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ORIGINAL ARTICLE

"We cannot escape this": discussing leverage points for sustainability across scales with the example of Ouvéa, Kanaky New Caledonia

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Abstract

Despite contributing minimally to global greenhouse gas emissions, Pacific Island Countries and Territories often shoulder an unequal burden of climate risks. To analyse pathways to sustainability, we conducted a leverage points analysis on the complex sustainability challenges facing the low-lying atoll Ouvéa in Kanaky New Caledonia (France). Leverage points are places within complex systems where interventions can lead to transformative change. Combining a literature review and qualitative interviews with regional, government, provincial, and local stakeholders, we contextualised eight leverage points: (1) expanding and improving coastal protection, (2) strengthening or creating monetary incentives, funding possibilities or forms of compensation to alleviate costs of climate change adaptation and sustainability measures, (3) conducting more research and monitoring, (4) strengthening environmental regulation and restrictions, (5) empowerment of women, youth, and local communities and increasing awareness of power imbalances to strengthen gender equity and social inclusion, (6) establishing new conservation management measures and improving existing ones, (7) increasing institutionalisation of environmental and climate change education, and (8) involving diverse knowledge systems and practices in research and management to strengthen participatory, transdisciplinary, and community-based initiatives. Our results emphasise the importance of acknowledging responsibilities across multiple scales, showing the non-transferability of some interventions due to perceived high costs and incompatibility with local culture. Illustrating dimensions of ocean equity in the context of Ouvéa, we discuss the importance of local values and knowledge systems to ensure fair distribution of costs and benefits in sustainability interventions.

Keywords Equity · Marine social science · Ocean Decade · Oceania · Pacific Island States and Territories · Sustainable development goals

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Introduction

Critical tipping points and planetary boundaries have been crossed due to the immense pressure human activities exert on the environment (Steffen et al. 2018; Richardson et al. 2023). The consequences of surpassing these tipping points can lead to long-lasting and potentially irreversible alterations of social-ecological systems over extended periods, as systems may become "locked-in" to alternate states where unsustainable dynamics becomes self-reinforcing (Cooley et al. 2022). The escalating human impact on the environment necessitates immediate attention to transform social-ecological systems to sustainable states.

Research on actions to counter sustainability challenges have been increasing over past decades, and yet many system trajectories remain unaltered (Abram et al. 2019). Deliberate human interventions targeting sustainability within specific systems can, on the one hand, inadvertently lead to maladaptation (i.e. actions intended to mitigate vulnerability end up exacerbating the vulnerability of systems, sectors, or social groups) (Magnan et al. 2016), and, on the other hand, potentially only scratch the surface without leading to meaningful and transformative change (Meadows 1999). To analyse existing interventions for their transformative potential, the use of a leverage points perspective has been suggested (Fischer and Riechers 2019). Leverage points represent places within complex systems where interventions can lead to transformative, system-wide change (Meadows 1999). These leverage points are classified into shallow (parameters, feedbacks) and deep (design, intent) leverage points, with the deeper ones having a more profound capacity to reshape systems. Abson et al. (2017) classified the 12 leverage points named by Meadows (1999) into four characteristics of a system. These four system characteristics are (1) parameters, which are the relatively mechanistic characteristics such as subsidies or taxes typically targeted by policy makers, and (2) feedbacks, which are the interactions between elements within a system of interests that drive internal dynamics. System characteristics with a higher transformative potential encompass (3) system designs, i.e. the social structures and institutions that manage feedbacks and parameters and (4) system intents, i.e. the underpinning values, goals, and worldviews of actors that shape the emergent direction to which a system is oriented. These system characteristics are intertwined and hierarchical. For example, if the intent of the system is changed, it will affect the structures, rules, delays, and parameters of the system. The leverage point perspective has been adopted by IPBES (Chan et al. 2020) and has also seen a recent increase in sustainability literature (Korhonen-Kurki et al. 2024). This includes a vast number of empirical applications (Rölfer et al. 2022; Shumi et al. 2023) and conceptual discussions (Riechers et al. 2022; Kosanic et al. 2023).

The (political) agency of actors to intervene in leverage points, however, needs to include discussions of responsibility across scales. This rings especially true for climate change, as it has been conceptualised as a form and a product of colonialisation (Gram-Hanssen et al. 2021), with national governments being detached from local needs (Jiren et al. 2021), and may lack integration of local knowledge systems in decision-making processes (Tengö et al. 2014). When discussing the transformative potential of interventions, research needs to consider historical socio-economic and cultural backgrounds and current developments of the places to be transformed to prevent maladaptation (Leach et al. 2018). To further the discussion on the scales of sustainability interventions, in this article, we apply the leverage point perspective on the sustainability challenges faced by Ouvéa, a low-lying atoll of Kanaky New Caledonia[1] (France, South Pacific). Based on a systematic literature review and a case study approach, we aim to (i) highlight potential leverage points for sustainability transformation, (ii) analyse perceptions of responsibility across scales to act upon the leverage points, and (iii) present which factors are hindering the implementation of interventions/actions.

The effects and burdens of crossing planetary boundaries are disproportionately felt across scales by communities which are least responsible but highly vulnerable to them (Oppenheimer et al. 2019). One example is Small Island Developing States (SIDS), which are located around the globe in the Caribbean, the Pacific, and the Atlantic, Indian Ocean, and South China Sea. The aggregate population of SIDS are 65 million (~ 1% of the world's population) (UN 2024), and this diverse group faces unique social, economic, and environmental challenges and ecological injustices, due to factors such as limited land mass, susceptibility to natural hazards, physical isolation, and high adaptation costs relative to their GDP (Beyerl et al. 2018; Mycoo et al. 2023). Another example is the Pacific Island Countries and Territories (PICTs), where multiple climatic, social, and economic tipping points have already been passed (Cooley et al. 2022; but also Persson et al. 2022). Focusing on Kanaky New Caledonia, where indigenous perspectives have been discussed and incorporated into political agreements designed to accompany negotiated decolonisation, can provide insights into meaningful

[1] While both "New Caledonia" and "Kanaky" are used in reference to the archipelago, Kanaky New Caledonia has gained prominence in the international press since May 2024, becoming the preferred designation. "New Caledonia is the official name, dating back to James Cook and his crew who named it in 1774 [..] For most Indigenous Kanak peoples, the country is called "Kanaky"" (Batterbury and Kowasch 2024: 3).

solutions for sustaining coastal ecosystems and the communities that depend on them.

