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Can Perceptions of Environmental and Climate Change in Island Communities Assist in Adaptation Planning Locally?

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Abstract Local perceptions of environmental and climate change, as well as associated adaptations made by local populations, are fundamental for designing comprehensive and inclusive mitigation and adaptation plans both locally and nationally. In this paper, we analyze people's perceptions of environmental and climate-related transformations in communities across the Western Solomon Islands through ethnographic and geospatial methods. Specifically, we documented people's observed changes over the past decades across various environmental domains, and for each change, we asked respondents to identify the causes, timing, and people's adaptive responses. We also incorporated this information into a geographical information system database to produce broad-scale base maps of local perceptions of environmental change. Results suggest that people detected changes that tended to be acute (e.g., water clarity, logging intensity, and agricultural diseases). We inferred from these results that most local observations of and adaptations to change were related to parts of environment/ecosystem that are most directly or indirectly related to harvesting strategies. On the other hand, people were less aware of slower insidious/chronic changes identified by scientific studies. For the Solomon Islands and similar contexts in the insular tropics, a broader anticipatory adaptation planning strategy to climate change should include a mix of local scientific studies and local observations of ongoing ecological changes.

Keywords Adaptation planning · Climate and environmental change · Local knowledge · Perceptions · Solomon Islands

Introduction

The impacts of human-driven environmental and climate changes on coastal ecosystems such as the decrease in ocean productivity and altered food web dynamics (Hoeg-Guldberg and Bruno 2010), in tandem with the increased frequency and intensity of extreme climatic events (McClanahan et al. 2009), affect not only the ecological function of coastal ecosystems but also seriously threaten human livelihoods and health. Impacts on people are not symmetric and there are differential impacts on vulnerable or politically disadvantaged communities, which tend to be those more negatively affected (Parks and Roberts 2006; Lazrus 2009; Oliver-Smith 2009; Clark 2010; Parks and Roberts 2010). Social scientists have analyzed distinct accounts of climate change and their consequences at a political, social construction, and personal and collective identity levels (Sherratt et al. 2003; Leiserowitz 2006; Crate 2008; Marino and Schweitzer 2009; Swyngedouw 2010; Szerszynski and Urry 2010). There has also been considerable effort to understand how local communities have responded and adapted to environmental and climatic

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change (Barnett 2001; Berkes and Jolly 2001; Vedwan and Rhoades 2001; Adger 2003; Orlove 2005; Ziervogel et al. 2006; Adger et al. 2012; Lazarus 2012).

Documenting local understandings of how, when, and where coastal environmental change is occurring, as well as understanding the causes for the existence of asymmetric perceptions of change (Deresa et al. 2011) and adaptive capacity locally (Dolan and Walker 2004) can help in designing contextually relevant mitigation and adaptation plans for coastal communities in small tropical island nations. Local and indigenous people's environmental knowledge can provide critical information about protracted and rapid climatic and ecological changes (e.g., Sagarin and Micheli 2001; Couzin 2007; Alexander et al. 2011), about the strategies that local populations have designed, consciously or not, to adapt to those changes (Berkes and Jolly 2001; Adger et al. 2005; Mawdsley et al. 2009; Ford et al. 2010), and to the role of local understandings in disaster risk reduction in resource management, conservation (McAdoo et al. 2009; Gelcich et al. 2010; Mercer et al. 2010), and migration (Mortreux and Barnett 2009). Because climate change is a phenomenon that is locally perceived as complex and multilayered, and because of actual climate variability and unpredictability, it is hard to translate into a tangible daily reality. Nonetheless, people do perceive or observe in situ changes during their lifetimes and interpret these based on their observations and exogenous information that they receive to determine their causes over time.

This local understanding, even if asymmetries within and between groups in culture, values, or ethics exist (Adger et al. 2009), needs to be documented in its various forms. Underpinning decision making and adaptation strategies are the perceptions of environmental change, associated risks, and the perceived causes (Grothmann and Patt 2005; Adger et al. 2008). Documenting local perceptions of environmental change, therefore, is fundamental to both discussing adaptation options locally (e.g., community-based disaster risk reduction) and for governments and other NGOs to design 'anticipatory' adaptive response plans locally. This, in turn, can assist in scaling up a more realistic adaptation policy that can be applied regionally, national, and internationally (e.g., climate change adaptation schemes) (Reilly and Schimmelpfennig 2000). In short, anticipatory adaptation projects to climate change need to be both top-down and bottom-up approaches (Gero et al. 2011) and the local understanding of environmental change can significantly assist both these efforts.

Anticipatory climate change adaptation planning is of particular importance for places like Oceania because there is still a widespread dependence on wild natural resources. For instance, the Solomon Islands (Fig. 1) are considered among the least developed in the world with limited access to education and health services, short life expectancy, high infant mortality, and high population growth rates (UNDP 2006). In terms of natural resources, however, the Solomon Islands are wealthy. The majority of Solomon Island communities have maintained a predominately subsistence lifestyle based on their abundant marine and terrestrial resources, and coral reef ecosystems, in particular, provide the primary source of nutrition for coastal communities. The central importance—both socio-culturally and in subsistence terms—of marine resources to coastal people in the region cannot be overemphasized. Solomon Islands rural communities depend on wild marine resources for the bulk of animal protein intake and national per capita consumption of seafood is among the highest in the world with an average of 33 kg/person/year (Bell et al. 2009). Fishing strategies are constrained or enhanced by the flow of information between fishers and the environment, the variability of spatiotemporal events and the uneven distribution of prey species across coral reef ecosystems (Aswani 2014). It follows, then, that local perceptions of environmental change are necessary for people's everyday decision making in environment–human interactions.

In this respect, the environmental social sciences are especially well placed to collect fine-grained qualitative and quantitative information that is needed for a local level analysis of environmental and climate transformations (Magistro and Roncoli 2001; Batterbury 2008; Crate and Nuttall 2009; Roncoli et al. 2009). Indigenous knowledge has the possibility to contrast old information with new perceptions of the environment identifying changes at very fine scales (Strauss and Orlove 2003; Hastrup 2013) and has established very concrete and context-dependent relationships with the environment. Therefore, it is capable of identifying change at scales not considered by standardized scientific knowledge (Vedwan and Rhoades 2001; Krupnik and Jolly 2002; Cruikshank 2005; Crate 2006; Roncoli 2006; Orlove et al. 2008; Lazrus 2009, Wolf and Moser 2011). For instance, Aswani and Lauer (2014) assessed the direction and periodicity of experimental learning of people in the Western Solomon Islands after a tsunami in 2007 and found that while detection levels differed between marine science surveys and local ecological knowledge sources across sampling years, local people were able to detect changes in the benthos over time. Social science research, therefore, contributes to the study of climate change by bringing methodological and conceptual tools that tap into the locally and finely contextualized ecological knowledge developed by small-scale communities all over the world.

