used in this study is rooted in constructivism and diverges from the dominant positivist epistemology (Smith, 1999).

All qualitative and quantitative data were organized for each district into seasonal calendars. Local indicator names were obtained and kept in their original version to respect the culture of the respondent and the constructivist nature of the study. The scientific names for the plant and animal indicators were determined with support from, respectively, the National Zoological Collection in Suriname (NZCS) and the National Herbarium in Suriname (BBS).

4. Results and Discussion

4.1 Indicators

The study shows that the citizens of Suriname rely on a comprehensive set of indicators for detecting changes in both the rainy and dry seasons. These indicators cover various meteorological and environmental factors, including wind, lightning occurrences, rainfall levels, river water levels, water quality, sunlight and heat, and air and soil quality. Also, citizens utilize biological indicators that give information about shifts in animal behavior, such as active insects or animal mating, and plant growth cycles expressed by flowering, fruiting, and fast growth spurs. For astrological indicators, citizens in the sample only assessed one indicator, the moon phase.

A total of 219 indicators were recorded (Table 2). Each district has several indicators to monitor climate variability, ranging from 13 to 43. Biological indicators on the plant (including Fungi) and animal behavioral changes outnumbered other categories in all districts, accounting for an average of 35% for plant indicators and 43% for animal indicators. An analysis using the Kruskal-Wallis test revealed no significant differences in the indicator means between the districts at a 5% significance level (p=0.423).

The observed indicators are either general or site-specific. Site-specific indicators (31% of total indicators) are unique to their respective sites, whereas general indicators are applied in two or more districts. Examples of general indicators are the presence of water lilies or fish nests in canals, fungi on plants, frog sounds, walking beetles, flying yellow butterflies, and mating reptiles. Site-specific indicators are more nuanced than general indicators; examples are the saltiness and dirtiness of river water, timing- and intensity of rainfall, cloud cover, wind intensity, and air humidity. These nested indicators are used for assessing crop or livestock productivity, which Hatfield and colleagues (2020) also observed.

The data shows that district Sipaliwini has the highest number of site-specific indicators (47% of total district indicators) related to changes in animals, plants, rainfall/water levels/water quality, and air- and soil quality. This relatively high number underscores citizens' deep understanding of the complex natural system they navigate. Contrastingly, district Wanica relies mainly on general indicators (85%), representing citizens' general understanding of the natural rhythms of the surrounding ecosystem. All other districts record between 23-35% site-specific indicators.

More than half of the districts utilize a subset of indicators (8%) for detecting climate variability, making these indicators common (Annex 1). These general indicators includes plant indicators locally known as "gras/onkuid, tayer, verdorren bladeren, groenhart, manjaboom," and animal indicators locally known as "mier, muskiet, kikker, gele vlinder, leguaan, zwarte tor, houtluis, kwie kwie." Additionally, citizens utilize common meteorological indicators like rainfall intensity, wind strength, cloud cover, lightning, and thunder activity. The common indicators recorded in this sample may also be applied to the three remaining districts (Marowijne, Commewijne, Coronie), which were not part of this study. Further research is necessary to assess their application in these areas.

Table 2: General and site-specific indicators for climate variability in the study sites

District	General indicators	Site-specific indicators	Total
Paramaribo	17	7	24 (11%)
Wanica	28	5	33 (15%)
Para	27	11	38 (17%)
Saramacca	10	3	13 (6%)
Nickerie	20	9	29 (13%)
Brokopondo	26	13	39 (18%)
Sipaliwini	23	20	43 (20%)
Total	**151 (69%)**	**68 (31%)**	**219 (100%)**

A closer look at the data demonstrates differences in the spectrum of observed indicators between the study sites (Figure 2). The broadest spectrum is seen in district Para, covering all eight categories of indicators identified by citizens in the study. This district is distinguished by its population, primarily descendants of former plantation workers and small groups of indigenous peoples. Sipaliwini and Brokopondo districts incorporate nearly all indicator categories (7 out of 8) except sunlight/heat and soil indicators, respectively. This finding aligns with the expectation that these regions are home to indigenous and maroon communities with a robust traditional knowledge system due to their dependence on nature.