Methods

Study area

Kanaky New Caledonia is an autonomous local authority within the French Republic, with its own territorial government, congress, and provincial assemblies (David and David 2019). Located in the South Pacific Region, Kanaky New Caledonia is home to many marine and coastal ecosystems as well as biodiversity hotspots with a considerable number of endemic species (Roberts et al. 2002; Payri and de Forges 2006; Payri et al. 2019). After colonisation and Christianisation in the eighteenth century, the *Indigénat* period, which lasted until 1946, and a period of significant unrest, known as "the Events" from 1984 to 1988, Kanaky New Caledonia began a long process of gradual and negotiated decolonisation, enshrined in the Matignon-Oudinot (1988) and Nouméa (1998) Agreements (Légifrance 2018). These agreements set out a path towards a gradual transfer of competences and self-determination referendums. The first inhabitants of the archipelago, the Kanak, constitute almost 40% of the population (INSEE 2022) and their conceptions of the world differ in parts from Western worldviews. In Kanak culture, humans are seen as part of the ecosystem in which they live, with a duty to take care of their places, land/country (incl. the ocean), and the diversity of lives who evolve in it (Tjibaou and Guiart 1976; Tjibaou 1996; Sabinot and Bernard 2016). The preservation of cultural heritage and nature is an integral part of the societal structure, passed down through generations through oral history and still plays a central role today (e.g. Long 2017; Sabinot and Herrenschmidt 2020).

Ouvéa (*Iaai*) is a low-lying atoll island located 90 km northeast of Grande Terre (the mainland) of Kanaky New Caledonia (Le Duff et al. 2017). Ouvéa has an average elevation at 2 m with numerous infrastructures built below 2 m, making them particularly vulnerable to climate-related submersion events, including major storm surges (Le Duff et al. 2020). Ouvéa holds diverse ecosystems, and its lagoon was designated as a UNESCO World Heritage site in 2008 (UNESCO 2023). Ouvéa belongs to the Loyalty Islands Province and has a population of about 3400 habitants, mainly Kanak (INSEE 2022). The French state transferred a number of its responsibilities to each province, including environmental management. In addition to the Indigenous languages Iaai and Faga-uvea (two among 28 Kanak languages), French is spoken on the island. Ouvéa is organised into three customary districts: Saint-Joseph, Fayaoué, and Mouli. Each district features a chiefdom that plays a crucial role in managing the environment. Decisions related to management can be debated and made at the clan, tribe,[2] district, or island-wide levels. Decision-making processes often involve customary chieftaincies, municipalities, and provincial authorities (Fig. 1).

Initial literature review

We conducted an initial systematic literature review on scientific articles in English and French languages, providing scientific perspectives on coastal sustainability transformation. The review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) system (Moher et al. 2009). The Scopus database (www.scopus.com) was searched using a search string to identify relevant peer-reviewed empirical articles (meaning those that collected original data). The search string consisted of different sections with the broad topics of sustainability transformation, social, ecological, and economic sustainability and coastal ecosystems in Fiji, Kanaky New Caledonia, or the South Pacific Region in general. The search string and the full list of articles can be found in the supplementary material 1 (Tables S1 and S3). The search string was constructed through discussions in the project "Pacific Ocean Pathways in support of sustainable development" (PACPATH). The literature was limited to articles published between 2015 and 2022, as 2015 was the year of the publication of the UN Sustainable Development Goals. A total of 599 papers were identified using the search string. After screening, 476 papers were excluded based the exclusion criteria (see supplementary 1). The remaining 123 papers were used for data analysis (see Fig. S1). Data analysis of the systematic literature review followed a qualitative content analysis according to Mayring (2008) using a deductive coding scheme (Table S2) that was developed based on discussion in the PACPATH project.

Triangulation through grey literature and workshop

The literature review encompassed 24 articles concerning Kanaky New Caledonia. To have a better understanding on the relevance of the 16 leverage points extracted from the literature review for Ouvéa, we supplemented and triangulated our results from the literature review with workshop insights, and additional (grey) literature on Ouvéa specifically (Fig. 2). The workshop was held by the PACPATH project with 58 participants over 3 days to identify the main threats and values around coastal and marine sustainability in Fiji and Kanaky New Caledonia (conducted in Nouméa,

[2] A tribe is a Kanak community living on customary land which can comprise one or several clans (Batterbury and Kowasch M 2024).