In this paper, we analyze people's perceptions of environmental and climate-related transformations in communities across the Western Solomon Islands (Fig. 1). Through various ethnographic and geospatial methods, we documented people's observed changes over the past decades across various domains, and for each change, we asked respondents to identify the causes, timing, and

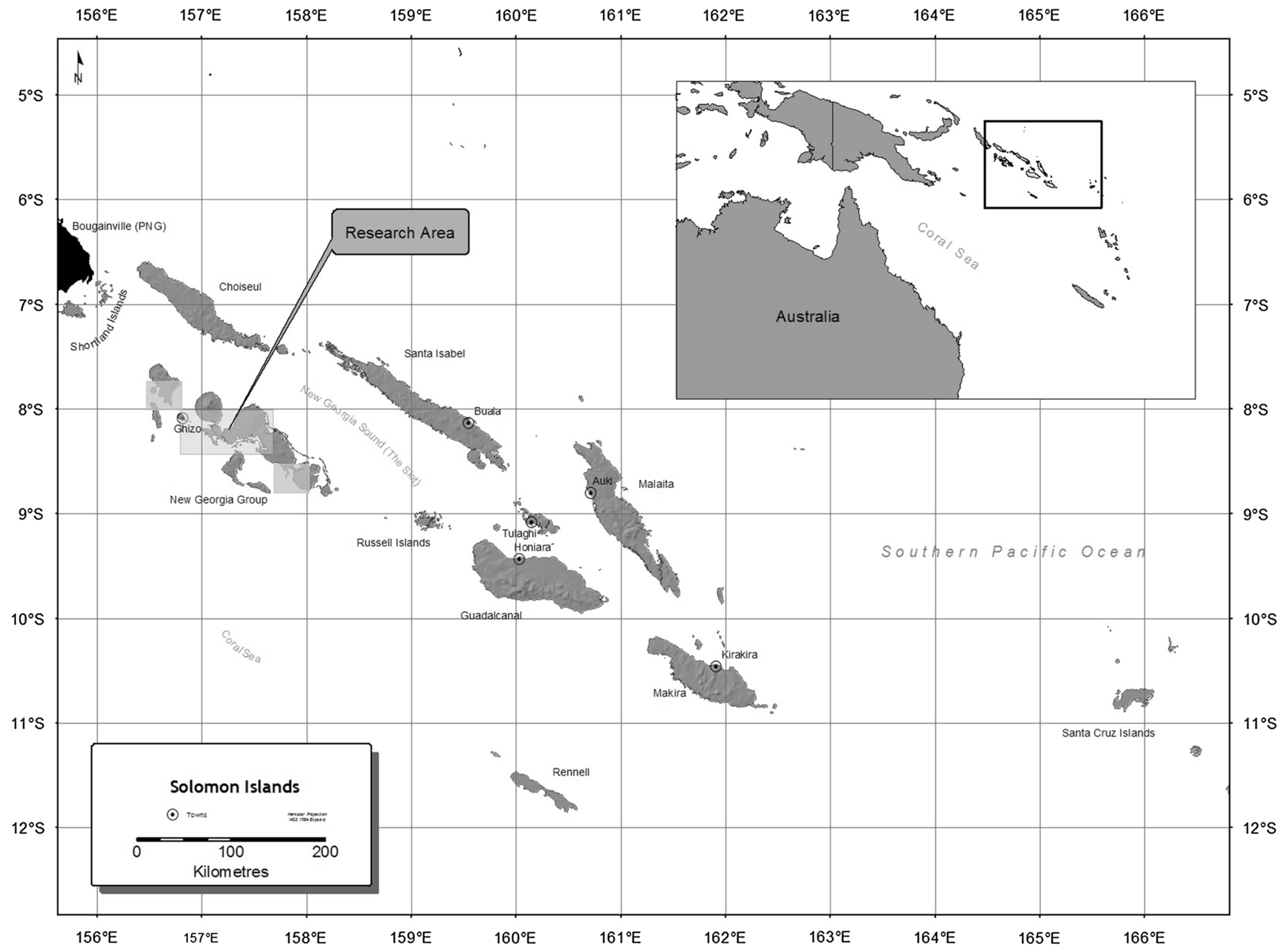


Fig. 1 The Solomon Islands (research areas marked in *gray*)

people's adaptive responses. We also incorporated some of this information into a geographical information system (GIS) database to produce broad-scale base maps of local perceptions of environmental change across time. The communities studied are ideal candidates for research on environmental and climate change and adaptation for several reasons: (1) they are directly dependent on the environment for subsistence (fishing and agriculture); (2) the environment they rely upon is vulnerable to change, increasingly fragmented, and the different ecological patches of its landscape and seascape react differently to climatic variations; and (3) the lead author has over two decades of experience in studying the ecology and society of the region (Table 1).

Research Area

The Western Solomons are densely forested, and the largest island of New Georgia is ringed by extensive lagoon systems including the Marovo, Nono, Roviana, and Vonavona lagoons (Fig. 1). The lagoons, which are dotted with numerous villages, have a gradient of habitats including mangrove forests, river mouths, mudflats, seagrass beds, patch reefs, barrier reefs, and marine lakes. People also live in coastal open-ocean-facing hamlets such as those in Simbo, Ranongga, and Vella Lavella Islands, and these communities exploit different habitats than lagoon dwellers. Approximately seventy-seven thousand people live in the Western Solomons (National Census 2009), who speak a variety of Austronesian and non-Austronesian languages. In most parts of the region, local communities still exercise control over the use of and access to natural resources within their particular customary land and sea estates, albeit these traditional systems are rapidly eroding institutionally.

People make cash by marketing of marine and terrestrial resources, the selling of handicrafts, copra production, and the operation of small stores, among other types of activities. The subsistence economy still plays a central role in the life of Western Solomons dwellers, but livelihoods are being threatened by the degradation of marine habitats.

Table 1 Respondent characteristics

Variables	Roviana Lagoon					Marovo/Nono Lagoons			Vella
	Nusa Hope	Kindu	Nusa Banga	Olive	Kinda	Ninive	Bopo	Bareho	Leona
Number of respondents	41	36	40	30	14	12	19	37	37
Mean age	46	42	42	40	46	44	43	43	43
Range age	22–62	25–76	20–71	22–67	23–73	27–71	27–70	28–68	25–77
% women	51	58	55	40	50	33	53	22	27
% identified themselves as fishers	90	86	88	87	93	92	79	92	78
% who own canoes	93	78	70	80	86	75	74	92	81
Mean number canoes	1.5	1	1.1	1.2	1.1	0.5	1.5	1.7	1.3
% people fishing lagoon	37	33	33	57	57	8	42	49	11
% people fishing reefs outside lagoon	34	42	58	43	36	58	32	46	65
% people fishing barrier islands	100	6	5	83	7	92	11	11	5
% people fishing open sea	24	11	5	27	14	50	21	24	19
Mean frequency of fishing trips per week	2.8	2.6	2.6	1.8	2.5	3.1	3.1	2.5	2
% people who own land	100	97	100	100	93	100	100	92	92
Mean number plots of land per person	2	1.3	2.7	2.1	2	2.3	2.2	2	2.2
Mean frequency gardening trips per week	3.3	2.4	2.9	2.8	4.1	5.3	3.4	2.3	2.5
% people involved in timber industry	15	8	23	23	43	17	26	35	11
Mean frequency of days working in/for the community per week	1.9	1.4	2.3	2	2	2	1.2	2	1.8
Mean education level (1–7)[a]	2.4	2.6	2.6	3.1	2.4	2.3	2.6	2.5	2.4
% religion Christian Fellowship Church	61	64	98	80	79	0	0	0	0
% religion Seven Day Adventist	2	0	0	3	0	0	0	89	0
% religion United Church	24	31	0	0	0	92	90	8	95
% religion other	12	6	2	17	21	8	10	3	5
% born in same region as currently resides	76	58	83	80	71	50	53	30	89
% engaged in paid work	10	39	38	33	29	0	32	41	27
% subsistence livelihood only	66	58	58	67	64	100	42	49	60