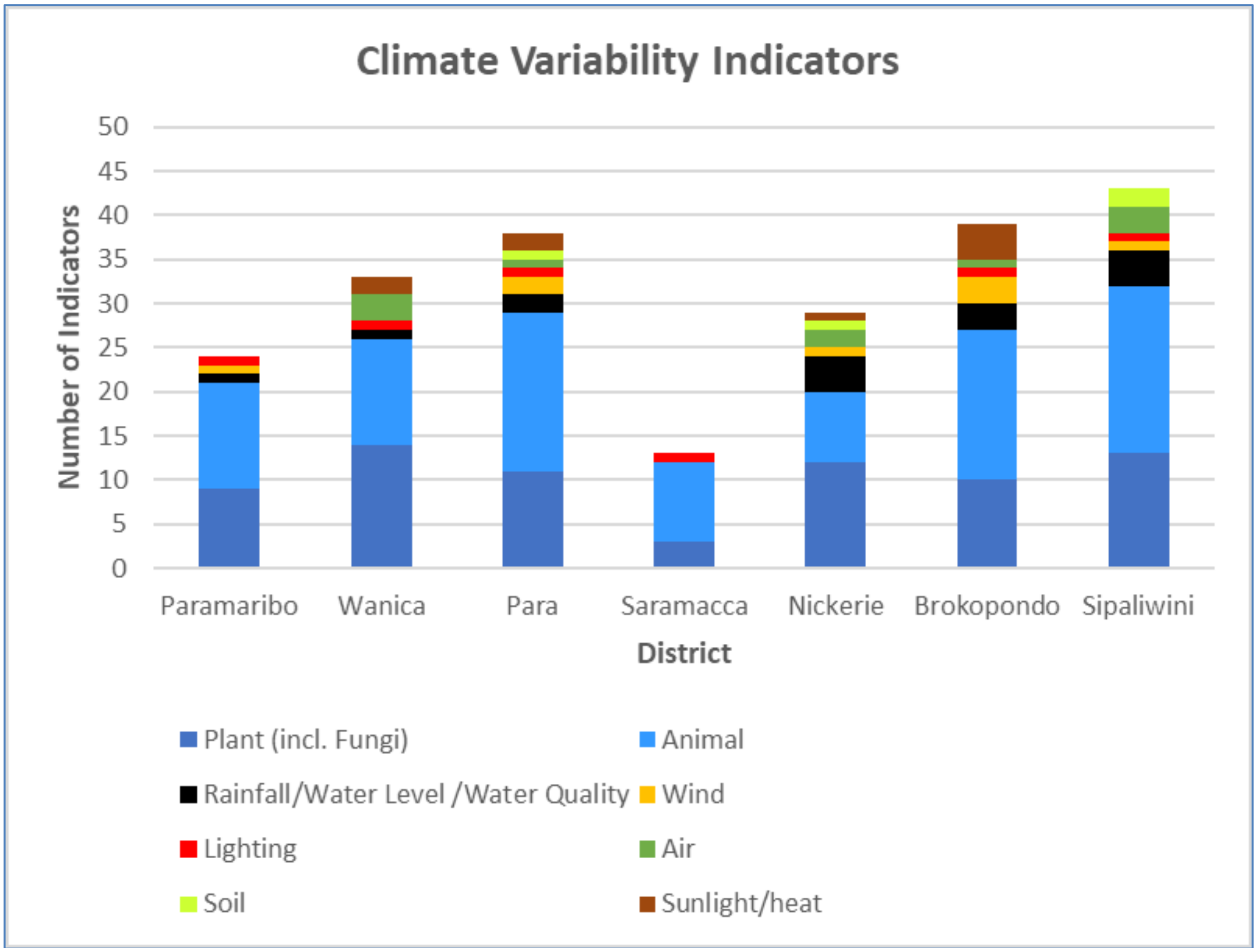

Figure 2: Observed indicators for climate variability in the various districts

In district Nickerie, citizens also detect changes in seven categories: sunlight/heat, air and soil quality, wind, rainfall/water level/water quality, and animal and plant phenology. It is worth noting that lightning indicators are absent in this district, primarily characterized by commercial rice cultivation and the relatively minor production of vegetables and fruits. A narrower set of indicators is seen in the district Wanica, home to a substantial rural population engaged in the commercial cultivation of vegetables and fruits and self-sufficiency in these agricultural activities, despite its official urban classification (ABS, 2023). Here, citizens detect six categories but exclude those for detecting changes in soil quality and wind patterns. Given the expected identification of soil and wind patterns in this rural district, conducting further research is crucial to enhance our understanding of this finding.