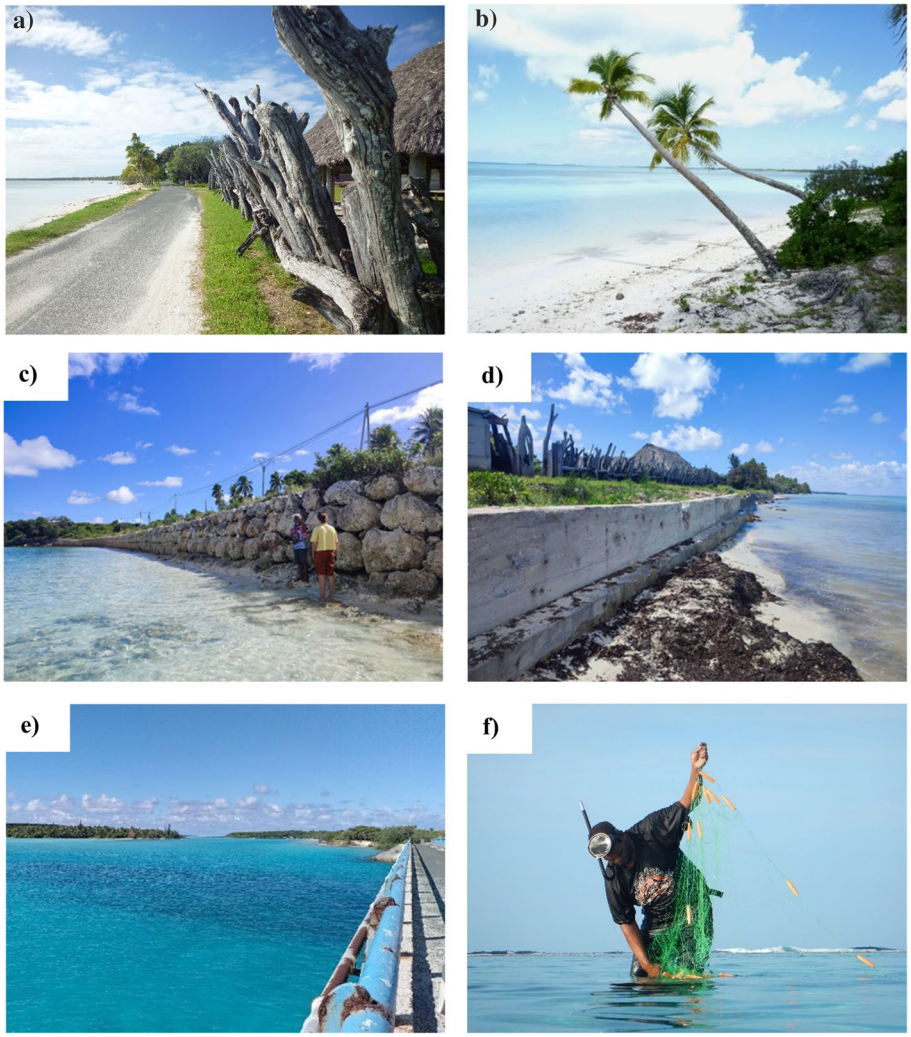

Fig. 1 Sustainability challenges at the low-lying atoll of Ouvéa in Kanaky New Caledonia in the South Pacific. **a**, **b** Signs of coastal erosion; **c**, **d** shore lines with seawalls; **e** Ouvéa's coastline; **f** coastal fishing. Sources: Lilly Baumann (**b**, **c**, **d**); Valentine Boudjema (**a**, **f**); Alexandre Ganachaud (**e**)

Kanaky New Caledonia, October 2022, with multiple stakeholders of Ouvéa present). For a better understanding of the transdisciplinary process, the workshop, and this research, see Riechers et al. (2024). Through these approaches, we synthesised and prioritised eight leverage points for our empirical work in the social-ecological case study of Ouvéa (Fig. 3).

Social-ecological case study: Ouvéa, Kanaky New Caledonia

To contextualise the eight leverage points with a focus on responsibility across scales, we conducted qualitative semi-structured expert interviews (Flick 2006; Meuser and Nagel 2010). Interviews were performed in December 2022 ($N = 13$ interviews with 16 experts). Experts were defined as persons with vast knowledge on a specific field and are able to speak from a specific stakeholder perspective. We included experts from different scales: from Ouvéa, the Loyalty Islands Province, Kanaky New Caledonia, and the South Pacific Region as a whole (Fig. 2). Ouvéan experts were selected in collaboration with a local contact. These interviews were conducted in French. Regional experts were selected in accordance with the transdisciplinary process of actor identification of the PACPATH project. Interviews with regional experts were conducted online and in English. The professional backgrounds of the experts interviewed included customary authorities, members of municipalities, actors from environmental or social organisations, the fishing and tourism sectors, the Loyalty Islands Province government, and three regional organisations: the University of the South Pacific, the Secretariat of the Pacific Community (SPC), and the Secretariat of the Pacific Regional Environment Programme (SPREP 2022).

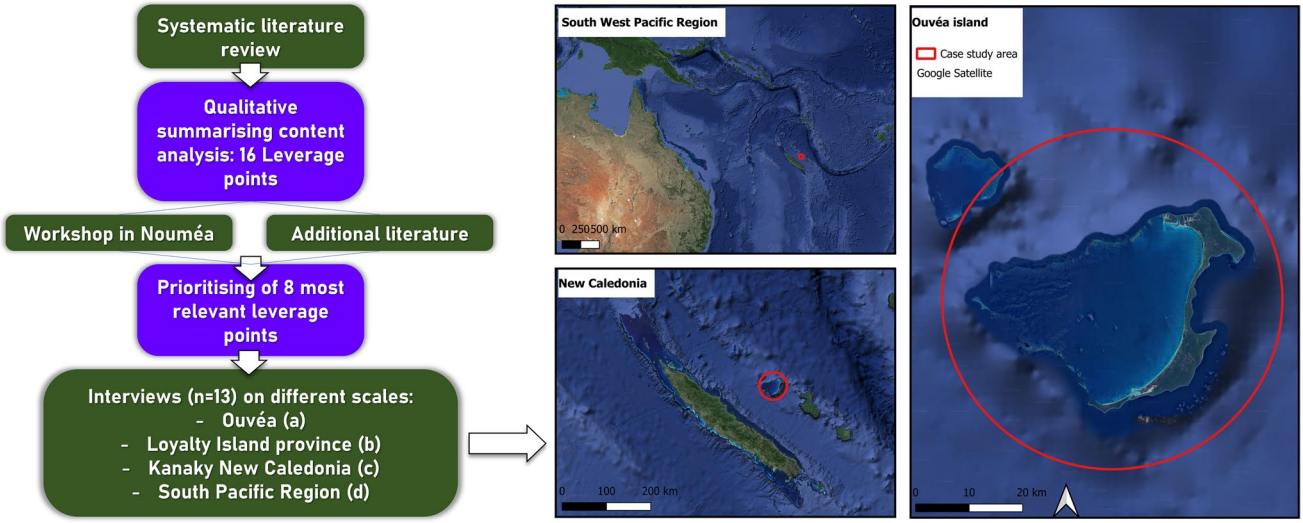

Fig. 2 Methodological approach: (1) systematic literature analysis was performed ($n=123$) to formulate 16 leverage points through a summarising qualitative content analysis (based on Mayring 2008). (2) The initial 16 leverage points were synthesised to eight through the input of a transdisciplinary workshop and screening of additional (grey) literature specifically on Ouvéa. (3) The eight leverage points were contextualised based on the perceptions of semi-structured interviews ($N=13$) with experts representing four different scales: (i) local (Ouvéa), (ii) provincial (Loyalty Islands Province), (iii) country (Kanaky New Caledonia), (iv) regional (South Pacific Region). Maps adapted from Google Maps and cia.gov

During the interviews, which lasted around 1 h, we conducted two interactive exercises in which the interviewees ranked the most relevant leverage points according to their perceived transformational potential and their perceived scale of responsibility for implementation, i.e. regional (South Pacific), government (Kanaky New Caledonia), provincial (Loyalty Islands), and local (Ouvéa Municipality) (see guideline in Supplementary Table S4). The interviews conducted in French were transcribed and translated in a summarising manner in English after a first automated transcription with the software trint (https://app.trint.com). The transcripts of the interviews conducted in English were transcribed with trint followed by minor corrections during the coding process. Subsequently, a qualitative content analysis (based on Mayring 2008) in MAXQDA was conducted to sort and summarise the information. Quotes, where necessary, were translated into English, and cited with reference to the "scale" of each expert. To guarantee anonymity, no further information is provided about the quoted persons.