[a] 1 = none, 2 = up to std 6, 3 = up to form 3, 4 = up to form 5, 5 = up to form 6, 6 = college or similar, 7 = university or similar

Detrimental activities include the small-scale, exploitation of commercial species like Holothurians, Trochus, and various shell species, the increasing pressures on the subsistence fishery include small-scale commercial netting of fish, night diving for Scarids, and for rock lobsters for the growing tourist industry, the collection of corals for building structures such as wharfs and seawalls, and the aquarium fish collection trade. This pressure coupled with the logging of coastal forests, increased agricultural pests, and other climate change-related environmental effects are increasingly degrading the environment and its future role in providing sustenance for people.

Local inhabitants have a deep awareness of the biological rhythms of their marine and terrestrial ecosystems, and the creatures that inhabit its numerous habitats, as well as an understanding of seasonal climatic variation. This knowledge is rooted in the long-term ecological interactive experiences of the ancestral coastal peoples who inhabited the lagoons and shores of these islands. Knowledge that is not only an intergenerational transfer of information, but is also one that is transformed within the context of people's practical engagement with, experience of, and performance of productive activities in a dynamic and changing natural environment (Ingold 1993). Today, however, indigenous ethnobiological knowledge is being transformed by the introduction of new exploitation technologies and Western environmental categories and discourses. In fact, recent research suggests that Western Solomons people are increasingly losing recognition of taxonomic distinctiveness of marine assemblages (Aswani 2014; Albert et al. 2015). For all this change, however, locals still possess (1) cognitive maps of the landscape and seascape and organisms therein, which translate into actual resource classification, use, and allocation geographically; (2) recognize the local ecological processes and changes, including habitat structure (habitat delineation), species composition and distribution, and spatiotemporal biological events of the resources that they exploit; (3) possess proxy information to identify sites that incorporate the ecological processes that support biodiversity, including the presence of exploitable species, vulnerable life stages, and inter-connectivity among habitats (Olds et al. 2014), and (4) are able to identify some past and ongoing environmental and climatic changes (Aswani and Lauer 2014). It is important to recognize, however, that ecological knowledge of aspects of the ecosystem or climate that are not related to harvest strategy are less well understood locally.

Methods

Indigenous knowledge of environmental and climate transformations was documented through interviewing, particularly semi-structured interviews and free-listing exercises. We designed an interviewing strategy capable of recording information about locally perceived environmental change with responses that were not contaminated by external preconceived biases (e.g., due to media exposure) about "climate change." The aim was to generate representative data that would not exclusively rely on anecdotal impressionistic information, but rather be based on direct empirical observations and through contact with the environment of informants.

Research was conducted across various sites in the Western Solomons including five villages in the Roviana and Vonavona Lagoons (Kindu, Kinda, Nusa Banga, Nusa Hope, and Olive), three communities in Marovo/Nono Lagoon (Ninive, Bareho, and Bopo), and one village on Vella Lavella Island (Leona). In each village, we attempted to identify fifty individuals to interview (with equal numbers of men and women represented), modified by the size of the community (e.g., Kinda, Ninive and Bopo are tiny communities). This sample was elaborated applying a systematic random selection process to a census previously developed by other members of the research team working on analyzing the local impacts of the 2007 tsunami. Only individuals between 25 and 60 years old were selected and we tried to avoid individuals from the same household. In villages with high levels of mobility, absenteeism, or unreliable information, however, we needed fall back strategies to reach the target of fifty interviews per village. The first fallback approach was to create a list of up to 70 possible interviewees with the right attributes. If after going over the list we did not generate enough interviews due to absentees, we attempted to get another individual from the household of the initially selected interviewee. If all failed, we randomly searched for individuals of designed age and gender in that village. This strategy resulted in a total of 266 interviews across all villages (Table 1).

Respondents were asked to describe and list the changes they had observed across predetermined environmental and climatic *domains* including "open sea" (open ocean outside the lagoons and coral reefs), "outer reef" (reef drops outside lagoons, and intertidal zone of the barrier islands), "lagoon (marine)" (lagoon pools, channels, shallow and mid-depth coral reefs and reef drops), "land ecology" (non-agricultural land ecology such as forests and mangrove), "agriculture" (agricultural plots and gardens), and "weather" (weather patterns, e.g., rainfall, temperature, seasonality, extreme events, etc.). During the interviews, we purposely never mentioned the concept of "climate change," and we asked informants to list the changes they had perceived over the last few decades for each domain. The responses were free listed allowing each respondent to list as many responses as they wanted. The assumption was made that the first response is the most significant change recognized by the informant (for each domain) and so forth. For each change, in turn, respondents were also asked to list the causes of change, whether or not the changes were negative, when they were first noticed, and how they had adapted to the change. For the causes of change, the scores for each cause were calculated in the same way as the perceived change data.

Changes and causes were each coded into a standard set of responses and were reduced to the codes that characterized 95 % of the replies. The remainders were given the code of 'other.' Data were examined to determine the most frequent changes observed for each system because respondents gave different numbers of changes and causes. For example, one respondent may have listed only one observed change in the open sea, while another had listed three changes. The maximum number of changes/causes listed for any individual was four. The scores for each "change" or "no change" observation were summed across all data (first listed observation = 4, second listed observation = 3, third listed observation = 2, fourth listed observation = 1) and then respondents were asked if they saw the change as a problem or an opportunity. Finally, respondents were asked when they first noticed the change and how they had adapted to it. The data were split into decades, except the 2000s that were cut from 2000–2007, and 2007–2011. The reason for the split was the 2007 earthquake and tsunami that many respondents used as a reference point for noticing the change.

For the participatory image interpretation research, we sampled in Olive and Nusa Hope villages to further investigate the spatial dimensions of local perceptions of change in the described predetermined domains over the past twenty-five years (1986–2011). Knowledgeable informants were selected through a snowball sample to interpreted remotely sensed data (e.g., identify reef, garden, and plantation types) and delineate changes in domains on large-format image printouts. Groups convened upon arrival in each community, and meetings were held in each

Table 2 All coded changes for each domain, including the number of respondents who mentioned the change (*n*), and the total free list score (*ts*)