In district Paramaribo, housing the capital city, citizens often spend time in nature for relaxation and occasionally engage in subsistence fishing or planting activities. However, Paramaribo's residents utilize five categories of indicators, excluding those for detecting changes in sunlight/heat, air, and soil quality. The number of categories residents utilize is surprisingly high, given its urban nature and the relatively small area of natural areas, estimated at 9.7% of the total land area of 17,368 hectares (Taus, 2020). District Saramacca presents the most limited spectrum, with only three indicator categories detected: animal and plant phenology, and lightning. This rural district is heavily engaged in agricultural activities, and compared to other districts, the number of indicators is relatively low.

4.2 Seasonal Ecological Calendars

In this section, we will elucidate the changes indicators detect. The seasonal calendars presented here are unique to each site and reflect the dynamic relationship between people and their surrounding environment. All respondents in this study confirmed experiencing intra- and inter-annual climate variations and relying on indicators for navigating these changes. Scientific climate studies also confirm the increased nationwide climate variability (Government of Suriname, 2023; Solaun et al., 2023).

The seasonal calendars give an overview of changes at the onset, peak, and end of the rainy and dry seasons per district in Suriname (Figure 3a-g). The calendars document the specific action of each indicator, for example, indicators that fly, make noise, bloom, or ripen. When interpreting the seasonal calendars, it is crucial to understand that they represent the local citizens' spatial and temporal knowledge rather than fitting them within a frame of abstract science.

Often citizens possess practical indicators for sustaining their own livelihoods, such as assessing the ripening of dryland rice during the peak of the dry season. Indicators linked to local livelihood are generally less important to the scientific community than those associated with meteorological or environmental data. This popularity of meteorological and environmental indicators stems from their easy validation through comparison with scientific data (Ndjazi et al., 2021; Radeny et al., 2019; Yang et al., 2019). Our seasonal data was validated in the social mapping exercise, during which respondents (and their families) engaged in detailed discussions about the behavior of each indicator. Such collaboration promotes the validity of the seasonal calendars (Kassam et al., 2021).

