Local studies provide a global perspective of the impacts of climate change on Indigenous Peoples and local communities

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ANALYSIS

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Local studies provide a global perspective of the impacts of climate change on Indigenous Peoples and local communities

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Abstract

Indigenous Peoples and local communities with nature-dependent livelihoods are disproportionately affected by climate change impacts, but their experience, knowledge and needs receive inadequate attention in climate research and policy. Here, we discuss three key findings of a collaborative research consortium arising from the *Local Indicators of Climate Change Impacts* project. First, reports of environmental change by Indigenous Peoples and local communities provide holistic, relational, placed-based, culturally-grounded and multi-causal understandings of change, largely focused on processes and elements that are relevant to local livelihoods and cultures. These reports demonstrate that the impacts of climate change intersect with and exacerbate historical effects of socioeconomic and political marginalization. Second, drawing on rich bodies of inter-generational knowledge, Indigenous Peoples and local communities have developed context-specific responses to environmental change grounded in local resources and strategies that often absorb the impacts of multiple drivers of change. Indigenous Peoples and local communities adjust in diverse ways to impacts on their livelihoods, but the adoption of responses often comes at a significant cost due to economic, political, and socio-cultural barriers operating at societal, community, household, and individual levels. Finally, divergent understandings of change challenge generalizations in research examining the human dimensions of climate change. Evidence from Indigenous and local knowledge systems is context-dependent and not always aligned with scientific evidence. Exploring divergent understandings of the concept of change derived from different

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knowledge systems can yield new insights which may help prioritize research and policy actions to address local needs and priorities.

Science highlights

→Place-based communities provide holistic, culturally-grounded, and multi-causal reports of change.

→Place-based communities rely on local means to adapt to change, but implementing responses incurs costs.

→Local reports of change reveal grounded needs and interests that could guide research and policy action.

Policy and practice recommendations

→Recognize Indigenous Peoples and local communities as legitimate custodians of climate change knowledge.

→Uphold Indigenous Peoples' rights to participate in climate change decision-making.

→Adjust research to ensure that funding, timing and data ownership align with local needs and interests.

Keywords Indigenous and local knowledge, Climate change adaptation, Local adaptation, Multiple evidence based approach

Introduction

In scholarly and policy circles, there is growing recognition that climate change widely and directly impacts place-based communities (i.e., Indigenous Peoples (IP) and local communities (LC) with an historical relationship with their environment) [1, 2]. Scientific research on the topic addresses three important questions: 1) How do IP and LC experience, understand, and describe climate change impacts?; 2) How do IP and LC respond and adjust to climate change impacts?; and 3) How can IP and LC experiences, understandings, and responses to climate change impacts contribute to climate action?

Drawing on LICCI Consortium research, we present novel evidence to address these three questions. The LICCI Consortium is an epistemically, culturally and geographically diverse community of practice, including Indigenous and non-Indigenous scholars organized around the *Local Indicators of Climate Change Impacts* (LICCI) project. This project aimed to document IP and LC reports of environmental changes attributed to climate change impacts and bring this place-based information to climate change research and policy [3]. Over five years, consortium members collaboratively reviewed literature and collected field-based data from 52 sites in 35 countries (Fig. 1 and SM1), aiming to increase the transferability, integration, and scalability of Indigenous and local knowledge into climate change research and policy [3]. Collection of locally-relevant and cross-culturally comparable information following a standardized protocol [4] allowed us to identify common trends and context-specific singularities of individual sites, bringing novel insights into the three aforementioned questions.

How do Indigenous Peoples and local communities experience, understand and describe climate change impacts?

To answer this question, it is important to highlight that the human perceptibility of climate change has been often interrogated [6, 7]. Some scholars in disciplines such as environmental psychology have argued that climate change is undetectable to the lay observer and invisible to the naked eye [8, 9], or that local understandings of climate change are often the product of media exposure [10, 11]. The underlying argument is that the trends of climatic variability may be beyond the threshold of human perception over the course of a lifetime – at least without instrumental records [12, 13]. Anthropologists and ethnobiologists have fundamentally contested this idea arguing that climate change is not inherently visible or invisible, but rather made perceptible through its local impacts and/or external knowledge of it [14, 15].