Our approach has a few limitations. While two of our authors are recognised experts in the region, the interviews were carried out by white, Western-educated Europeans; hence, our interpretation of the results is biased. We approached this study with a commitment to cultural sensitivity and engaged extensively with local knowledges and perspectives to respect and accurately represent the cultural context. Second, access to the case study was provided by one stakeholder, which may influence the representativeness of our sample despite the selection criteria for interviewees. Third, some participants struggled to work with our explanation of the transformative potential of interventions. Nevertheless, they prioritised interventions based on their perceived importance, what should be implemented first, or which aspects seemed fundamental. Fourth, whereas we triangulated our interviews with a literature review, and a transdisciplinary process culminating in a workshop, our study is not and does not aim to be representative for Ouvéa, Kanaky New Caledonia, or the general South Pacific.

Results

In this section, we present (i) eight potential leverage points for sustainability transformation on Ouvéa, (ii) contextualisation of each leverage point based on interviewees' perspectives, (iii) interviewees perspectives on hindrances, and (iv) perceived responsibilities to act on the leverage points.

Leverage points

The literature review resulted in 873 codes for interventions, summarised into 56 intervention strategies, and 16 leverage points (see supplementary 1 and raw data). Using methodological triangulations, namely a workshop and (grey) literature, we prioritised the eight most relevant leverage points (LP) (Fig. 3) and ordered them by system characteristic (parameters, feedback, design, intent). The identified leverage points, ordered from lowest to highest transformative potential, were as follows: (LP1) expanding and improving coastal protection;

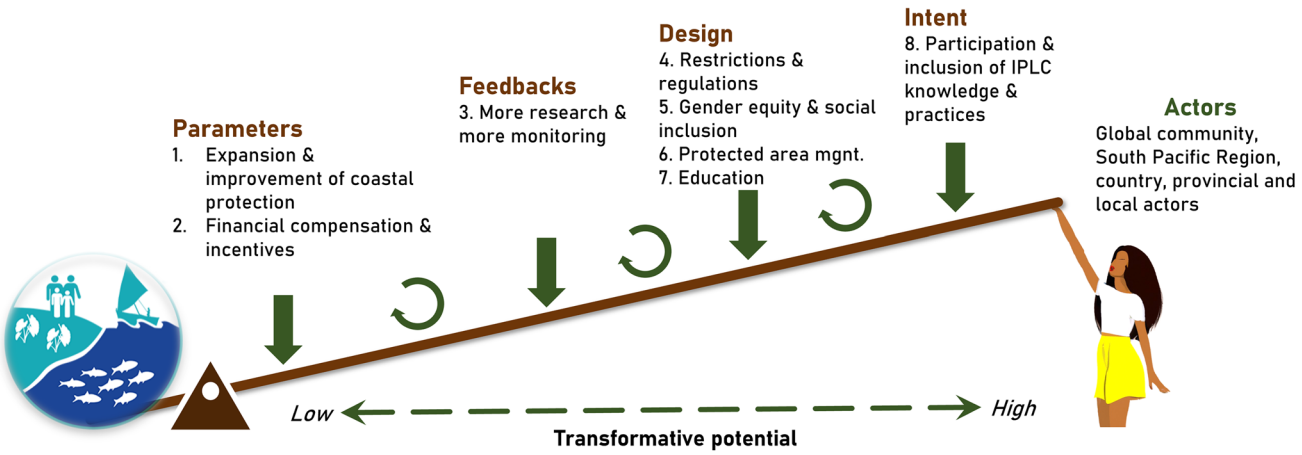

Fig. 3 The eight most relevant leverage points identified in this study grouped into parameters, feedbacks, design and intents, and the main actors with responsibility to act as identified by the interviewees. Graphical depiction based on Fischer and Riechers (2019); female generated by DALL.E (Open Ai, https://openai.com/dall-e-2); graphical depiction of the system to transform is the PACPATH logo (pacpath.org)

(LP2) strengthening or creating monetary incentives, funding possibilities, or forms of compensation to alleviate costs of climate change adaptation and sustainability measures; (LP3) conducting more research and monitoring; (LP4) strengthening environmental regulation and restrictions; (LP5) empowerment of women, youth, and local communities and increasing awareness of power imbalances to strengthen gender equity and social inclusion; (LP6) establishing new conservation management measures and improving existing ones; (LP7) increasing institutionalisation of environmental and climate change education; and (LP8) involving diverse knowledge systems and practices in research and management to strengthen participatory, transdisciplinary, and community-based initiatives.

Contextualisation of the leverage points through interviewees

Through our interviews ($N = 13$) with participants from different scales (Ouvéa, Loyalty Islands province, Kanaky New Caledonia, South Pacific Region, see Fig. 2), interviewees contextualised these eight leverage points specifically to the Ouvéa case study. In the following sections, we present the opinions and perceptions of interviewees on the leverage points, ordered from shallow to deep leverage.

Leverage point 1: expanding and improving coastal protection

According to our interviewees, it is not only the land that is slowly disappearing but also parts of Ouvéa's history and identity. As one interviewee put it: "I am aware of the fear that other people are facing every day. That at night they can't sleep because there might be a big wave appearing. […] [We can] see a part of the island disappearing. This also means seeing a part of the history disappearing and also a part of our identity […] You have to know that there are many traditions that have been lost […] It also has an impact on our culture" (Interview 10, province). Previously on Ouvéa, seawalls have been put into place without sufficient participation from the inhabitants or long-term scientific evaluation of the effects (Le Duff et al. 2017). Several interviewees highlighted that this had led to potential maladaptation. For instance, Fig. 1c shows a seawall that has been put into place to protect the main road and important infrastructure for energy supply, which connects the northern part of the island with the central part. After the seawall had been put into place, the sandy beach almost disappeared completely. Other nature-based solutions for coastal protection, such as stabilising banks with seagrass or ensuring coral reef health, have been mentioned by the interviewees as more effective alternatives than seawalls. However, compliance to rules may differ: "They [the scientists] say that we should not take the gravel and the sand from the beach. But the water will rise anyways, even without us taking the sand" (Interview 5, local).

