



Livelihood diversity and dynamism in Timor-Leste; insights for coastal resource governance and livelihood development



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ARTICLE INFO

Keywords:

Small-scale fisheries
Rural livelihoods
Vulnerability
Food security
Shocks

ABSTRACT

Coastal communities within small island developing states are typically highly dependent on fisheries and other natural resource-based livelihoods. However, specialisation as a ‘fisher’ is rare compared to diverse livelihoods that can be adapted as opportunities and challenges emerge. Understanding this dynamic “livelihood landscape” is important for improving governance and livelihood opportunities associated with natural resources. Using data from 495 households across 15 communities on Atauro Island, Timor-Leste, this study evaluates the importance of fisheries within a suite of livelihoods; the correlation of livelihoods structure with wellbeing; and the spatial and temporal variation of those livelihoods. Activities linked to primary production were nominated by 67% of households as their primary livelihood, 41% fished, and of those 54% considered fishing their primary livelihood. Almost all households (95%) owned livestock, and even respondents who considered themselves ‘fishers’ ranked livestock disease, rather than fisheries related concerns, as their most critical livelihood challenge. Engagement in fishing varied by location and time of year. Communities in more protected locales fished throughout the year, and had less diverse livelihoods. This study highlights that interventions focused on self-identified ‘fishers’ would only engage a fraction of the population that derive benefit from fisheries resources, would likely overlook the most prevalent challenges fishers face, and would focus on those with relatively high food security and income. Measures of wellbeing were better explained by geography and socio-cultural settings, rather than dominant income sources. The results emphasise the value of cross-sector development interventions informed by contextualised analysis of livelihoods and wellbeing outcomes.

1. Introduction

People living in the archipelagic and island states of Asia-Pacific rely heavily on terrestrial, freshwater and marine resources for food and income [1,2]: in many situations, alternatives are limited [3]. As a result, these populations (particularly poorer households) are sensitive to resource decline [4] and this sensitivity is heightened by the vulnerable nature of (at least partially) closed island ecosystems [5]. Archipelagic and island states face a unique and persistent set of challenges in ensuring the benefits they derive from natural resources are secure and support human wellbeing. Crisis narratives of resource depletion are near-ubiquitous [1], while effective, affordable and scalable governance solutions remain evasive. Where post-colonial

centralised governance has come to prominence, it has often displaced customary institutions [6]. Inevitably the reach and efficacy of central government is impeded by the geographically dispersed nature of fisheries, social diversity of resource users and the variability of fisheries and associated concerns between different locales [7]; by contrast more collaborative forms of management better account for local knowledge and resource user buy-in [8,9]. Where customary institutions that control the use of resources persist, they risk being overrun to the point of ineffectiveness by new market penetration [10], increasing pressure on resources due to population growth [11] and rapidly evolving harvest technologies [12,13]. To secure and improve the wellbeing of island populations, innovative governance solutions must move beyond tired and ineffective sectoral paradigms, to engage

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<http://dx.doi.org/10.1016/j.marpol.2017.04.021>

Received 28 April 2017; Accepted 30 April 2017

Available online 16 May 2017

0308-597X/ © 2017 Published by Elsevier Ltd.

simultaneously with natural system dynamics, institutional plurality and diverse livelihoods – and be designed in a manner that fits local, national and regional contexts.

Livelihoods are “... a set of capabilities, activities and assets (including both material and social resources) that contribute to a means of living” [14], and are central in mediating human-environment interactions. In coastal communities of developing countries, including small island states, livelihood portfolios of households and individuals are typically diverse – spanning fisheries, agriculture, casual or informal labour, and to a lesser extent, formal employment [15]. Households and individuals shift the focus of their livelihood pursuits in the face of seasonal change, exogenous shocks or emerging opportunities. The structuring, dynamism and diversity of livelihoods are key factors that affect governability of natural resources, the stability and degree of benefits that people derive from resources, as well as people's ability to respond to, and cope with, change [15,16].

Small-scale fisheries commonly feature as a dominant livelihood in many coastal communities across the Asia-Pacific region and fisheries play a central role in food systems of coastal communities globally, and within islands in particular [17,18]. Fisheries are well placed to provide income, quality protein and micro-nutrients to areas that are beyond the reach of formal market chains. In coastal regions away from urban centres, the level of household dependence on fisheries, and ultimately the substitutability of income and nutrition obtained from fisheries, is closely linked to cultural, institutional and demographic drivers [12,19] that play out in the structuring of livelihoods [20]. Small-scale fisheries themselves are characterised as being diverse and dynamic [7,21]. However, in practice small-scale fisheries are just one of many livelihoods that an individual or household might pursue within the same year, week or even day (e.g. [15]). This study, rather than delving into the diversity within fisheries, examines the diversity of livelihoods in livelihood portfolios that include fisheries. Development studies and livelihoods research (e.g. [16]) suggest that even if fisheries governance and development is an entry point for improving environmental outcomes and human wellbeing, understanding the “livelihood landscape” (sensu [15]), and interactions between livelihoods, is a critical early step to guiding the design of those interventions.