This article aligns with this view, by considering local observations of climate change impacts as part of a larger system of knowledge, developed locally, passed down through generations, and integrating with both local values and information from external sources, as well as experiential and belief systems [16, 17]. Over the last two decades, numerous studies have provided insights into how IP and LC experience, understand, and describe climate change impacts (e.g., [2, 18]). While most studies have focused on atmospheric and physical changes (e.g., [19]), some have described impacts on wild (e.g., [20]) and managed biodiversity (e.g., [21]), food systems (e.g., [22]), and lived experiences of change (e.g., [23]). Our research extends previous studies in three ways.

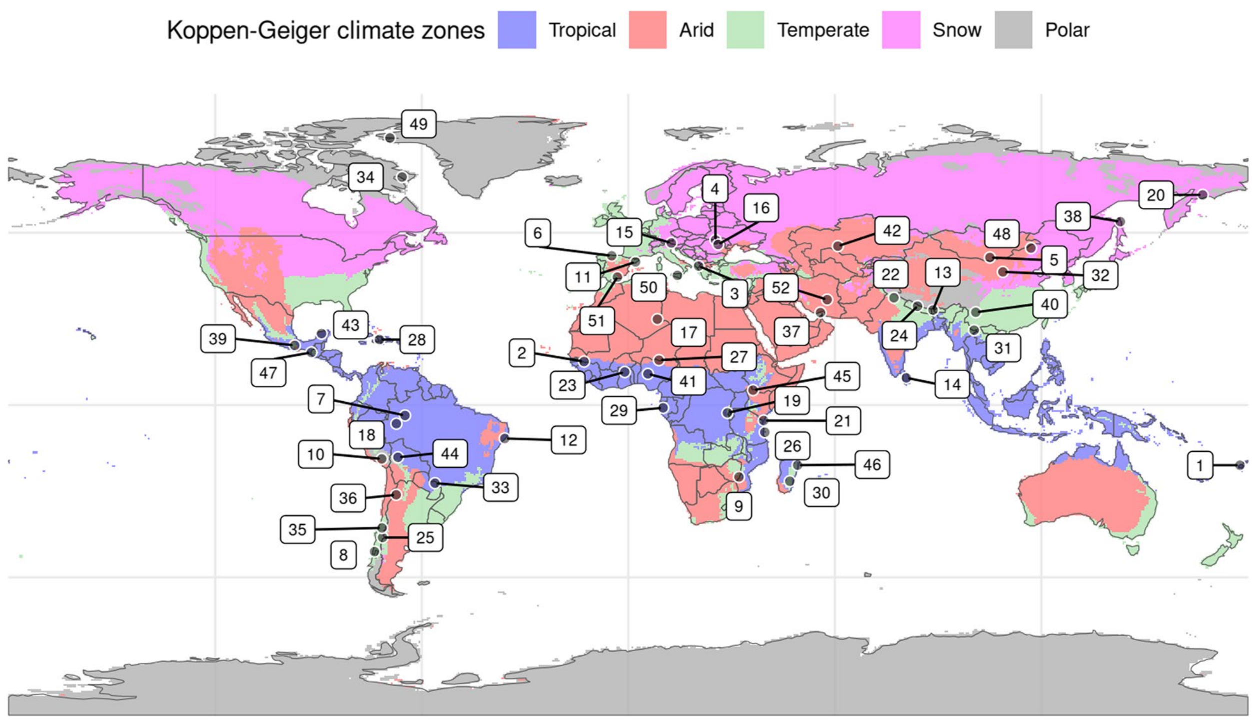

Fig. 1 LICCI field-sites geographical distribution by climate zones. Descriptions of the sites and references can be found in SM1. Climate zones adapted from the Köppen-Geiger climate classification [5]

Indigenous Peoples and local communities report numerous, ongoing, tangible, and situated climate change impacts and cascading effects