Codes	Open sea		Outer reef		Lagoon		Land ecology		Agriculture		Weather	
	n	*ts*	*n*	*ts*	*n*	*ts*	*n*	*ts*	*n*	*ts*	*n*	*ts*
Less fish/fishing more difficult	**61**	**231**	**61**	**227**	**25**	**95**						
Fishing/gleaning easier												
Habitat damage	8	28	**39**	**147**	9	32					1	3
Reef now exposed/higher	9	35	25	98	5	20						
Less marine life (not fish)	17	53	43	146	15	53	2	7				
More marine life (not fish)			11	35	4	15						
Sea level change	13	51	13	51	7	24						
Dirtier/more turbid water	16	57	12	45	**32**	**120**	3	10	1	3		
Change in tides	34	128	19	71	19	72					2	7
Stronger current	**37**	**134**	7	28	10	39					1	4
More waves	10	37										
More bad weather											8	29
Unpredictable seasons	8	29					1	4			**60**	**225**
More wind	2	4									32	109
More rain											**141**	**550**
Hotter sun/hotter temp											23	81
Less rain											6	22
Less available land					2	7	4	16	1	4		
Less mangrove			1	2	19	72						
Less vegetation					7	26	**87**	**337**				
Crops eaten by pests					5	18	7	22	**53**	**190**		
Soil damage							14	55	19	69		
Less productive crops							11	43	**175**	**692**		
More flooding/landslides							14	54	3	10		
Deforestation/overharvesting							13	51				
Logging introduced					4	16	**45**	**178**	1	4		
Increase population			1	4	21	75	7	27				
More conservation	2	6	3	12	1	4			1	4		
Other	11	40	19	76	23	90	26	94	18	68	6	22
No change	**105**	**420**	**74**	**296**	**106**	**424**	**69**	**276**	**34**	**136**	**49**	**196**
Total number of codes	333	1253	328	1238	314	1202	303	1174	306	1180	329	1248

The top three changes for each domain are in bold. Blank values indicate no respondent gave this coded response

village's town hall. The group was informed that the objective of the exercise was to map collectively observed changes in their environment across their neighboring areas. They did this by drawing points, lines and polygons on the satellite images, color-coded according to the nature of the impact. Afterward, we photographed the marked-up images with a digital camera for digitizing. To enable further analysis, Esri's ArcGIS software was used to scan the participants' drawings and associated written descriptions. The photographs of each marked-up satellite image were geo-referenced, and each drawing was digitized as a unique point, line, or polygon feature representing the location of an impact on the environmental domains. The digital features were assigned attributes corresponding to the ancillary written data collected during the mapping exercise. These attributes describe (a) the village of the participants who created the drawing; (b) the domain associated with the picture, and (c) a description of the noticed impact. In this paper, examples are presented to complement the free-listing and interviewing exercise.

Results

For changes in each domain, data were examined to determine the most frequent changes observed for each system. Table 2 shows all coded changes for each field, including the number of respondents who mentioned the

Table 3 Summary of top three changes for each domain, the total number of change codes for each domain, and the number of respondents who mentioned the change (*n*), and the total free list score (*ts*)

Domain	No. codes	Change 1	Change 2	Change 3
Open sea	14	No change ($n = 105$, $ts = 420$)	Less fish/fishing more difficult ($n = 61$, $ts = 231$)	Stronger current ($n = 37$, $ts = 134$)
Outer reef	14	No change ($n = 74$, $ts = 296$)	Less fish/fishing more difficult ($n = 61$, $ts = 227$)	Coral reef damage ($n = 39$, $ts = 147$)
Lagoon	18	No change ($n = 106$, $ts = 424$)	Dirtier/turbid water ($n = 32$, $ts = 120$)	Less fish/fishing more difficult ($n = 25$, $ts = 95$)
Land ecology	14	Less vegetation ($n = 87$, $ts = 337$)	No change ($n = 69$, $ts = 276$)	Logging ($n = 45$, $ts = 178$)
Agriculture	10	Less productive crops ($n = 175$, $ts = 692$)	Crops eaten by pests ($n = 53$, $ts = 190$)	No change ($n = 34$, $ts = 136$)
Weather	11	More rain ($n = 141$, $ts = 550$)	Unpredictable seasons ($n = 60$, $ts = 225$)	No change ($n = 49$, $ts = 196$)

Table 4 Summary of three most cited causes for main changes (excluding 'no change'), including the number of respondents who mentioned the cause (*n*), and the total free list score (*ts*); and total number of causality codes for each domain and change

Domain	Change	No. codes	Cause 1	Cause 2	Cause 3
Open sea	Less fish/fishing more difficult	18	Harvesting pressure ($n = 22$, $ts = 79$)	Don't know ($n = 15$, $n = 60$)	Population increase ($n = 11$, $ts = 42$)
	Stronger current	6	Don't know ($n = 18$, $ts = 72$)	Sea changes[a] ($n = 6$, $ts = 24$)	Climate change ($n = 6$, $ts = 22$)
Outer reef	Less fish/fishing more difficult	17	Harvesting pressure ($n = 38$, $ts = 140$)	Don't know ($n = 11$, $ts = 44$)	Habitat disturbance ($n = 9$, $ts = 33$)
	Coral reef damage	11	Logging ($n = 10$, $ts = 38$)	2007 Earthquake & tsunami ($n = 12$, $ts = 47$)	Don't know/Sea changes (*both:* $n = 8$, $ts = 29$)
Lagoon	Dirtier/turbid water	9	Logging ($n = 28$, $ts = 101$)	Soil erosion & runoff ($n = 7$, $ts = 23$)	Climate variability ($n = 5$, $ts = 19$)
	Less fish/fishing more difficult	13	Harvesting pressure ($n = 14$, $ts = 50$)	Population increase ($n = 10$, $ts = 37$)	Logging/Don't know (*both:* $n = 3$, $ts = 12$)
Land ecology	Less vegetation	10	Logging ($n = 65$, $ts = 252$)	Need for money & 'greed' ($n = 19$, $ts = 68$)	Don't know ($n = 4$, $ts = 16$)
	Logging	10	Loggers ($n = 23$, $ts = 88$)	Need for money & 'greed' ($n = 12$, $ts = 46$)	Don't know ($n = 7$, $ts = 28$)
Agriculture	Less productive crops	14	Reduced soil fertility & overuse of land ($n = 80$, $ts = 292$)	Pests ($n = 59$, $ts = 218$)	Don't know ($n = 34$, $ts = 135$)
	Crops eaten by pests	8	Don't know ($n = 24$, $ts = 96$)	More pests ($n = 14$, $ts = 54$)	Logging ($n = 12$, $ts = 44$)
Weather	More rain	7	Don't know ($n = 102$, $ts = 408$)	Climate change ($n = 11$, $ts = 44$)	Climate variability ($n = 7$, $ts = 27$)
	Unpredictable seasons	7	Don't know ($n = 36$, $ts = 144$)	Climate change ($n = 12$, $ts = 45$)	Logging ($n = 5$, $ts = 19$)

[a] Sea changes refers to changes in the sea such as size of tides and waves, and "reef getting higher"

change (*n*), and the total free list score (*ts*), and the three top perceived changes for each environmental domain are summarized in Table 3. For all aquatic fields, the first change was "no change" followed by other causes including less fish, dirty/turbid water, coral damage, and stronger currents. For land ecology, the three main changes

Table 5 Perceived changes by domain and number of respondent who perceived the change as a problem or opportunity, or both