Leverage point 2: strengthening or creating monetary incentives, funding possibilities, or forms of compensation to alleviate costs of climate change adaptation and sustainability measures

Financial mechanisms, including international aid and incentives for climate change adaptation, were perceived by the interviewees as having high transformative potential in addressing the low financial capacity of South Pacific countries and territories. However, the interviewees agreed that the transformative potential of financial mechanisms was

dependent on how these incentives are used and embedded within local policies and institutional dynamics. Scientific research, in turn, links monetary incentives to a low transformative potential (see, e.g. Meadows 1999; Abson et al. 2017). One interviewee stated the link between the expansion of coastal protection and the need to consider monetary funding/incentives: "It's fairly basic engineering. Bringing sand back [to the beach, and] building a resilient drinking water infrastructure are things that can be done. [They] just cost money" (Interview 13, government and local).

Leverage point 3: conducting more research and monitoring

In order to achieve the desired outcomes, interviewees saw it as important to conduct more research in partnership with other South Pacific countries to share experiences, and to use a combination of scientific and traditional knowledge. The lack of (long-term) monitoring data for the South Pacific was emphasised and it was suggested that climate change adaptation measures should be accompanied by scientific research to prevent adverse outcomes. Research was said to be needed on a variety of topics including species protection, invasive species (e.g. coconut beetle), alternative building materials for huts, and the effects and causes of coastal erosion: "Erosion is accelerating more and more and we need surveys to rapidly respond […]. Coastal erosion […] is causing more and more inundated land where we cultivate taro.[3] And we maybe cannot cultivate it anymore in three or four years. We can see that in some places the salinity increases. […] And it's with science […] that we are able to make future projections […] to know: here we will not be able to plant anymore […]" (Interview 9, province). Interviewees suggested to strengthen long-term research engagement and the transfer of knowledge between projects and with the local population (see also LP8). The interviewees also mentioned trust as being essential for fostering open and collaborative relationships between communities and researchers and for effective knowledge transfer.

Leverage point 4: strengthening environmental regulation and restrictions

On Ouvéa, fishing is an important part of the local community's livelihood and culture, but interviewees said that overfishing and other anthropogenic pressures have led to a decrease in stock sizes, making it increasingly important to implement stronger regulations and restrictions to protect certain species and ensure sustainable fishing practices, especially on a regional scale. Strengthened environmental regulations and restrictions were said to have some transformative potential, but interviewees stated that they often failed in development, implementation, or enforcement. Interviewees, hence, deemed it important that local communities are involved in the establishment and writing of environmental regulations to ensure ownership and alignment with local cultural values and norms, a process that has been fully engaged by the Loyalty Islands Province in the recent drafting of their environmental code (David and David 2019). Furthermore, the environmental regulations needed to be adapted to changing environments and their enforcement was seen as crucial, particularly regarding the reduction of anthropogenic pressures such as fishing and pollution. The cultural continuity of traditional regulations and their enforcement was seen from different perspectives: "Living in tribes means living in community. And living in community means paying attention to our environment, to each other […]. We don't take out more than we need. Which is perhaps a bit contradictory to the economic development system. The customary authorities take care that no one is taking too much. If we go fishing it is for our families, not to exploit the lagoon" (Interview 9, province). Further showing the need for stronger regulations is a lack of compliance with customary restrictions: "Back in the days [those regulations] were put in place by the customary authorities. And everyone respected them, because they knew that otherwise in ten days there wouldn't be any more fish of this or that species. But today this respect is no longer the case" (Interview 1, local).

Leverage point 5: empowerment of women, youth, and local communities and increasing awareness of power imbalances to strengthen gender equity and social inclusion

The leverage point of gender equity and social inclusion elicited different perspectives and discussions between the interviewees. Kanak society is a patriarchal society in which men and women have different roles to fulfil. Although change is slowly taking place in some areas, gender roles, reinforced by colonisation and religion, tend to give women little visibility in decision-making. They are expected to raise their children, run the household, and act as a link between clans through marriage (Salomon 2000; Nicolas 2017). While some interviewees recognised the potential for change in the empowerment of women to break out of their expected roles, others did not see the need for change. One interviewee stated: "[women], carry so much of the load in the community, that means that they're also carrying the potential for change. And without including them, you lose the potential for change" (Interview 12, regional). Social inclusion and equity with special focus on women, youth, and Kanak culture were described by some interviewees as key assets for effective governance

[3] Taro is a tuber of great cultural and food value locally.

and institutional systems, yet stated to be often missing in governance—from global development frameworks to local decision-making processes. The interviewees emphasised the importance of strengthening capacity to enable adaptation to a changing environment with local communities and their traditional knowledge as principal actors rather than relying on outside organisations (and funding). "We've been on this island for decades and decades. Erosion is not something that happened today. You have to go back in time and since our elders, they have known how to do things with their own intelligence, their own means to protect the population. […] That's the point, to give the population a chance by providing them with means. That's the point. Instead of bringing people from elsewhere […] to tell us [what to do]. That's what I don't like because we're doing things the wrong way around. Because the people of Ouvéa are no longer autonomous. […] I want the local population to be responsible and to be called actors for the protection of the environment" (Interview 10, province).

Leverage point 6: establishing new conservation management measures and improving existing ones

Nearly all interviewees agreed that local communities should be involved in the management of protected areas as they heavily depend on their coastal and marine resources. When implementing marine protected areas (and other area-based managements, such as locally managed marine areas), environmental regulations, and restrictions, interviewees saw it as important to consider cultural values, norms, power relationships, equity, and social inclusion (LP5). Interviewees highlighted the need for community-based marine and coastal co-management that considers the knowledge, cultural values, and customary practices of the local communities. Particularly, the importance of involving customary authorities and adapting legal tools to the cultural concepts of the Kanak society was emphasised.

Leverage point 7: increasing institutionalisation of environmental and climate change education

Environmental and climate change education was recognised as a crucial aspect in promoting sustainable practices and ensuring the effectiveness of future research, co-management, and environmental regulations. Education on climate change was implemented, but interviewees criticised that the education was not always well adapted to the local context (e.g. teaching subjects, pedagogical methods, teaching language): "[…] I have worked quite a bit in schools and often the programs are far from reality. I think we need to give more space to sensitise, to raise awareness. Rather than to educate on abstract topics. It's time now to tell the truth to the children and that is: from our ancestors to today we have polluted the world and we need to change. […]. And we need to create educational tools that are not only used within the scholarly system, but that also have a positive effect on the public. This means to create awareness by using *la langue*, our local language, instead of doing this in French or English. […] If you see, that there are still young people here [..] who struggle to integrate easily into the French education system, people who still struggle to speak or to write in French. That's why I am saying that we need to adapt. We have to find ways to know how to put into place new ways of teaching to protect the environment" (Interview 10, province).