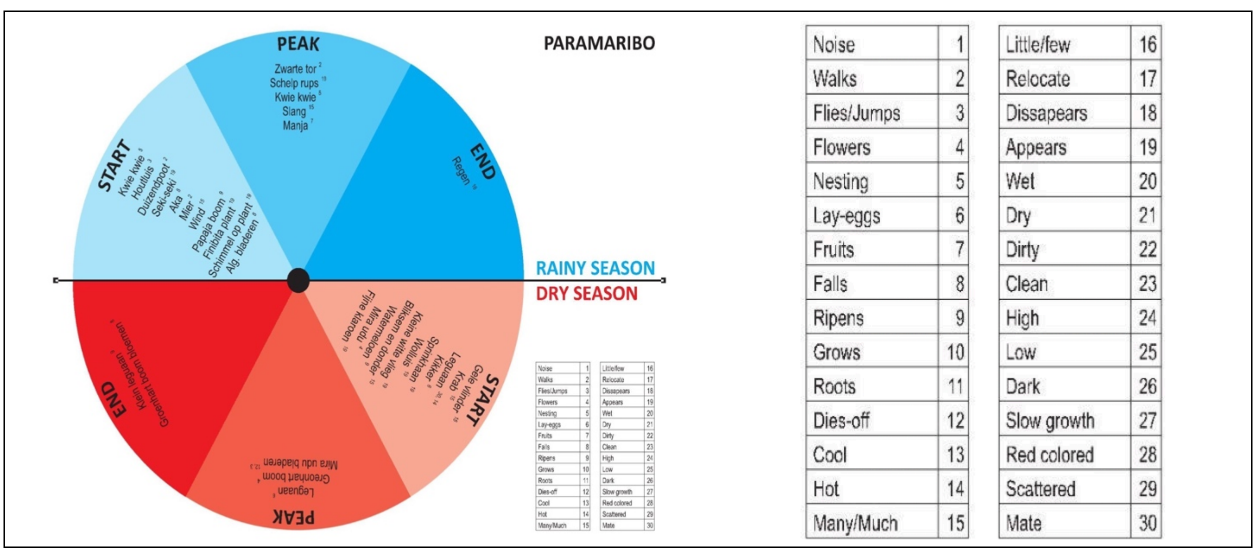

Figure 3-a: Seasonal calendar for district Paramaribo

Figure 3-b: Seasonal calendar for district Wanica

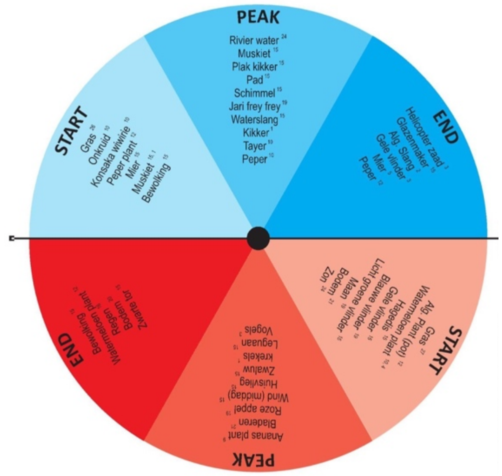

Figure 3-c: Seasonal calendar for district Para

Figure 3-d: Seasonal calendar for district Saramacca

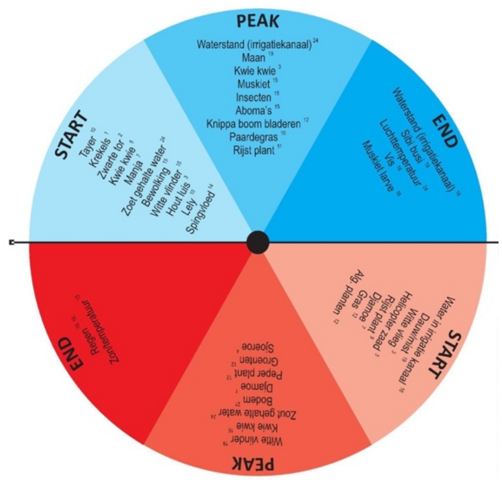

Figure 3-e: Seasonal calendar for district Nickerie

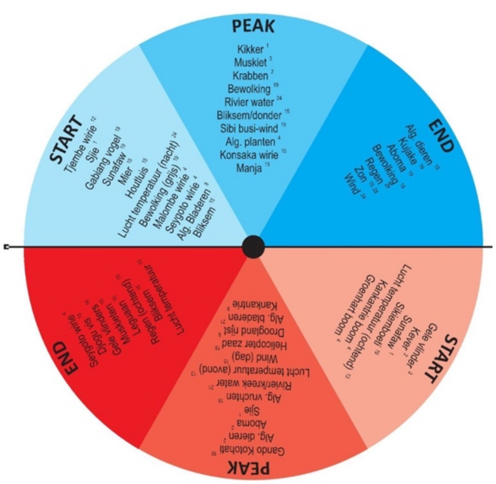

Figure 3-f: Seasonal calendar for district Brokopondo

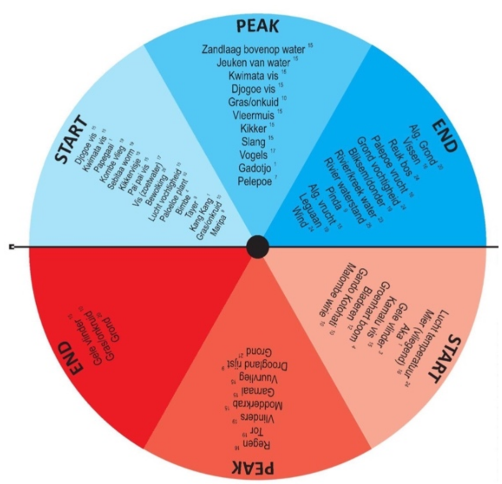

Figure 3-g: Seasonal calendar for district Sipaliwini

The calendars demonstrate that every district recorded at least one indicator for identifying the onset, peak, and end of the rainy and dry seasons. This result shows the extensive nature of the local knowledge system across all participating districts. While we expected this depth of knowledge to exist in the forested and rural districts, it is surprising to find such extensive systems in the urban districts of Paramaribo and Wanica. This finding suggests that a significant portion of Suriname citizens possess knowledge about nature and climate variability. A similar presence of substantial local knowledge was observed among citizens in Accra, an urban city in Ghana, where they utilized fauna, astrology, and sea indicators to detect climate variability (Codjoe et al., 2014).

5. Conclusion

The study revealed that citizens across all districts in Suriname possess an extensive body of local knowledge to detect climate variability, including biological, meteorological, environmental, and astrological indicators. This ethnoecological information intends to help citizens align their livelihoods with the rhythms of their environment. The strength of this knowledge body is particularly evident in the broad spectrum of indicators detecting changes in wind, lightning, plant- and animal phenology, rainfall and water levels, sunlight/heat, air- and soil quality. Also, the prevalence of phenological indicators in all districts affirms the strength of the knowledge base, as these indicators have consistently proven their reliability across different times and locations globally (Møller, 2015).

In addition to its robustness, the knowledge base shows a high level of specialization. Approximately one-third of the sample consists of site-specific indicators, which reflect nuance and detail, used by communities to detect climatic changes. Particularly within the forested districts of Brokopondo and Sipaliwini, local communities demonstrate a higher level of specialization in understanding the intricacies of nature than in the coastal districts. Furthermore, the level of specialization is evident in the completeness of the seasonal calendars: local communities recognize changes all year round - at the onset, peak, and end of the rainy and dry seasons.