Domain	Change	Problem (n)	Opportunity (n)	Problem & opportunity (n)
Open sea	Less fish/fishing more difficult	58	1	0
	Stronger current	33	1	1
Outer reef	Less fish/fishing more difficult	57	1	0
	Coral reef damage	37	0	1
Lagoon	Dirtier/turbid water	30	0	0
	Less fish/fishing more difficult	25	0	0
Land ecology	Less vegetation	75	7	4
	Logging	44	0	1
Agriculture	Less productive crops	161	2	2
	Crops eaten by pests	50	0	0
Weather	More rain	128	4	7
	Unpredictable seasons	56	1	1

correspondently were less vegetation, no change, and logging, while for agriculture they were ordered as fewer productive crops, crops eaten by pests, and no change. Finally, for weather the three more common changes in order of importance were more rain, unpredictable seasons, and no change (Table 3). Table 4 shows a summary of the top three perceived causes of primary changes for each system. In marine ecosystems, change was driven by harvesting pressures, logging effects, "sea changes," and population growth, while for terrestrial systems the main drivers of change were logging, reduced land fertility and overuse, and pests. Finally for weather, the drivers of change were unknown, climate change and climate variability, respectively. For each of these, respondents were also asked if they saw the change as a problem or an opportunity. Some respondents saw it as both a problem and an opportunity, but most respondents saw most changes only as a problem in each system (Table 5).

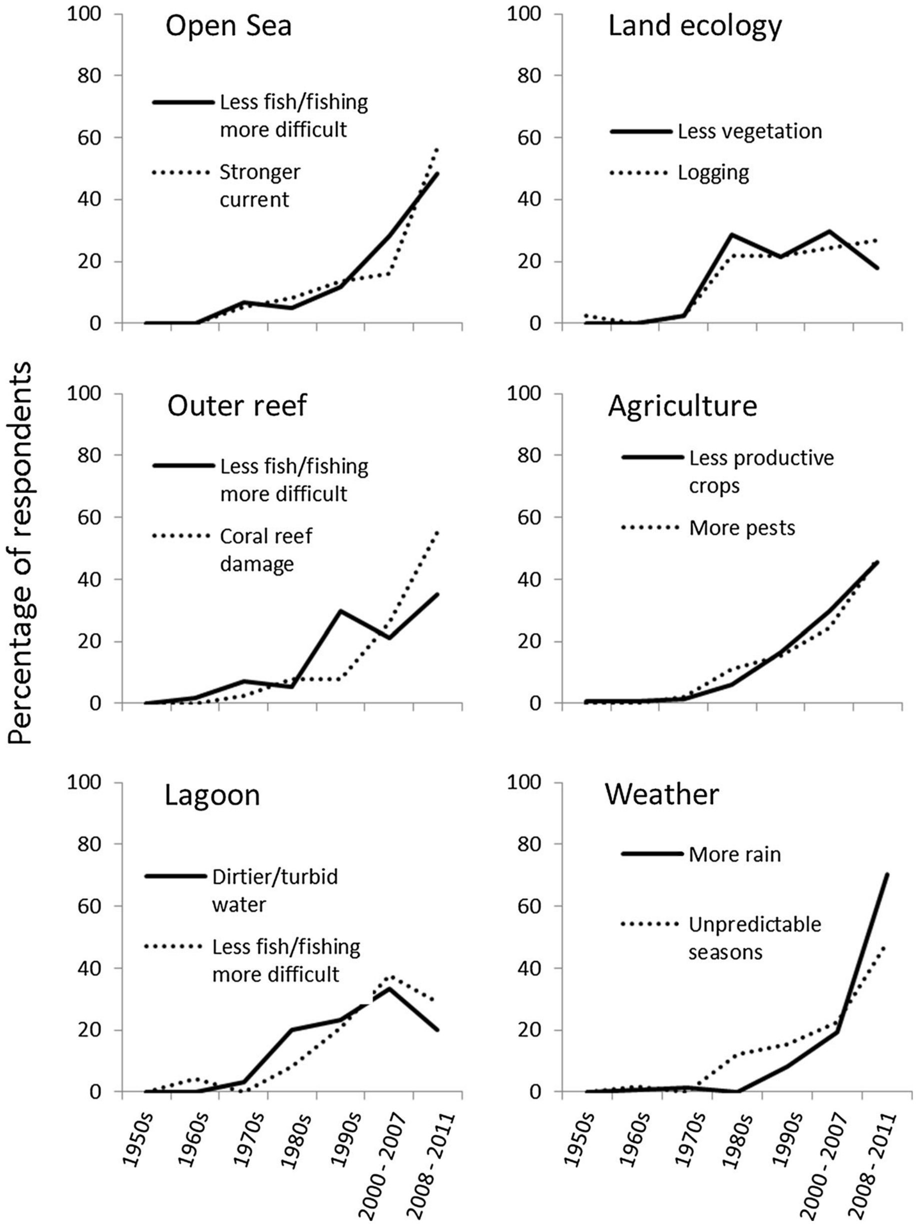
Respondents were also asked when they first noticed the change. Many respondents used the 2007 earthquake and tsunami as a reference point for seeing changes. This is particularly relevant for the lagoon system, where most respondents connected changes in the lagoon with the tsunami event. Changes in the open sea, outer reef, agriculture, and weather systems have mostly been noticed in the past few years, and changes in land (less vegetation and logging) have been seen mainly since the 1980s (Fig. 2). In terms of adaptation to these changes, the most common actions, or lack thereof, were no response, change of location or change activity correspondently (Table 6).

Results for the mapping exercise revealed that informants recognized changes in areas that are essential for their subsistence including changes in both aquatic and terrestrial ecosystems between 1986 and 2011. For marine domains, particularly the open sea and the outer reef habitats, the main changes identified for particular locations were a decrease in the frequency of certain important species for both subsistence (tunas, barracudas) and for commercial purposes (deep water/red snappers) caused by harvesting pressure (Fig. 3), which parallels the views of a number of informants who participated in the free-listing exercise (Tables 2, 3, and 4). In the terrestrial domain, land ecology and agriculture, informants identified a substantial expansion of gardening (Fig. 4) and plantation (Fig. 5) areas in the barrier islands between 1986 and 2011 and the concomitant reduction of natural vegetation caused by logging, overuse of land, and the increasing commercialization of certain crops such as cocoa and copra (i.e., "greed" in Table 4).

Discussion

This paper has documented local perceptions of environmental and climate change and analyzed the adaptations that local populations have designed to adapt to those changes. The complementary participatory mapping exercise also obtained spatial insight into the participants' perceptions regarding past and ongoing environmental changes in the region. The results suggest that islanders are detecting some changes in their environment, particularly changes that tend to be acute (e.g., water clarity, logging intensity, and agricultural diseases). This kind of information is necessary for incorporating local change detection perceptions and capabilities into climate change adaptive management and disaster risk reduction plans (Adger et al. 2005; Berkes and Jolly 2001; Mawdsley et al. 2009; Gero et al. 2011).