Consistent with previous work, we found that IP and LC report numerous observations of environmental changes that they entirely or partially attribute to changes in climate. IP and LC reports of change are extremely diverse, providing many place-based indicators of climate change impacts. The most frequently reported observations involve changes in the atmospheric system. This includes nuanced observations of changes in precipitation patterns (e.g., Site #16, #36), temperature (e.g., Sites #4; #48), wind direction (e.g., Site #49), fog (e.g., Site #19), weather predictability (e.g., Site #10), and seasonality (e.g., Sites #17; #20), which are often interlinked with other changes. For example, Dagomba farmers in Kumbungu (Ghana) attribute temperature increase to a warmer *Harmattan* (i.e., dry wind blowing from the Sahara) (Site #23) and Chilote farmers in the Chiloé archipelago (Chile) associate temperature increases with decreased precipitation and streamflow (Site #8).

Documented observations emphasize cascading effects of atmospheric changes on the physical system. Agropastoralists in Sierra Nevada (Spain) report that decreasing precipitation leads to reduced river discharge, fewer natural springs, decreased soil humidity, and increased soil erosion (Site #49). Similarly, *ribeirinhos* in the Juruá River (Brazil) associate precipitation changes with shifts in river dynamics, including alterations in flood duration and height, and sedimentation patterns (Site #18). Decreasing rain levels are associated with cascading effects on groundwater quality and levels (e.g., Sites #14, #36, #43).

Aligned with ecological research (e.g., [24, 25]), IP and LC emphasize cascading effects of changes in the atmospheric system on the life system. However, in contrast with ecological studies that primarily focus on modelling shifts in key species' distribution and populations [26], IP and LC reports concentrate on ongoing impacts on culturally-significant species. These reports include changes in abundance, phenology, and distribution of culturally-important wild plants, fish, and mammals, often overlooked by scientists [27, 28].

Our findings dovetail with research demonstrating substantial impacts of climate change on nature-based livelihood activities, like agriculture and livestock farming (e.g., [29]). We found changes in agricultural calendars (e.g., Sites #6; #10; #16) and livestock species behaviour (Site #49), decreases in crop productivity (e.g., Sites #9; #23), and increases in pest prevalence (e.g., Sites #23; #45). Bassari farmers in Southeast Senegal report reduced productivity of sorghum long-cycle landraces due to shortening of the rainy season (Site #2). Csángó farmers in Gyimes (Romania) report declining potato yield due to temperature-related pest infestations (Site #16).

Contrasting with research focusing on major crops [30, 31], IP and LC reports of impacts on nature-based livelihood activities include many culturally-valuable species. For example, Takab farmers in Kerman (Iran) report declines in the productivity of date palms due to drought and increasing soil erosion (Site #48) and Twa foragers in Kahuzi (DRC) report a decrease in edible caterpillars which they attribute to reduced rainfall (Site #19).

LICCI Consortium findings also echo previous work highlighting cascading impacts of climate change on cultural institutions, beliefs, and practices [32, 33]. Atmospheric changes, including warmer temperatures and unpredictable rainfall, not only impact groundwater levels and water quality in Yucatan (Mexico), but also impair ancient Mayan institutions regulating groundwater caves (*cenotes*), including the erosion of spiritual beliefs (Site #43). Climate change impacts on the ripening of grassland vegetation interrupt culturally-important communal haymaking events among Csángó farmers (Romania, Site #16). Other under-documented cascading effects of climate change on cultural institutions include changes in the use and relevance of folklore, poems, idioms, and anecdotes that forecast and inform weather patterns (e.g., Site #49).

Overall, we found IP and LC reports offer comprehensive and context-specific perspectives on change. These reports go beyond well-documented global trends, future modelling, and iconic species to provide a holistic, relational, placed-based, and culturally-grounded understanding of change, largely focusing on natural processes and elements relevant to local livelihoods and cultures.