We adopted a participatory methodology to gain a thorough understanding of the indicators and their effectiveness in detecting climate variability. This approach encouraged engagement from the respondents, many of whom were discussing climate variability and change for the first time. As local knowledge remains undervalued in the broader context of national adaptation efforts in Suriname (Government of Suriname, 2023), this discussion is important for complementing Western science with local knowledge. Increased collaboration between the two knowledge generation approaches would legitimize local knowledge, and motivate citizens to continue using indicators and calendars to observe and adapt to climate change using indicators and calendars. Such collaboration would enable the development of a citizen science network across the country, which can strengthen climate change policymaking.

Our study has several limitations that should be acknowledged. The study relies on people's perceptions, which are subjective and difficult to verify. To mitigate this, we conducted participatory social cartography, complementing data collected with the semi-structured survey. Additional data collection could involve a quantitative perception survey using predefined indicators extracted from this study. This method would allow data triangulation from three sources, successfully applied in a similar study conducted with the Trio indigenous community in South Suriname (Smith, 2013). Moreover, the study was conducted in seven out of the ten districts of Suriname, leaving out three coastal districts due to limited resources (Marowijne, Commewijne, Coronie). Future research should prioritize the inclusion of these remaining districts which would facilitate data comparison and the creation of a complete set of climate indicators across the country.

Climate-related changes are occurring at a rate that surpasses human adaptation capacities. Documentation of local knowledge is becoming critical because there is evidence that the pace of the ongoing changes is already disrupting traditional knowledge, leading to a decrease in confidence in the knowledge system (Jiri et al., 2015). The extensive knowledge system found across all districts proves to be a valuable resource in addressing the challenges posed by climate change, as it is already assisting people in adaptation. Local citizens can receive training and install software on their phones or tablets for documenting climate change indicators in their surroundings. Such efforts can assist policymakers in formulating action plans with the constraint of limited financial resources and institutional capacity in Suriname. It emerges as the most practical solution for rapidly combating climate change.