Fig. 2 Percentage of respondents who noticed most common changes by decade



Unexpectedly, coastal people of the sampled Western Solomons were more likely to have perceived changes in the terrestrial environment and with weather patterns than for the marine environment. For marine systems, if changes were recognized, the variety of changes perceived tended to be greater than for agricultural and weather systems, where the changes observed were more consistently reported. It is possible that those people who often engaged in fishing were those who identified varied changes in marine ecosystems, whereas those who do not regularly fish were more likely to see "no changes." This is possible because most people do not spearfish, and transformations underwater are not as apparent as terrestrial and climatic changes, which are more visible and direct. In a parallel study (Abernethy et al. in press), we used census data for each respondent as predictors of how individuals may perceive change differently according to gender, education, age, economic status, and modernization among other factors. Results from this study suggest that for the open sea and outer reef systems only distance to markets and gender principally were statistically significant. Males were more likely to have perceived change than females who saw "no change" at a greater frequency. This difference makes sense because open sea and outer barrier reef fishing are the domain of men. For the lagoon system, only years of education and distance to market were statistically significant, and age and gender had little discernible effect. The further away from markets people lived, the less likely

Table 6 The most common adaptation response to the most common changes for each domain

Domain	Change	Most common adaptation	Description
Open sea	Less fish/fishing more difficult	Changed location	In response to less fish in open sea, fishers have changed where they fish. There was no common theme of where
	Stronger current	Changed location	In response to stronger current, fishers have changed where they fish. There was no common theme of where
Outer reef	Less fish/fishing more difficult	No response	
	Coral reef damage	No response	
Lagoon	Dirtier/turbid water	No response	
	Less fish/fishing more difficult	Changed location	In response to less fish in the lagoon, fishers have changed where they fish. 3 out of a total of 8 respondents said they fish further outside the lagoon
Land ecology	Less vegetation	No response	
	Logging	No response	
Agriculture	Less productive crops	Change of planting regime	In response to less productive crops, respondents have changed what they plant. Cassava tends to be planted instead of other root crops. Alternatively respondents have made their gardens larger
	Crops eaten by pests	No response	
Weather	More rain	No response/ changed activity	In response to more rain, respondents tend to stay at home rather than work in the garden or fish
	Unpredictable seasons	Changed activity	In response to unpredictable seasons, respondents tend to stay at home rather than work in the garden or fish

to recognize the change, probably as a result of reduced population and commercial pressure and concomitant ecological degradation in resilient lagoon ecosystems.

Results also suggest that people are experiencing a shifting baseline (Pauly 1995) and that the characteristics of a changing marine environment have been normalized into daily foraging activities. This idea is supported by a recent study of time series fishing data (1995–2011) in the Roviana Lagoon which shows that within a span of about 15 years fishers are traveling further and spending more time fishing than before. The data also show that the average catch per fishing trip has increased slightly as people venture further and spend more time fishing than before (Albert et al. 2015). Fishers, therefore, have adapted and responded to ecological change by expanding their fishing range and effort, and have likely regularized this behavior into their subsistence practices. This is supported by the adaptation data in marine systems (Table 6) and the spatial analysis. Fishers, said their main adaptive response to environmental change in all systems except outer reef, was to move fishing grounds. The spatial analysis shows that nearby fishing grounds are less abundant today than in 1986 and that the more distant sites are still plentiful, particularly for barracuda (Fig. 3). Hence, their failure to quickly identify change when interviewed may be a result of inherent or sub-conscious adaptive capacity to changes rather than lack of environmental change perception or understanding. This is a potential limitation of relying on structured survey perception data alone for identifying local understanding of ecological change. This limitation can be minimized with parallel participatory remote sensing/GIS and foraging analysis studies.

Insofar as causes of change, people did not know or even attempted to answer what the causes of change were, which perhaps could have been better recorded through other ethnographic approaches (e.g., participant observation and open-ended interviews). When providing an answer, a lot of blame for a change was assigned to logging and ‘climate change,’ and this may be more a product of NGO-led awareness than direct understanding of the causes of change. It is important to recognize that “climate change” is also a cultural category that has been globalized in people’s discourse, and even more so in this area because this research was part of a climate adaptation research program led by the first author (albeit the study was conducted before the awareness campaign). Everyone has heard about climate change, and even the most remote of communities have been exposed to the imagery of rising temperatures and sea level rise. If the research with human subjects inquires about climate change, it will have difficulty disentangling this ‘imported’ information from the locally contextualized knowledge. Research on climate

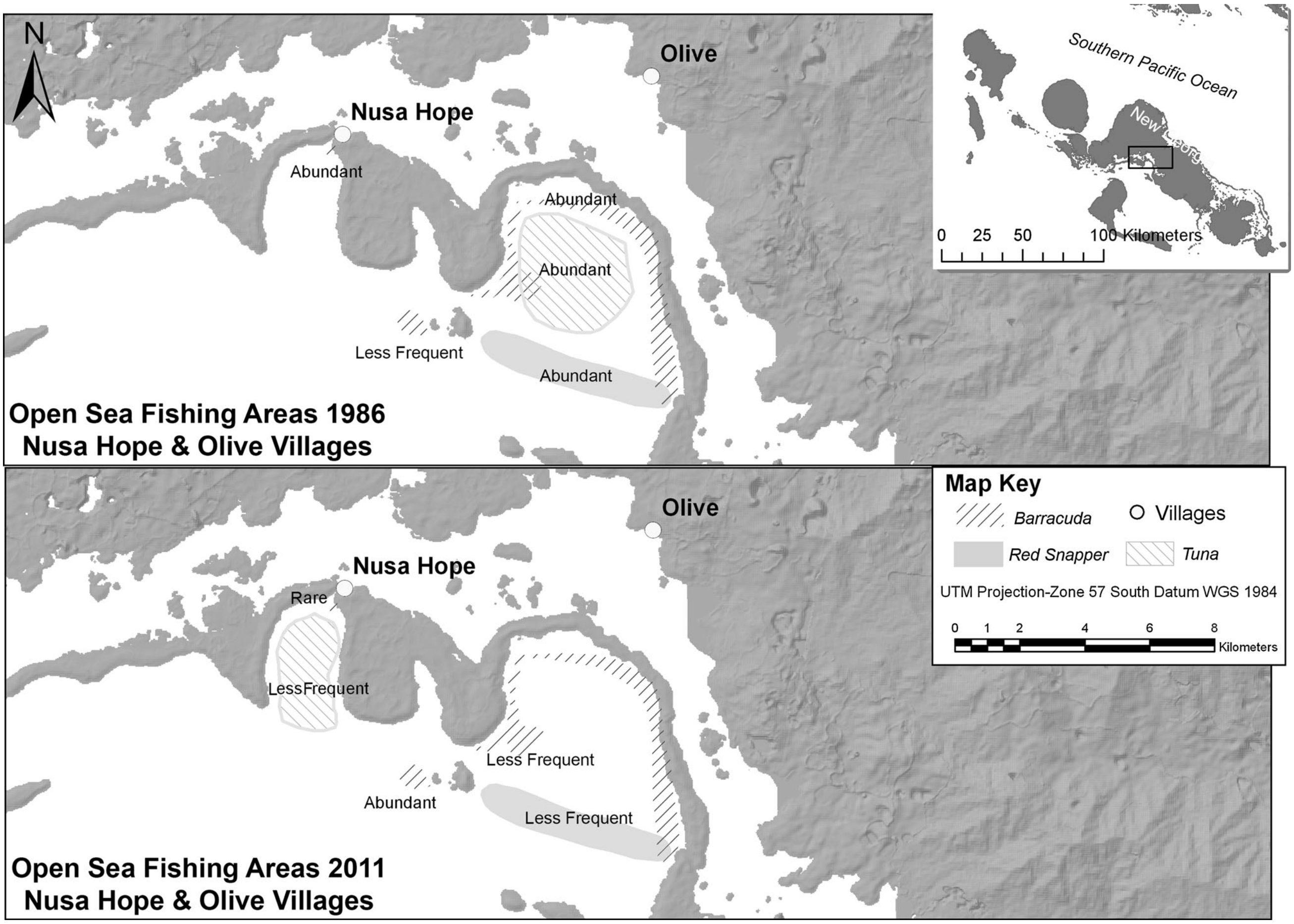


Fig. 3 Locally recognized changes in abundance of key prey species in the Olive and Nusa Hope areas between 1986 and 2011