Indigenous Peoples and local communities recognize climate change as one of several drivers of environmental change

Research increasingly recognizes that climate change not only affects IP and LC through direct impacts and cascading effects but also through synergistic interactions with other drivers of environmental change, such as land-use change or resource extraction [34]. Climate change impacts interact with historical influences of colonialism, inequality, and environmental injustices [35]. We found that IP and LC attribute environmental change to simultaneous drivers, among which climate change is only one and not necessarily the most significant [36]. Factors that exacerbate climate change impacts are context-specific, varying from extractive pressures (Sites #18; #36; #44) to economic development programs (Sites #2; #10; #23), infrastructure development (Sites #36; #45) and adverse state policies (Sites #3; #25; #40). For example, Daasanach agropastoralists in Ileret (Kenya) attribute water scarcity to the simultaneous effects of precipitation changes and the construction of large water infrastructure projects diverting water to agribusiness in Ethiopia (Site #45). Similarly, Kolla-Atacameños pastoral communities in the Dry Puna (Argentina) link the degradation of natural wetlands, essential for providing water and grazing resources (*vegas*), to precipitation reduction and economic activities associated with lithium mining (Site #36). For Koryak, Chukchi, and Even peoples in the Kamchatka Peninsula (Russia), climate change impacts are exacerbated by legacies of social transformation from the Soviet era and subsequent post-Soviet disruptions of the local economy (Site #20).

While culturally-grounded dimensions of change were not a central focus of our work, our findings dovetail with research showing that climate change impacts are often presented through cosmological explanations (e.g., [37]). We documented cosmological interpretations attributing environmental change to the destabilization of human relationships with the environment, often expressed through concerns regarding the loss of cultural and spiritual traditions and the increasing disregard for caring practices (e.g., Sites #2; #40; #43; #44; #52). Mapuche-Pehuenche spiritual authorities (Chile) report that the spirits that protect natural places (e.g., forests, trees, rivers) are leaving them, making people's spirits sick and increasingly disconnected from nature (Site #25). These perspectives align with the argument that an epistemic shift of societal paradigms and values is needed to address the ongoing environmental and climate crises [38].

Overall, LICCI Consortium research underscores IP and LC relational and multi-causal views of change combining observations of environmental change with socioeconomic, cultural, and political realities in which such observations are grounded. Such views emphasize that climate change impacts intersect with and exacerbate historical legacies of socioeconomic and political marginalization. IP and LC provide social-political views of environmental and climate change.

Indigenous Peoples and local communities' reports of environmental change are not uniform

IP and LC reports of change generally exhibit variations and are nuanced by their place-based, context-specific, and historically-situated nature. Beyond climate zones, our research shows that livelihood activities shape reports of impacts. In that sense, it is not surprising that, Inughuit communities from Qaanaaq (Greenland) highlight how decreased sea-ice duration affects fish species composition (Site #50), while Bassari communities (Senegal) focus on the impacts of soil erosion and flash floods on crops (Site #2). Farmers' and herders' reports frequently note changes in rainfall patterns (e.g., Site #41), whereas fishers report changes in winds, ocean currents, or sea-ice (e.g., Sites #14; #50). Other context-specific factors also shape reports. For example, in the Romanian Carpathian Mountains (Site #16), EU accession and out-migration of younger generations impacts landscape and vegetation. In the Eastern Himalayan mid-montane (Site #13) a rapidly expanding mountain tourism industry – partly driven by recent extreme summer temperatures in the plains – reduces villagers' commitment to mountain agriculture.

We also found that individual characteristics (e.g., age, gender, engagement with nature-dependant activities, or family history in the area) drive variation in reports of climate change impacts (e.g., Site #21, #30, #49). Betsileo men in Namoly valley (Madagascar) report changes in livestock, game species, and cash crops, while Betsileo women focus on changes in water provisioning, home gardens, and gathering of wild edible plants (Site #30). Swahili fisherwomen in the South Coast (Kenya), who—unlike men—mostly fish during the Southeast monsoon season, report more critical changes in air and sea temperatures than Swahili fishermen (Site #21).

Overall, LICCI Consortium research underscores the importance of community-level and individual-level factors on reports of climate change impacts. A comprehensive understanding of place-based changes requires engaging with diverse actors.

