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Stakeholder perceptions of ecosystem service declines in Milne Bay, Papua New Guinea: Is human population a more critical driver than climate change?

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ABSTRACT

Milne Bay Province (MBP) in Papua New Guinea is a priority seascape in the Coral Triangle marine biodiversity hotspot. Goal 4 of the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security promotes adaptation planning for small island ecosystems and communities threatened by climate change, but information to identify vulnerable islands and priority interventions is limited. This study adapted the Millennium Ecosystem Assessment (2005) framework in MBP with regional stakeholders to project trends in harvested or cultivated 'provisioning' ecosystem goods and services (EGS), human well-being, drivers of change and necessary management strategies, based on their tacit knowledge. In 2010 five island subregions which are susceptible to food insecurity were assessed. Workshop participants identified freshwater, garden food crops, coral, bêche-de-mer, reef fish and sharks as the most important EGS in all subregions. Terrestrial EGS contributed 43% of aggregated ecosystem-derived well-being, and marine EGS 57%. By 2030 the overall condition of EGS was projected to decline by $>50\%$. The primary driver in all subregions was human population growth, and climate change impacts were predicted in only two subregions. Improved garden and agricultural productivity and population control were the highest ranked management strategies. Population relocation was also prioritised for two subregions where human carrying capacities may soon be exceeded. Although none of the strategies addressed climate change directly, all could yield climate adaptation and marine conservation co-benefits by enhancing ecosystem-based adaptation and community adaptive capacity. It is suggested that there is a 20–30 year 'adaptation window' in which to address population growth, which otherwise will continue to erode the capacity of communities and ecosystems to cope with potentially extreme climate impacts after mid-century.

1. Introduction

Change, including climate change, is occurring at unprecedented rates, resulting in compounding impacts on ecosystems [1]. Rural communities in less developed regions are particularly sensitive because their livelihoods and well-being are highly dependent upon local ecosystem goods and services (EGS) for their subsistence and cash needs [2,3], exacerbated by their limited adaptive capacity [4,5]. Adequate scientific data on the status and trends of ecosystems and the EGS that they provide, plus the nature of stressors on these EGS, are typically scant in such regions, accentuating their vulnerability [2].

In these situations stakeholders' tacit knowledge, garnered through rapid participatory assessments, may be an important source of information with which to formulate policy and management interventions [3,6]. Engaging local stakeholders to characterise social–ecological systems and design management strategies can also foster adaptive capacity by enhancing social learning, the co-production of knowledge, mitigating power asymmetries and creating ownership of problems and solutions [2,7–11]. Conversely, the utility of local information may be constrained by stakeholders' world-views which are based on local experience, and a lack of awareness of influences from higher scales [12]. Also, the integration of complex scientific information into participatory processes, such as climate change modelling and its inherent uncertainties, can be problematic. Unless information is contextualised in local terms [13] and stakeholders are sufficiently engaged in the production of knowledge it may lack salience,

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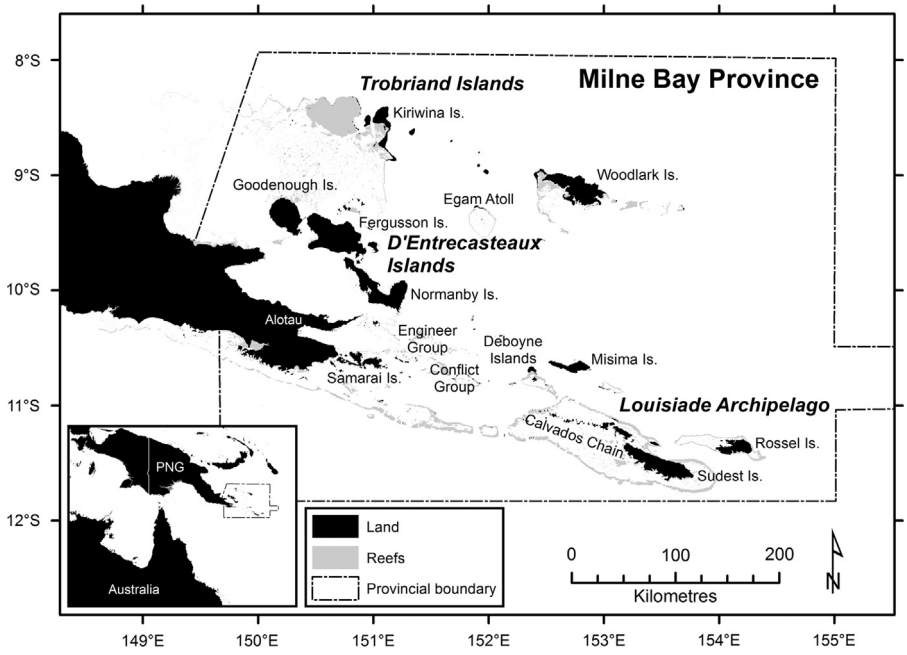