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Annex 1: Overview of climate variability indicators in various districts in Suriname. Bold names indicates common indicators

Indicator			**Location**						
Local Name	**Scientific Name/English Explanation**	**Type**	**PBM**	**WAN**	**PAR**	**SAR**	**NIC**	**BRO**	**SIP**
Biological Indicators									
Gras/onkruid	*Poaceae* spp.	Grass/Weed		X	X		X		X
Water lelie	*Nelumbo nucifera*	Plant		X	X		X		
Konsaka wiwirie	*Peperomia pellucida*	Plant		X	X			X	
Peper	*Capsicum* spp.	Plant			X		X		
Tayer	*Xanthosoma sagittifolium*	Plant		X	X		X		X
Schimmel op plant	*Colletotrichum* spp., *Dacrymyces* spp. found on plants	Fungi	X		X	X			
Helicopter zaad (Also Bosguave)	Seed of *Triplaris surinamensis*	Tree			X		X	X	
Watermeloen	*Citrullus lanatus, Citrullus vulgaris*	Plant	X		X				
Roze appel	*Syzygium samarangense*	Tree			X				
Ananas	*Ananas comosus*	Plant			X				
Bladeren	Plant leaves	Plant		X	X		X	X	X
Markoesa	*Passiflora edulis flavicarpa*	Plant				X			
Mira udu	*Triplaris weigeltiana*	Tree	X	X		X			
Batato bita	*Physalis surinamensis Miq.*	Plant		X					
Pritfinga	Fungi growth on humans hands and feet	Fungi		X					
Kouseband	*Vigna unguiculata ssp. sesquipedalis*	Plant		X					
Bimbe (also Gronposren)	*Portulaca oleracea* L.	Plant		X					X

Groenhart	*Tabebuia serratifolia*	Tree	X	X				X	X
Manja	*Mangifera indica*	Tree	X	X			X	X	
Sjoeroe (Also Redi Katoen)	*Gossypium barbadense*	Plant		X			X		
Kankantrie	*Ceiba pentandra*	Tree		X					
Rijst (nat)	*Oryza sativa*	Grass					X		
Paardegras	*Echinochloa stagnina*	Grass					X		
Knippa	*Melicoccus bijugatus*	Tree					X		
Djamoe	*Syzygium cumini*	Tree					X		
Finibita	*Phyllanthus amarus*	Plant	X						
Papaja	*Carica papaya* L.	Tree	X						
Maripa	*Attalea maripa*	Tree							X
Paloeloe	*Heliconia* spp.	Plant							X
Palepoe	*Bactris gasipaes*	Tree							X
Pinda	*Arachis hypogaea*	Plant							X
Gando Kotohati	*Peperomia pellucida*	Plant							X
Malombe wirie (Also Anesi wiwirie)	*Piper marginatum*	Plant						X	X
Rijst (droogland)	*Oryza* spp.	Plant						X	X
Tjembe wirie (also Merki wiwiri)	*Ephorbia thymifolia*	Plant						X	
Seygoto wirie (also Blaka uma)	*Struchium sparganophorum*	Plant						X	
Fijne Klaroen	*Amaranthus lividus*	Plant	X						
Seki seki	*Crotelaria* spp.	Plant	X						
Mier	*Formicidae* spp., *Atta* spp.	Ant	X	X	X	X		X	

Muskiet	*Culicidae* spp.	Musquito		X	X		X	X	
Plakkikker	*Pseudis paradoxa*	Frog			X				
Pad	*Rhinella marina*	Toad			X				
Jari frey frey	*Hodotermitidae* spp.	Termite		X	X				
Waterslang	*Helicops angulatus*	Snake		X	X				
Kikker	*Ranidae* spp.	Frog	X	X	X	X	X	X	X
Glazenmaker	*Perithemis lais*	Dragonfly		X	X	X			
Gele vlinder	*Phoebis sennae marcellina*	Butterfly	X	X	X	X			
Hagedis	*Ameiva ameiva*	Lizard			X				
Huisvlieg	*Musca domestica*	Fly			X				
Lichtgroene vlinder	*Gonepteryx rhamni*	Butterfly			X				
Blauwe vlinder	*Morpho menelaus*	Butterfly			X				
Krekel	*Gryllidae* spp.	Cricket			X		X		
Leguaan	*Iguana iguana*	Lizard	X		X			X	X
Vogels (algemeen)	Birds in general	Bird		X	X				X
Zwarte tor	*Tenebrio molitor*	Beetle	X	X	X		X		
Zwaluw	*Atticora melanoleuca*	Bird			X				
Kever	*Dynastes* spp., *Megasoma* spp.	Beetle				X		X	X
Houtluis	*Isoptera* spp.	Termite	X	X		X	X	X	
Kwie-kwie	Presence of nests. *Hoplosternum littorale*	Fish	X	X		X	X		
Vlieg	*Coleoptera* spp.	Fly				X			
Broko ston	*Lepiselaga crassipes*	Fly				X			