How do Indigenous Peoples and local communities respond and adjust to climate change impacts?

IP and LC history of engagement with the environment provides them with experiential knowledge in dealing with climate variability [39]. Drawing on these experiences, they have developed diverse place-based responses, which constitute a first line of action against climate change impacts. LICCI Consortium research yields three significant findings.

Indigenous and local knowledge systems enable context-specific responses to climate change impacts

Numerous authors note that IP and LC draw on their rich and extensive bodies of inter-generational knowledge to respond to change (e.g., [37, 39, 40]). Our research expands these findings, emphasizing that local responses to climate change impacts often rely on local resources and means, draw on local governance systems, and are contingent upon cultural preferences (e.g., Site #1, #25, #34). For example, to ensure food security after climate disasters, iTaukei fishers (Fiji) prioritise resource sharing, a culturally-based response (Site #1). Most responses to climate change impacts by Mapuche-Pehuenche communities (Chile) aim to support the continued practice of livestock farming, a culturally-relevant activity (Site #25).

Not all local responses draw on local knowledge or are locally developed. Responses such as introducing chemical fertilicers and pesticides, adopting hybrid varieties, or transitioning to off-farm work are commonly documented (e.g., Sites #2; #6; #9; #15). Dagomba farmers in northern Ghana report applying chemical fertilizers and changing to introduced crop varieties in response to higher rainfall variability and increased frequency of crop pests (Site #23). To overcome unexpected weather and navigational challenges, Inuit in the Baffin Island (Canada) have adopted new technologies for fishing and hunting (e.g., GPS, VHS radios, and advanced rifles) (Site #34). Smallholder farmers in the Darjeeling Himalaya (India) explore new markets for organic and traditional food products through online marketing (Site #13). Bridging insights from different knowledge systems can result in the development of new responses, although in many cases this potential remains untapped (e.g., [41]).

Our research shows that local responses often address the combined impacts of multiple drivers of change, rather than exclusively targeting climate change. Sherpa, Rai, Gurung, and Tamang farmers in Darjeeling (India) make alternate crop choices in response to increasing crop depredation from wild animal herbivores, which may be linked to climate changes (Site #13). Participatory, bottom-up responses have proven valuable in managing multiple stressors. For example, among Inuit fishers (Canada) co-management practices respond to climate change and enhance overall resilience by improving food security, fostering social learning and co-producing knowledge (Site #34). Weaving such responses into adaptation policy could result in more locally-relevant action plans addressing multiple stressors.

Responses by Indigenous Peoples and local communities to climate change impacts are diverse, but costly

The literature notes that most adaptation strategies led by IP and LC consist of relatively subtle, incremental adjustments to existing and familiar practices [42]. Yet, the unprecedented speed, magnitude, and complex nature of climate change impacts are also leading to transformational responses, involving fundamentally new combinations of livelihood elements, or deeper changes, such as migration to urban areas.

Our work reveals that while incremental responses are most common [43], transformational responses are widespread across different geographical areas and livelihood activities [44]. Documented incremental responses include, for example, adjustments to farming system diversification (e.g., Sites #7; #10; #39). Csángó farmers (Romania) adjust their mowing, sowing, and harvesting practices to adapt to unpredictable weather (Site #16). Bassari people (Senegal) rely on different landscape uses and crop diversity to cope with drought and climate variability (Site #2). Incremental responses also extend to actions not directly linked to nature-based activities, like community networking and food sharing (Site #1). Takab women (Iran) have taken on leadership roles to strengthen traditional water infrastructure and governance and have built greater autonomy by further diversifying incomes (Site #48). Transformational responses often involve trends towards off-farm work and outmigration. In Eastern Tyrol (Austria) and in Eastern Himalaya (India), synergistic climatic and socio-economic factors pressure farmers to accept off-farm work, reducing agricultural labour force and leading to land abandonment (Sites #13; #15).