change, therefore, is better avoiding the use of climate change language when interviewing local subjects to avoid directing them toward an exogenous discourse about the environment. Instead, research on environmental and climatic transformations must inquire about generic change, so the very specific locally contextualized ethnobiological knowledge is prioritized as much as possible. While our understanding of climate change benefits from scientific gathering of world data and the construction of generic models, on-the-ground research is the micro-foundation of global environmental change research because this is how it is experienced and lived (and adapted to) by both ecosystems and human populations.

As argued by Marin and Berkes (2013), climate change media discourse can influence local people's perceptions, but these tend to be only superficial. Local people experience their environment differentially and can discern local processes beyond these superficial narratives. Environmental and climatic changes can be observed in local populations with prolonged and intense connections with their environments that experience high natural variability, and consequently, they are well equipped to identify change and adapt to it. Scientific evidence such as altered food web dynamics, reduced abundance of habitat-forming species, and shifting species distribution (Hoeg-Guldberg and Bruno 2010) is what researchers are looking for in local contexts around the globe, i.e., specific generic indicators with local and wide geographic validity. Coastal climate-related environmental changes are occurring, and local populations are experiencing change on a daily basis as they forage across their marine and terrestrial habitats. The local perception and eventual response to these changes goes well beyond the need for its documentation. Therefore, we need further methodologies designed to connect responses or adaptation planning with this locally generated environmental knowledge emerging from the direct experience of climate change.

The livelihoods of coastal communities in the Pacific Islands are increasingly becoming vulnerable to anthropogenic and naturally driven disturbances. Thus, to build resilience in coastal social and ecological systems requires a capacity for communities to learn from ongoing

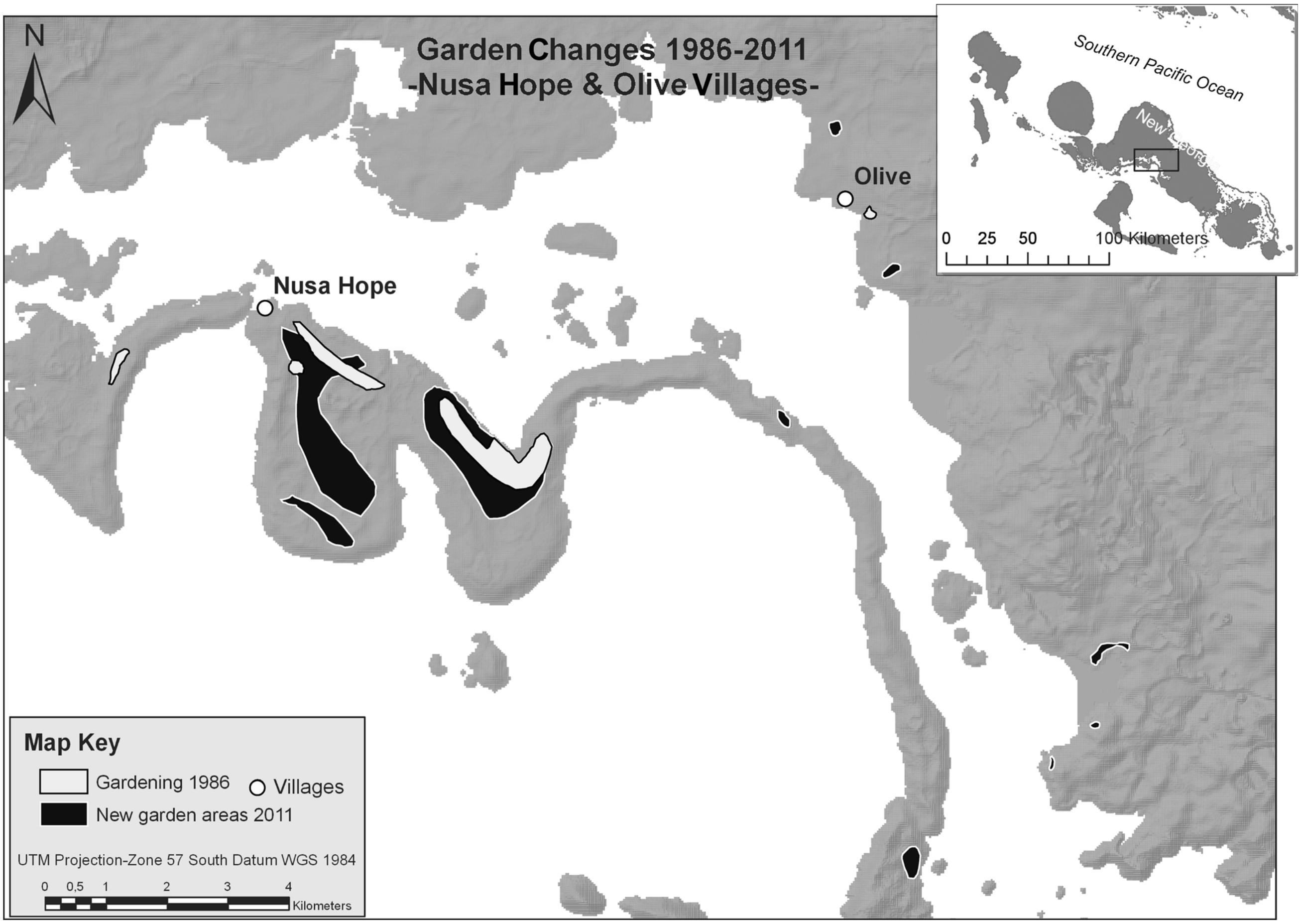


Fig. 4 Locally recognized changes in garden areas in the Olive and Nusa Hope areas between 1986 and 2011

environmental changes, which in turn enhances locally autonomous and anticipatory adaptive response of communities. This is because the ways in which individuals detect and respond to change shapes how information feeds back into the social and ecological system, a process that influences people's livelihoods and their managerial responses as they adapt to new environmental circumstances. The failure to detect, understand, interpret, and thus respond to change undermines resilience and exacerbates vulnerability to ecological transformations. Measuring this capacity for adaptation is essential for building heuristic models of feedback loops in social and environmental systems. This theoretical and practical link needs further exploration in social-ecological research if we are to develop an understanding of how humans adapt to a changing environment (Aswani and Lauer 2014).