Fig. 1. Milne Bay Province in Papua New Guinea (PNG) and its major island groups and coral reefs.

credibility and legitimacy [14], resulting in an underestimation of potential future impacts [10]. Furthermore, external scientists can exercise considerable power in participatory processes, potentially influencing the results generated [11].

The Coral Triangle is one such region. It consists of the developing nations of Malaysia, Indonesia, the Philippines, Timor Leste, the Solomon Islands and Papua New Guinea (PNG), and is a global hotspot for marine biodiversity, containing over 75% of the world's known hard coral species [15], over 3000 species of reef fish [16,17], and 31% of the world's mangroves [18]. Approximately 120 million people benefit directly from marine-derived EGS [19], and many inhabit the region's numerous remote, small islands [20,21]. In response to escalating anthropogenic degradation of coastal and marine habitats, exacerbated by climate change, and the imperative to simultaneously protect biodiversity and livelihoods, the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI) was established in 2009. A partnership between the six Coral Triangle countries, the CTI is funded by the Asian Development Bank, USA and Australian Governments, the Global Environment Fund and non-government organisations (NGOs) including Conservation International (CI). The CTI aims to achieve biodiversity conservation, sustainable fisheries and food security through the implementation of marine protected areas (MPAs) and ecosystem-based approaches to fisheries management.

An additional focus of the CTI is climate change adaptation. Under both 'worst case' and 'best case' scenarios of global carbon emissions, climate projections suggest that until mid-century the region is expected to experience increased sea surface temperatures, ocean acidification, sea level rise and more variable rainfall and intense tropical storms. This is likely to impact coral reefs through bleaching and impeded calcification processes, and hence declines in the productivity of reef fisheries. Sea level rise is expected to impact mangrove and sea grass habitat, and extreme rainfall and storms will cause erosion and run-off from terrestrial catchments, further degrading inshore seagrass and coral habitats. After mid-century projections diverge, and climate impacts may stabilise or escalate considerably [22]. Small island ecosystems will be particularly exposed to sea level rise [19] and increasingly variable rainfall [23].

Consequently Goal 4 of the CTI's Regional Plan of Action [19], and the subsequent Region-wide Early Action Plan for Climate Change Adaptation [24] is to plan adaptation for near-shore and small island ecosystems. However, there is a lack of local-scale scientific information and methodologies with which to prioritise vulnerable communities and habitats, and to develop appropriate adaptation strategies [19]. In addition, fine-scale analyses of livelihood and food security issues are required to account for the heterogeneity of social contexts typical of the CTI region [25]. Also, while there has been a recent focus on adaptation for marine fisheries [e.g. [26–28]] and coastal ecosystems [e.g. [29]], there has been little consideration of the relative importance of terrestrial EGS to small island communities, or linkages to marine resource use and conservation. Consequently, many adaptation studies have been fishery-focussed and overlook broader human development and livelihood issues which may be of greater relevance for the improvement of community well-being [30,31].

This paper presents the results of a pilot participatory exercise designed to address these challenges in Milne Bay Province, PNG, which is a priority seascape in the CTI and contains many small islands of differing geomorphology, ecological and livelihood characteristics. Our results show that regional stakeholders predict acute declines in EGS and human well-being, and that human population pressure is a more pre-eminent stressor than climate change. Furthermore, some islands may be approaching carrying capacity under current livelihood and technological systems, requiring the relocation of inhabitants. Management strategies identified to address population growth and its effects are likely to generate co-benefits for future climate adaptation by building community and ecosystem adaptive capacity. We discuss the relevance of these results for future adaptation planning in Milne Bay, PNG and the CTI, and discuss shortcomings and potential improvements for the method.

2. Study site and methods

2.1. Study site

Milne Bay Province (MBP) is located at the south-eastern tip of the PNG mainland (Fig. 1). MBP's total area is 256,804 km^2, of which 12,943 km^2 is land, and 243,861 km^2 is sea. There are