Leverage point 8: involving diverse knowledge systems and practices in research and management to strengthen participatory, transdisciplinary, and community-based initiatives

Integrating traditional and scientific knowledge was seen as essential for creating effective and sustainable solutions that can transform the social-ecological system of Ouvéa into a desired sustainable state. The interviewees emphasised the importance of taking innovative approaches that honour the existing cultures and the strengths of traditional knowledge to address environmental issues: "Yes, this [participation and inclusion of local knowledge] is very important. It's also my vision. Because before science arrived [from Western culture], we already had a science but based on the culture and values of our [Kanak] society" (Interview 7, local). Interviewees stated that solutions from the Global North cannot be readily applied in the South Pacific region without acknowledging the cultural, societal, economic, and ecological context, as well as differing resource availability. The participation of the local population and especially, Indigenous Peoples, women and the youth (LP5), was seen as crucial to find solutions that are appropriate for Ouvéa and that would be accepted by the community. Without participatory research that includes the local community, a knowledge transfer between research projects is unlikely, and stakeholder fatigue (i.e. stakeholder losing interest or trust to engage with research) possible.

Hindrances to transformative potential

The transformative potential is impacted by hindrances and interferences in the implementation of interventions, including leverage points potentially interfering with each other. Interviewees saw hindrances from a global to a local scale. Often, interviewees stated that the transformative potential of interventions on Ouvéa significantly depends on the evolving trajectory of climate change, as exemplified by

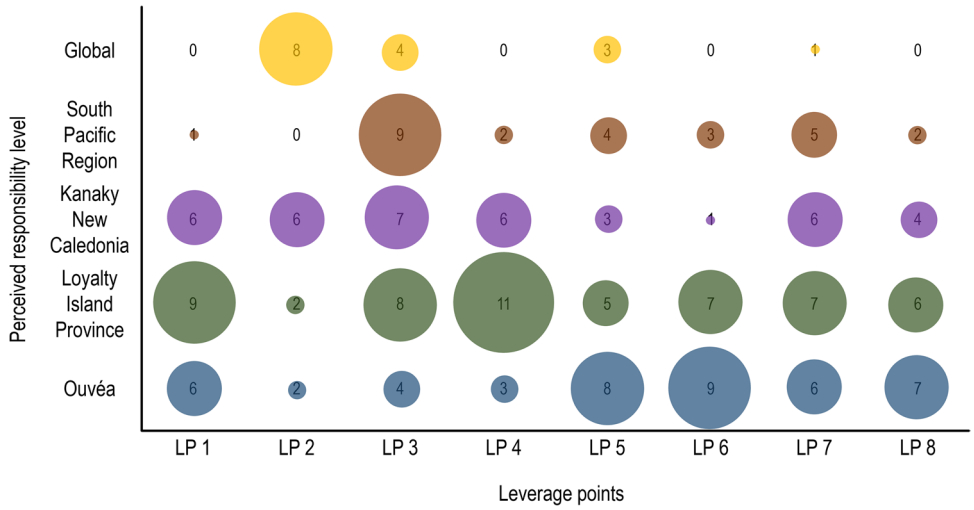

Fig. 4 Visual presentation if the response count of the $N = 13$ interviews for the scale of responsibility for the implementation of the eight most relevant leverage points sorted by the experts according to scale (local = Ouvéa, provincial = Loyalty Islands Province, country = Kanaky New Caledonia, regional = South Pacific Region, global). One leverage point could be put into more than one scale if multiple actors from multiple scales need to implement interventions. Leverage points: (LP1) expanding and improving coastal protection; (LP2) strengthening or creating monetary incentives, funding possibilities, or forms of compensation to alleviate costs of climate change adaptation and sustainability measures; (LP3) conducting more research and monitoring; (LP4) strengthening environmental regulation and restrictions; (LP5) empowerment of women, youth, and local communities and increasing awareness of power imbalances to strengthen gender equity and social inclusion; (LP6) establishing new conservation management measures and improving existing ones; (LP7) increasing institutionalisation of environmental and climate change education; and (LP8) involving diverse knowledge systems and practices in research and management to strengthen participatory, transdisciplinary, and community-based initiatives

interventions such as seawalls for coastal protection (LP 1): "But the change potential depends a lot on what we [humanity] do. We should not do mistakes. And we can do all the compensation we want […]. It will only have a superficial impact as long as we do not stop climate change. If the industrialized countries don't do what's necessary to stop this, we can spend as much money as we want" (Interview 12, regional). Regarding financial compensation and incentives, interviewees perceived that development assistance did not get to the location where it was needed, was too short-term and "success" was not evaluated at the project's conclusion. Further hindrances were seen regarding expectation of high local input requirements, whether these were financial, material, or related to necessary social or cultural changes. Furthermore, interviewees stated that solutions from industrialised countries were often not transferable as they were seen as too expensive and not adapted to the local context, or the allocation of financial resources was often tied to short-term partnerships with insufficient participatory processes. Furthermore, interviewees from Ouvéa sometimes noted issues of non-compliance with local (customary) laws. Cooperation and education initiatives were often based on Western culture and language, which excluded local communities and knowledge systems. Especially, communication gaps between some scientists and the local population were raised by the interviewees.

Responsibility to act

Responsibilities for intervening at the leverage points on Ouvéa are particularly diverse due to the multiple levels of governance involved. Locally, the Ouvéa municipality works closely with the chiefdoms to offer different possibilities for action (Nayral 2024). The Ouvéa municipality also works closely together with the Loyalty Islands Province (of which Ouvéa is one of three). Furthermore, the government of Kanaky New Caledonia as a whole, as well as influence from the state of France (and therewith also the European Union), has to be taken into account. This can also mean that if there is disagreement around interventions, e.g. if the chiefdoms or specific clans disagree with the province or other institutions, a successful implementation cannot be guaranteed. Hence, we asked interviewees to sort the eight leverage points according to which actors on which scale (local, provincial, government, regional, global) they saw being responsible for the implementation on Ouvéa (Fig. 4). Overall, our results showed that higher responsibility to act upon leverage points was perceived at the local (Ouvéa's municipalities; local population) and provincial level compared to the global, regional (South Pacific), and governmental (Kanaky New Caledonia) levels. The interviewees, however, emphasised the importance of addressing leverage points across scales. For example, the responsibility

for involving diverse knowledge systems and practices in research and management to strengthen participatory, transdisciplinary, and community-based initiatives (LP8) was mainly identified as responsibilities at the local level. For the empowerment of women, youth, and local communities and increasing awareness of power imbalances to strengthen gender equity and social inclusion (LP5), the responsibilities differentiated among the interviewees (Fig. 4). While some interviewees saw the responsibility on the local scale, others noted that addressing gender equity and social inclusion are a shared responsibility across all scales. Interviewees also mentioned that the Indigenous People's participation in decision-making processes takes place on the local level and that the local communities were responsible for bringing themselves into different processes and projects, as phrased by one interviewee: "what makes things happen on the ground, and what makes things change is really a bottom-up approach – lead by the local communities that are living there. Hence, bringing them into management practices or even research projects and partnerships is at the core of a potential for change" (Interview 11, regional).