This research focusses on Timor-Leste; a young post-conflict island state. The nation exhibits rapid population growth and significant social and economic development concerns. Timor-Leste faces multiple challenges in lifting its people out of food insecurity and generating wealth to fuel national and local economic growth. Timor-Leste is ranked eighth on the Global Hunger Index [22] and has among the highest global prevalence of childhood stunting (low height for age), with more than 50% of children under five stunted [22]. A looming challenge for the nation is to look beyond the current heavy reliance on oil (currently ca. 90% of national income) to a future with a diversified, sustainable and distributed income base that makes optimal use of renewable natural resources.

Fisheries have the potential to play an important role in this nation-building process, however the sector is currently considered to be functioning well below its potential [18,23] – a diagnosis that contrasts with that of most developed and developing countries [24]. A recent consumption survey estimated national average per capita fish consumption to be 6.1 kg per person per annum [25], well below Timor-Leste's neighbour Indonesia (27 kg per person per annum) or the global average (over 20 kg per person per annum)[26]. Low fish supply has been attributed to Timor-Leste's land-based cultural focus [27], physical constraints (e.g. small areas of coastal habitat), supply-demand dynamics [18] and a lack of economic incentive to invest in the sector due to poor infrastructure and low economic returns [28]. Fisheries do, however, play an important role in nutrition and livelihoods of coastal communities. Coastal communities consume an estimated 17.6 kg of fish per person per year – almost three times the national average [25]. There are about 4000 to 5000 fishers in Timor-Leste [29,30]; and about 3000 registered fishing boats [29].

This study comes at a time when the Government of Timor-Leste is pursuing the re-design of fisheries governance systems in line with national strategies to improve nutrition security and food sovereignty. There is broad acknowledgement that existing policy does not capture the potential of fish in food systems, and is not suited to the institutional context of today's Timor-Leste. This study represents the first analysis from a comprehensive livelihood and food security baseline study. The purpose of the study is to ultimately guide the integration of livelihood development activities with improvements to fisheries governance. The study focuses on the most fish-dependent communities in the country. It set out to understand the livelihoods on which households and individuals depend, which of these can be characterised as “natural resource dependent”, and the position of fisheries relative to other livelihoods. Secondly, it aims to determine how different livelihoods and livelihood combinations correlate with three indicators of human wellbeing (i.e. assets, income and food security). Third it seeks to determine temporal and spatial variations within livelihood portfolios. Finally, it seeks to determine where people perceive there to be threats or vulnerabilities associated with their livelihoods.

2. Methods

2.1. Study site

Timor-Leste lies at the eastern end of the Indonesian archipelago and the northern edge of the Arafura Timor Sea (Fig. 1). Timor-Leste is situated within the most marine biodiverse region in the world: the Coral Triangle [31]. Our study concentrates on those communities on Atauro Island, some 26 km north of the nation's capital, Dili, and at the intersection of the deep oceanic straights of Wetar and Ombai. Extreme topography, rising rapidly to 999 m at the peak of Mt Manukoko, continues underwater with very narrow fringing reef giving way to walls and steep slopes often exceeding a 1:1 slope ratio. Strong currents interacting with monsoonal wind systems can effectively cut Atauro off from Dili for days or weeks at a time. The recent development of an airstrip has improved year-round access for emergencies or those who can afford to fly. Atauro has a population of approximately 10,000 residents. The main towns or administrative centres are on the eastern side of the island, and road systems span the eastern side and extend up the mountainous spine. Western coastal villages are reached by foot or boat only. Atauro Island is the most fishery-dependent region of Timor-Leste [23] and for this reason has become the focus for a number of fishery governance and livelihood interventions supported by government, non-government and international development investments.

2.2. Survey design and field methods

A household socio-economic survey was conducted using a structured questionnaire in 15 coastal and inland villages (Fig. 1) of Atauro Island between December 2014 and April 2015. The study was designed to collect both integrative long-term indicators and short-term indicators that could be re-sampled on a seasonal basis with a reduced survey; (only results from the initial survey are presented here). The research team partnered with a local NGO based on Atauro Island for survey implementation. Men's and women's focus groups were held to ensure that questions were appropriate to local context. The survey team comprised six Atauro Islanders who were familiar with the culture, and were fluent in Tetum (one of two official languages spoken across Timor-Leste) and at least one of the 3 dialects of Wetarese spoken on the island (Rahesuk, Resuk/Wawa and Raklungu). Training of the team included a day of classroom training prior to conducting any surveys, a day of field testing, and a review of data after each of the team had completed five surveys. Data were entered into an MS Access database by the field team leader, allowing for further questioning of the field team if answers were unclear.