Our research highlights that regardless of whether responses are incremental or transformational, they imply costs that may destabilize IP and LC long-standing relations with surrounding landscapes [44]. For example, due to changes in Caribou migration driven by climatic changes, Inuit fishers (Canada) are transitioning to livelihoods less reliant on nature. This results in a decline in traditional activities, higher market dependency, and loss of culture, tradition, and social bonding (Site #34). Thus, LICCI Consortium research emphasizes that the range of livelihood adjustments made by IP and LC incur costs that should inform loss and damage compensation efforts.

Indigenous Peoples' and local communities' response adoption depends on political, economic and socio-cultural contexts

Research shows that IP and LC encounter multiple challenges in implementing adaptive responses [45, 46], a recurrent finding in our field sites (e.g., Sites #10; #23; #25). Among farmers in Benin, gender, age, farm size and ownership, and access to labour and information are significant determinants of the adoption of climate-smart agricultural technologies [47]. Insufficient financial means prevent Dagomba farmers (Ghana) from switching to climate-resilient crop varieties or building rain-harvesting infrastructure (Site #23). These constraints are often rooted in past and present situations of discrimination and marginalisation [48]. For example, political marginalization inherited from colonial times and persistent socio-economic inequalities limit Mapuche-Pehuenche (Chile) in their access to resources and hamper community responses (Site #25). This, in turn, leads to maladaptive practices, such as selling young animals before they reach an optimal market price, that further increase their dependence on external support and globalized markets.

Response adoption is also shaped by culture. Traditional norms, protocols, and customs may boost or hinder adaptation processes [49, 50]. Spiritual knowledge and values can promote community-based adaptation. The Ovoo offering ritual practised by Inner Mongolian herders (China) aims to protect their communities from environmental hazards and misfortunes (Site #52). In contrast, some Daasanach agropastoralists (Kenya) are unwilling to switch to unfamiliar livelihoods or change their diets towards foods that are not part of the traditional foodscape (Site #45). Traditional gender roles hamper iTaukei (Fiji) women's participation in village governance and decision making (Site #1).

Constraints to response adoption also operate at community and household levels. At the community level, large-scale demographic changes can hamper adaptation processes. The decline in rural population due to rural out-migration in Eastern Tyrol (Austria) leads to workforce shortages, hampering the transformational adaptation needed to revive communal traditional land management practices (Site #15).

Low uptake has been observed when adaptation measures are introduced without considering the local socio-cultural context, whereas cooperation and respectful partnership between communities, governments, and the private sector are associated with higher uptake [40]. For instance, Inuit communities (Canada) report that co-management of fisheries by Indigenous Peoples, private and government institutions can enhance climate resilience through shared responsibility, knowledge, and decision-making (Site #34). In Shangri-la (China), government investments in new road infrastructure and the use of common lands for ecotourism provide Tibetan agropastoralists with new opportunities to diversify their livelihoods and income (Site #40).

Overall, LICCI Consortium findings emphasise the ways political, economic, and socio-cultural contexts steer and shape response adoption. Decision-making processes and responses will benefit from understanding how these elements interact.

How can Indigenous Peoples and local communities' experiences, understandings and responses to climate change impacts contribute to climate action?

Indigenous knowledge (IK) and local knowledge (LK) systems are increasingly recognized for their contribution to understanding environmental change [1, 51]. As a result, there have been multiple attempts to bring together different knowledge systems (e.g., [52–54]). However, not all these efforts directly serve the interests of IP and/or LC [55]. The work of the LICCI Consortium offers three novel reflections.

Indigenous Peoples' and local communities' conceptualizations of climate change often differ from scientific conceptualizations

Many authors have discussed differences and similarities among knowledge systems, with growing recognition of the profound ontological and epistemological differences in the ways climate change impacts and responses are perceived and understood [56]. In fact, most Indigenous languages lack a direct translation of terms such as 'climate' or 'change' [57]. An illustrative example is the Inuit term *sila*, which some researchers equate to "weather". Inuk author Rachel Qitsualik explains the complex meaning of *sila*, a term that connects life, climate, knowledge, and the essence of existence, proposing that it would be better translated as the "spirit of the air", the "mystic power which permeates all of existence", or "a god-like Supreme being" (in [58] p. 237). The lack of direct translations reflects deep ontological differences. Non-Western societies often perceive the world as dynamic, acknowledging long cycles of change passed down through oral tradition across generations. This has significant implications for understanding climate change [37]. Quechua farmers (Bolivia) perceive climate change as part of a larger cycle, thus incorporating notions of ancient eras and mythical references deeply rooted in the historical and cultural context of the Andean region [59].