Improving infrastructure for coastal protection, as example, was seen as a local need but the perceived responsibility varied from country to provincial to local level. The stated responsibility for increasing institutionalisation of environmental and climate change education (LP7) was recognised from the local up to the South Pacific level. On Ouvéa, education is a provincial responsibility for the primary school and becomes a governmental responsibility at the secondary level, when pupils have to move to Grande Terre (the mainland) or Lifou Island for their further education. Regarding the leverage point of "conducting more research and monitoring" (LP3), interviewees identified responsibilities at all scales, but emphasised the provincial and South Pacific level. Interviewees mentioned that global research approaches are needed but require that research is conducted in cooperation with the local level to be effective and to overcome colonial modalities.

The strongest global responsibility was found regarding providing financial compensation and incentives for local communities to adapt to climate change. Here, interviewees highlighted the responsibility of countries in the Global North and their national governments to reduce greenhouse gas emissions and implement measures to mitigate the effects of climate change. In this context, the agreement on the loss and damage fund at the COP27 was mentioned by (provincial and regional) interviewees. In addition, interviewees (regional, provincial, and local) stated that industrialised countries must recognise their responsibility for global warming, and mitigate climate change at international level with special focus on reducing greenhouse gas emissions, especially through changing their lifestyles to adopt more "sustainable" behaviours: "But in the end, we can do as much as we want for the protection of the environment. As long as the industrialised countries don't change anything, coastal erosion will continue to threaten small islands like ours and we cannot escape this. We have to make sure that we are not reaching an irreversible point of destruction" (Interview 9, province).

Discussion

Ouvéa and its people are facing several interacting sustainability challenges. Our results highlighted how Ouvéa inhabitants perceive these challenges and their views on how to address them. The eight leverage points that we identified and contextualised resonated with key considerations in the current sustainability discussions in the South Pacific region. For instance, climate change maladaptations is a re-occurring topic (LP1: Narayan et al. 2020; Mycoo et al. 2023), as is the importance of empowering key local stakeholders to help design sustainable adaptation pathways (LP5, LP8; Begum et al. 2022; Mycoo et al. 2023). Furthermore, our results echo the 2050 Pacific Island Countries Strategy for the Blue Pacific Continent (Pacific Islands Forum Secretariat 2022; Morgan 2022), especially regarding the need to enhance education about climate change (LP7) and the necessary empowerment of all Pacific Island peoples and their knowledge (systems) in research and management (LP5, LP8).

When discussing system-wide sustainability transformation across social, economic, and ecological dimensions, for practitioners and laypersons, it may often be easier to think within existing system structures (path-dependencies) (Korhonen-Kurki et al. 2024). Thinking outside the current dominant system or voicing disruptive opinions to enable change can be challenging for stakeholders and researchers (Baumann et al. 2023). Previous research around leverage points for sustainability transformation showed the high importance of values (Horcea-Milcu 2022), inner transformations (Woiwode et al. 2021), but also the current economic (Lübker et al. 2021) and financial systems (Jouffray et al. 2019). Our empirical research around the sustainability challenges of the low-lying atoll Ouvéa mirrors these discussions. Our findings on leverage point 3 "more research and monitoring" showed that, whereas the sharing and providing of knowledge, information, or data could be interpreted as a deep leverage point (system design), on Ouvéa, it is a shallower leverage point in the area of system feedback. Due to the relative high amount of research already done on Ouvéa, the suggested increased research and monitoring would not foster transformation without changes on how knowledge is created and research results implemented (see LP5 and LP8). We should also notice the great involvement of the people of Ouvéa, among other initiatives and participative

research, in the Coral Reef Observation Network (RORC), which has been run since 2011 by the Pala Dalik association and is closely linked to the research being carried out in the country. This engagement shows that it is possible to co-create knowledge. Co-production of knowledge through transdisciplinary (Indigenous-led) research is a suitable approach for a social-ecological system with high complexity and uncertainty such as on Ouvéa.

It is crucial to carefully co-produce sustainability interventions (Staffa et al. 2021; Chambers et al. 2022) to dislodge path-dependencies and empower actors to envision courageous and equitable futures (Chambers et al. 2021). We see it as essential that scientific research continues to play its part in the process of decolonisation in Kanaky New Caledonia and in the necessary reduction of social inequalities. As David et al. (2018) wrote, research is not just a stakeholder in the processes of decolonisation by being involved in the study of the processes of decolonisation and territorial rebalancing, but also must support these processes. Despite efforts to involve local people in research projects and to train local researchers, there is still a great deal of progress to be made. Within the PACPATH project, we aimed at co-creating definitions of sustainability problems and discussed how transdisciplinary research can be a part of the solution. These discussions included (but was not driven by) Indigenous Peoples and local communities. Together with our PACPATH members from Ouvéa, we chose this atoll as an example, and the empirical research was guided and supervised by a local representative. Only a transparent and co-constructed scientific approach can facilitate the emergence of useful research questions and the appropriation of the results, especially in the context of a decolonisation that is still in progress, and which today faces unprecedented political, social, and economic issues, fuelled by significant inequalities and a strong break between generations (e.g. Beck et al. 2021; Trisos et al. 2021). Aspects of ocean equity are influenced through power differentials across all scales—local and national politics, as well as global economic processes (Bennett 2019; Gill et al. 2023) and, hence, need comprehensive reinforcements on all scales.