For instance, building conceptual models (e.g., multinomial logit, Abernethy et al. in press) are critical to that examine differential perceptions of change within and between communities, and the existing asymmetries of how individuals may perceive change differently according to gender, education, age, economic status, and distance to markets among other factors. Other researchers have used approaches such as Bayesian Network Analysis to understand what contributes to the probability of attributing change to a particular cause, which can include the demographic, social, and economic characteristics of the respondents as well as other internal and external variables. Such approaches are also developing conceptual models of the variables and relationships that help drive/influence adaptation action (or conception of) to perceive future changes (van Putten et al. 2013). Hence, many promising approaches are being developed to better to understand human perceptions of environmental and climatic changes, their causes, and adaptation actions taken by people to locally cope with these transformations.

In sum, local perceptions of change documented through this study tended to be acute shifts in water clarity, logging intensity, and agricultural diseases rather than gradual chronic changes in parameters such as sea level, air temperature, and seawater temperature. These progressive changes resulting from climate change are perhaps more susceptible to shifting baselines syndrome where many observers may not notice distinct changes within their

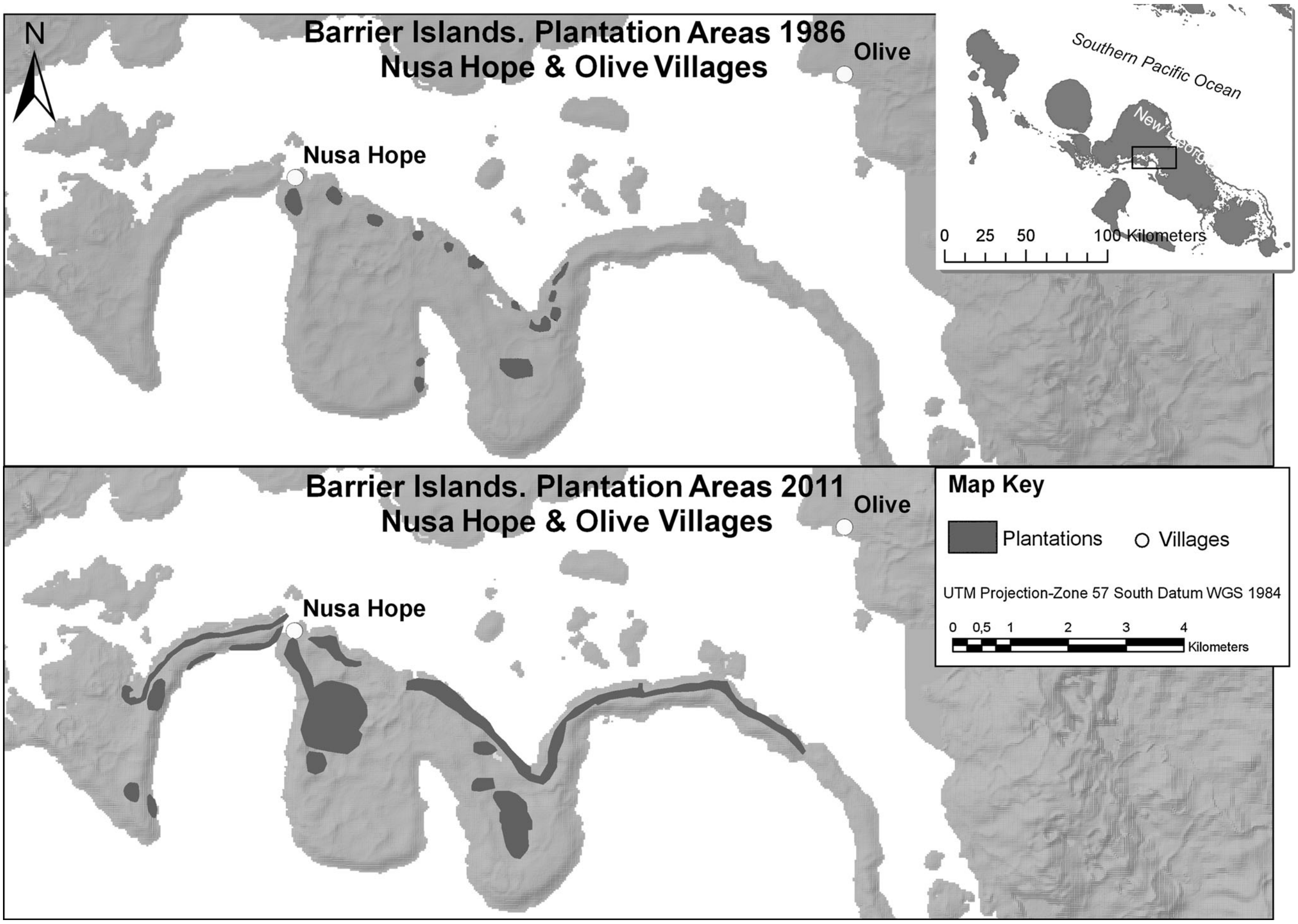


Fig. 5 Locally recognized changes in plantation areas in the Olive and Nusa Hope areas between 1986 and 2011

temporal frame of reference. As such, it is important to understand possible deficiencies or gaps in ethnobiological understanding and utilize quantitative scientific data to fill these gaps in understanding. Likewise, many of the changes observed by local community members are occurring at fine spatial scales that western scientific knowledge or numerical models are not able to assess. These temporal and spatial limitations of both the scientific and ethnographic approaches can best be overcome by combining these two methods into trans-disciplinary assessments to guide local-scale adaptation.

This integrated information is critical if we are to scale up from local adaptive response planning to regional and international policy. This is because the nuanced detection (or lack thereof) adaptation/response that is community driven and which may, or may not, build social and ecological resilience locally are the building information blocks of any larger policy initiative that relies on either bottom-up or top-down or both approaches. In this research, the interview and mapping results suggest that adaptation planning should be a combination of top-down and bottom-up approaches in which local understandings are documented and combined with scientific studies for both discussing adaptation options locally (e.g., community-based disaster risk reduction) and for outside agencies to design and implement 'anticipatory' adaptive response plans locally. This experience, in turn, can invariably assist in the development of wider regionally, national, and internationally climate change adaptation schemes.

Conclusion

It can be inferred from the results in this paper that most local observation of change is related to parts of environment/ecosystems that are directly or indirectly related to harvesting strategies. Therefore, for understanding some components of environmental and climatic change, local observations may be very accurate, but for others such as seawater temperature that have a less obvious link to harvesting success, the observations of change may be inadequate. Our results suggest that adaptation planning could include a mix of scientific and local observations, with the latter being relied on more for aspects of the environment that are directly related to harvesting strategies. Scientific data could be relied on for slower insidious/chronic changes that perhaps people do not as readily perceive because they are not directly related to harvest pressure, or the changes are so slow that shifting baselines cause people not to identify the changes.

Research on local climate change and its environmental and social consequences requires an interdisciplinary approach that includes quantitative and qualitative research and combines different types of knowledge. The significance of the study herein reveals the importance of combining scientific ecological data with local fine-grained qualitative and spatial ethnobiological data. The ethnobiological data can only be rich enough if quantitative (representative, covering a large set of the population) and qualitative (deep knowledge resulting from thorough understanding of the local categories and meanings) knowledge are combined. This kind of integrated information will be critical for designing bottom-up community-based disaster risk reduction plans as well as top-down 'anticipatory' adaptive response plans to climate change locally.

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