IP and LC experiences of changes in their climate and environment are not necessarily or uniquely attributed to anthropogenic climate change. These changes may be driven by agents or objects unrecognized by scientific frameworks (e.g., [60]), as is supported by LICCI Consortium findings (e.g., Sites #2; #25; #44). The Tsimane' people (Bolivia) report that disrespectful behaviour towards the guardian spirits of nature generates their anger and punishment, resulting in environmental change (Site #44). Bassari people (Senegal) attribute unpredictability and shortening of the rainy season to the abandonment of the rainmaking rituals (Site #2). While attributing change to divine agents or objects may be seen to shift the responsibility away from humans, it can also highlight the lack of stewardship resulting from human destruction of nature [61].

Divergent cosmologies and understandings of change highlight the challenges of conducting climate change research involving different knowledge systems (e.g., [62]). Previous work has often relied on the problematic assumption that specific aspects of Indigenous and local knowledge systems can be isolated, documented, categorized, and "integrated" into mainstream science, ignoring their own internal validation processes [63]. Critical researchers argue for the need to situate knowledge production, recognizing the existence of diverse knowledge systems, while acknowledging power inequalities within these systems [64, 65]. By involving diverse expertise, knowledge, and actors, knowledge co-production is crucial for tackling climate change impacts and, more generally, within sustainability research. In this line, such knowledge co-production should be context-specific pluralistic -recognizing the multiplicity of knowledge and worldview, articulated around defined and shared goals through an interactive approach with all the actors involved [66]. When working with IP and LC, this requires decolonizing research processes, building respectful partnerships among knowledge systems, and radically transforming the dynamics between them, acknowledging knowledge-holders' primary responsibilities to their communities [53, 67].

Understandings of climate change impacts derived from different knowledge systems do not always overlap

The LICCI Consortium adopted the Multiple Evidence Based approach as a conceptual framework for connecting information derived from different knowledge systems respectfully, equitably, and transparently [52]. This approach suggests that complementarities and mismatches between different knowledge systems may provide complementary evidence, generating a nuanced picture of reality. Our research provides instances of agreements and divergences among knowledge systems. Hutsul agro-pastoralists in Bukovina (Romania) report changes in temperature and in seasonal events that mostly overlap with records from the closest meteorological station (Site #4). Koryaks, Chukchi, and Even people (Russia) report increasing frequency of "rain-on-snow" events and changes in seasonality as indicated by river ice, closely matching scientific evidence (Site #20). In contrast, reports of Mongolian herders in Bulgan soum (Mongolia) show differences from meteorological station records, arguably because the field site was located 500 m higher in elevation and over 60 km away from the closest meteorological station (Site #5). Similarly, Ghana meteorological agency weather stations report a higher number of observed rainy days over Kumbungu district than do Dagomba farmers' reports, arguably due to the sensitivity of meteorological instruments (Site #23).

Investigating disparities in reports stemming from distinct knowledge systems can unearth fresh insights into change, potentially guiding the prioritization of research efforts aligned with local needs. IP and LC often highlight elements that directly impact their livelihoods, which might be overlooked by scientists. This divergence could explain why climatic models for the Juruá River (Brazil) present inconclusive or conflicting precipitation trends, in contrast to local knowledge that underscores a wetter summer despite unmeasurable precipitation changes (Site #18). The divergence might also stem from differences in spatial and temporal scales; global models frequently encompass broader areas and extended timeframes compared to the localized experiences and historical recollections upon which IP and LC reports rely (Sites #7, #17, #44). For instance, while seasonal activities of the Tuareg of Illizi (Algeria) are aligned with instrumental records, their recognition of climate change lacks explicit acknowledgement of multi-decadal trends, possibly affecting their adaptation efforts (Site #17).