Ocean equity in sustainability transformations

Indeed, in recent years, researchers and international institutions alike have brought attention to strengthening equity and justice in sustainability transformation (Blythe et al. 2018; Lécuyer et al. 2024; Loos et al. 2024). These discussions have found broad appeal in the marine (social) sciences (Bennett et al. 2023; Partelow et al. 2023; de Vos et al. 2023), especially as research showed positive effects of integrating ocean equity into the management of protected areas, fisheries, or climate change adaptations (Klain et al. 2018; Österblom et al. 2020; Bennett et al. 2021). Yet, governance and management efforts still frequently neglect or insufficiently integrate ocean equity considerations (Crosman et al. 2022), which potentially reinforces negative effects for vulnerable coastal communities (Friedman et al. 2018; Blythe et al. 2023).

Recently, Bennett (2022) suggested the focus on six dimensions of ocean equity: (i) *recognitional equity*, i.e. the acknowledgement and consideration of local rights, values, visions, knowledge, needs, and livelihoods; (ii) *procedural equity*, as the level of inclusiveness and participation in decision-making, and the embodiment of good governance principles; (iii) *distributional equity*, i.e. the degree of fairness in the allocation of benefits, and the minimisation of harms to local populations; (iv) *management equity*, as the extent of local capacity for, leadership in, and authority over management activities; (v) *environmental equity*, i.e. safeguarding and maintenance of local environmental quality, sustainability, and nature's contributions to people; and (vi) *contextual equity* as the extent to which broader contextual factors (e.g. economic, governance, social structures, climate change, environmental conditions, rule of law) enable or undermine local ocean equity and the advancement of equity in policy and practice (from Bennett 2022:2).

In relation to the eight contextualised leverage points to tackle sustainability challenges, *recognitional equity* could be achieved through acknowledging the different values, knowledge (systems), and worldviews within the South Pacific Region in general (Hau'ofa 1994) and especially recognising and acknowledging the difference to Western values, knowledge systems, and worldviews (Tjibaou and Guiart 1976; Tjibaou 1996; Sabinot and Bernard 2016) (LP8). Acknowledging the colonial past and oppressions and the structural and institutional legacies, considering that decolonisation is an unfinished and ongoing process (Gagné 2015; Kowasch and Batterbury 2020), are key to strengthen ocean equity.

Procedural equity could be strengthened by empowering and including local and marginalised actors (LP5), their values and knowledge systems (LP8), in decision-making (co-)processes of conservation management (Taboada et al. 2020; Ziervogel et al. 2021) while adhering and supporting local environmental regulations and restrictions (incl. customary laws) (Johannes 1978; Outeiro et al. 2015; Bambridge et al. 2021) (LP4, 6). One example of a step towards incorporating Kanak cultural values and norms into ocean management was the Loyalty Islands Province's new environmental code (David and David 2019). This code proposes a hybrid law by handling the principle of subsidiarity to the benefit of local authorities, and acknowledges the respect of the hierarchy of norms and the constraints resulting from international

law (David and David 2019). Additionally, the Customary Senate, with the support of the Kanaky New Caledonian Government, NGOs, and social researchers, was working in 2023 and 2024 to integrate the Kanak cultural dimension of the ocean into the "*loi pays*" (a quasi-legislative act adopted by Congress), which includes the Coral Sea Natural Park that encompasses Kanaky New Caledonia's entire Exclusive Economic Zone.

Distributional equity may be strengthened through a better understanding of benefits and disadvantages of local environmental changes through more and participatory research (LP3, 8). It also includes the distributional equity between Kanaky New Caledonia's main island (Grande Terre) and Ouvéa by helping to generate job possibilities for the younger and future generations on Ouvéa. Distributional equity could be reinforced by better understanding diverse local perceptions of fairness (Gurney et al. 2021), colonial legacies (Gram-Hanssen et al. 2021; Trisos et al. 2021), and strengthening or creating funding possibilities and compensations from the responsible actors for climate change and biodiversity loss (LP2).

Our interviewees implied that *management equity* could be strengthened by including local populations, their values and knowledges, in the improvement of coastal protection (see also Arkema et al. 2015; Sabinot et al. 2018), and by enabling and strengthening locally managed marine areas (LMMAs) based on traditional, customary laws (Webb et al. 2004; Bennett and Dearden 2018; Kitolelei et al. 2022) (LP6). Furthermore, *environmental equity* could be strengthened through an integrated approach towards sustainability of the South Pacific Region (e.g. SPREP 2010; SPC 2022), including acknowledging and leveraging the multiple values of nature for transformative change to just and sustainable futures (Pascual et al. 2023a, 2023b).

Lastly, *contextual equity*, generally, again draws back to a recognition of power imbalances within local and national institutions, economies, and governmental structures (Bennett 2022), as well as to the broader scale the responsibility of polluting countries for climate change and biodiversity loss (e.g. Gram-Hanssen et al. 2021). By discussing these dimensions in the context of Ouvéa, further research could explore ways to identify power dynamics, acknowledge local values and knowledge systems, and ensure a fair benefit distribution.

Conclusion

The ongoing UN Decade of Ocean Science for Sustainable Development (2021–2030) underscores the imperative of heightened efforts and interventions to "conserve and sustainably use the oceans, seas, and marine resources for sustainable development" (UN Sustainable Development Goal 14, UN 2015). Pacific Island Nations, despite contributing minimally to global greenhouse gas emissions, shoulder a disproportionate burden of climate risks. In this article, we undertook a detailed examination of sustainability interventions pertinent to Kanaky New Caledonia, particularly within the context of the low-lying atoll Ouvéa. Using the leverage points perspective, we contextualised eight leverage points through qualitative expert interviews. In addition, we identified challenges hindering sustainability transformations, including short-term approaches, quick-fixes, and prioritisations based on Western-centric approaches and worldviews. Mismatches between solutions that are imported from outside and local contexts, communication gaps between scientists, engineers, agencies, NGOs and local communities, and funding tied to non-participatory partnerships emerged as major obstacles regarding our interviewees. Integrating ocean equity into the discussion illuminated power differentials, advocating for comprehensive reinforcement across scales. In essence, this study offers a comprehensive view of sustainability transformations, stressing the critical role of recognising power relations and cultural contexts for sustainable outcomes in Ouvéa and possibly other locations of similar configuration. Through our emphasis on the interplay of leverage points, multi-scale approaches, and equity considerations, we contribute to a more holistic and effective understanding for fostering sustainability in this unique region.

Since May 13, 2024, after more than 30 years of peace made possible by the Nouméa agreements, violent conflicts erupted in the capital, Nouméa, and its surroundings. Ouvéa was physically little affected, and we believe that the existing resilient socio-environmental dynamics will be allowed to persist and contribute to the revitalisation of the social (and scientific) connections of the country that have been damaged by the violence.

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