Pier	*Lumbricus terrestris*	Worm		X					
Witte vlinder	*Aleyrodida* spp.	Butterfly		X			X		
Vissen (algemeen)	Fish in general	Fish					X	X	
Aboma	*Eunectes murinus*	Snake					X		
Duizenpoot	Red-colored, *Chilopoda* spp.	Caterpillar	X						
Aka	*Herpetotheres cacbinnans*	Bird	X					X	X
Schelprups	*Lepidoptera* spp.	Caterpillar	X						
Krab	*Callinectes boucorti*	Crab	X						
Sprinkhaan	*Orthopteroida* spp.	Grashopper	X						
Djogoe	*Hemiodus unimaculatus*	Fish						X	X
Kwimata	*Prochilodus rubrotaeniatus*	Fish						X	X
Kang kang	*Heliotropium indicum*	Bird							X
Kombe vlieg	*Coleoptera* spp.	Insect							X
Sebitaa	Black with yellow stripes. *Lumbricidae* spp.	Worm							X
Vleermuis	*Desmodus rotundus*	Bat							X
Slang (algemeen)	Snakes in general	Snake			X				X
Papegaai	*Amazona amazonica*	Bird							X
Dier (algemeen)	Animals in general	Animal						X	X
Kumalu	*Myloplus rhomboidalis*	Fish							X
Modderkrab	*Brachyura* spp.	Crab							X
Garnaal	*Caridea* spp.	Shellfish							X
Vuurvlieg	*Coleoptera* spp.	Beetle							X

Sije	*Cicadidae* spp.	Insect						X	
Sonufaw (Also Rotshaan)	*Rupicola rupicola*	Bird						X	
Kujake	*Ramphastos toco*	Bird						X	
Pai Pai	*Ageneiosus marmoratus*	Fish							X
Sikiemboeti	*Cerambycidae* spp.	Beetle						X	
Gadotjo	*Troglodytes aedon*	Bird							X
Kikkervisje	Tadpoles from *Rhinella marina*	Frog							X
Meteorological and Environmental Indicators									
Waterstand	Water level	Rain			X		X	X	
Regen intensiteit	Rain intensity	Rain	X	X	X		X		X
Springvloed	High tide	Rain					X		
Zoutwater gehalte	Saltwater content	Rain					X		
Jeuken van water	Water itches on human body	Rain							X
Zandlaag bovenop water	Sandfilm located on top of water	Rain							X
Schoon water	Clear water	Rain							X
Verspreiding van regen	Spatial distribution of rainfall	Rain						X	
Frequentie van regen	Frequency of rainfall	Rain						X	
Winstoten	Wind gusts	Wind			X			X	
Wind (contant)	Continuous wind breeze	Wind	X		X			X	X
Sibi busi	Intense rain with wind gusts	Wind					X	X	
Bliksem en donder	Lightning and thunder	Lightning	X	X	X	X		X	X
Wolkbedekking	Cloud cover	Air							

Benauwdheid	Muggy	Air		X					
Dauw/mist	Dew/mist	Air					X		
Luchttemperatuur	Air temperature	Air							X
Luchtvochtigheid	Air moisture	Air							X
Bodemvochtigheid	Soil moisture	Soil			X				X
Bodemscheuren	Soil cracks	Soil					X		
Bodemtemperatuur	Soil temperature	Soil							X
Astrological Indicator									
Maanstand	Moon phase	Air		X	X			X	X

Legend
PBM= Paramaribo, WAN= Wanica, PAR= Para, SAR= Saramacca, NIC= Nickerie, BRO= Brokopondo, SIP= Sipaliwini