Current research practices often fail to uphold Indigenous and local knowledge systems and overlook the environmental impacts of research

Research requires self-reflection—continuous assessment, evaluation, and learning—to avoid deviating from overarching goals and perpetuating inequalities. Research processes must constantly reorient towards the desired trajectory [63, 68]. Within this self-reflective lens, we report three additional learnings and adjustments made by the LICCI Consortium to better serve community interests and the broader goals of social and environmental justice.

First, LICCI Consortium members noted a mismatch between the project's research goals and its research strategies that privileged colonial norms and standards, entrenching power dynamics set by professional researchers. Such strategies could overlook local protocols and hinder the co-construction of new knowledge [69, 70]. We consequently requested additional funding to enhance our partnership with Indigenous organizations and make our research more relevant and accessible to communities. This resulted in the creation of Oblo data collection platforms inspired by LICCI research but that ultimately placed community priorities at the centre of the tool's design with academic research priorities in the periphery.

Second, LICCI Consortium members noted a discrepancy between the project's goals and the adoption of standard scientific data management practices that could result in the misappropriation and misrepresentation of IK and LK systems [71]. We therefore pursued additional funding to better align LICCI research with Indigenous data sovereignty and governance principles [72, 73]. This led to the creation of a toolkit which offers various mechanisms, including retrospectively applying Traditional Knowledge and Biocultural Labels and Notices [74] to existing LICCI data.

Third, LICCI Consortium members identified divergence between the project's goals and the environmental impact of research activities, which ultimately aggravate climate change impacts among IP and LC. We therefore evaluated the carbon impact of research activities conducted during the initial phase of the LICCI project [75]. Results were discussed and used to develop a strategy to minimize the carbon impact of future research activities. This formed the basis for a wider set of Responsible Travel Policies adopted by the host institute.

Conclusion

Indigenous Peoples and local communities hold extensive, complex, and rich bodies of knowledge and deep-rooted understandings of climate and environmental change. This knowledge often informs their immediate response strategies. However, such knowledge is systematically overlooked in climate research and policy, which do not acknowledge the independence and validity of Indigenous and local knowledge. LICCI Consortium findings highlight the urgent need to recognize Indigenous Peoples and local communities as legitimate custodians of critically-important knowledge regarding climate change and its impacts. They should be acknowledged as key rights-holders to participate in and contribute to climate change decision-making at local and international levels. Considering the great diversity of socio-environmental contexts in which Indigenous Peoples and local communities live, we emphasize that any policy recommendations need to be carefully contextualized and co-created with local stakeholders.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s42055-023-00063-6.

Additional file 1. SM1.

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Authors' contributions

VRG conceptualized the paper, supervised the project, and wrote the first draft of the manuscript. DGA, APF, and AS conducted a case study and were major contributors in writing the first draft of the manuscript. MA, EA, JA, AA, DB, PB, LCM, RC, JC, JCh, RCh, ACS, AFL, EG, DG, SG, TH, JI, AJ, XL, YLM, GM, AS, CS, RS, VS, PS, ATN, and MTT contributed data through a case study or the review of the literature, and reviewed and edited the first draft of the manuscript. VRG, SG, and RS edited the final draft of the manuscript. Members of the LICCI Consortium contributed data through a study site or the review of the literature. All authors read and approved the final manuscript.

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Availability of data and materials
The analysis presented here is based on multiple case studies from the LICCI project. Datasets from the LICCI project are embargoed until June 2024. After that date, datasets will be freely available at https://dataverse.csuc.cat/dataverse/licci. Before the date, the datasets are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The Ethics Committee of the Universitat Autònoma de Barcelona approved the research protocol used in this project (CEEAH 4781). Before data collection started, we obtained permits from local authorities in each site to conduct research, as well as the Free Prior Informed Consent of all participants. Where necessary, we also obtained authorizations from national ethics committees.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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