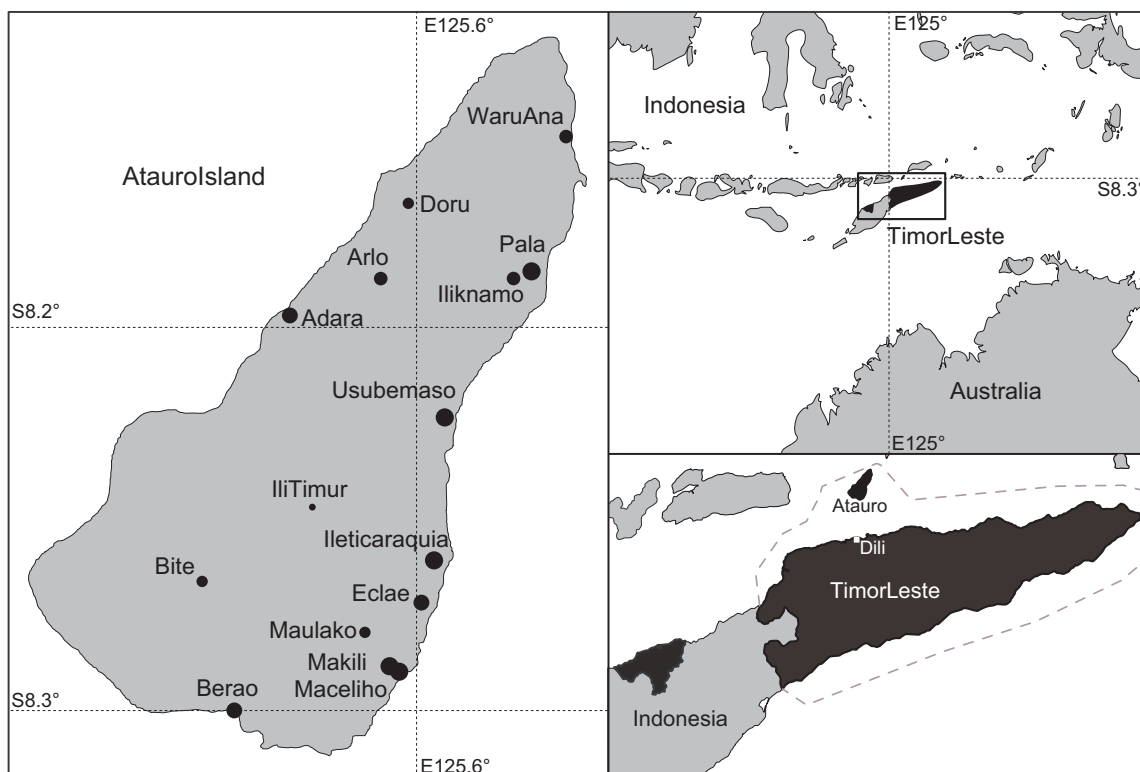


Fig. 1. Location of Atauro Island within Timor-Leste and the Arafura Timor Sea Region. The map of Atauro Island shows the 15 surveyed communities, with marker size showing relative village population.

The survey was applied following multi-stage cluster sampling methods [32,33]. This was implemented by firstly randomly selecting large, primary sampling units which corresponded to ‘Suco’ administrative divisions adopted as enumeration areas by Timor-Leste’s census. Secondly, smaller clusters were identified within each Suco, corresponding to villages (Aldeias), for which reliable data on household numbers were available. Household data were cross-checked between the national census and lists held by the local government administration. Lastly, households were randomly selected from the clusters following ‘probability proportional to population size’ sampling (PPS) because this method reduces the risk of bias when the sampling units have markedly different sizes [34]. This ensured that the probability of any unit being selected was proportional to its size (i.e. number of households, in this case). The final sample size ($n = 495$) was nominated considering the design effect of cluster sampling and this represented about 30% of the total number of sampled households within the aldeias.

Respondents for the survey were the household heads (as defined by the respondents themselves), with 460 male and 35 female respondents. Where the household head was not available in the randomly selected household, the closest adjacent house was substituted. The position of each household sampled was recorded using GPS. Verbal informed consent was obtained before proceeding using a standard statement that required a positive response to continue the interview. Respondents were asked questions about: household demographics; household member livelihoods; income and assets; food insecurity, challenges and shocks; and fishing behaviour and seasonality. Questions were closed and respondents could select a response from a pre-defined list. Lists (e.g. assets that differentiated poorer households from well-off households, livelihood types, shocks, food groups) had been developed in men’s and women’s focus groups held by project scientists and field workers with local community members during the survey pre-testing phase. Each survey took 1–1.5 h to administer.

2.3. Survey structure and analysis

2.3.1. Livelihoods

Respondents were asked to nominate the primary livelihood for the household and per family member according to 12 categories. Students and unemployed household members were grouped into one category of ‘other’. If a livelihood was not present in the list it was recorded separately. A related question on the income derived from each livelihood over the past 14 days provided further means to understand livelihood structuring at the household level. Due to the sensitivity of the questions related to income, respondents were not pressed for answers if they hesitated or suggested they were uncomfortable with the question.

2.3.2. Assets, income, services and food security

Respondents were asked to select the number of assets and productive assets owned by each household (presence or absence was recorded against the pre-defined list of common assets). The assets were ranked by approximately equivalent value (Supplementary information) through discussions with local survey implementers. The relative asset wealth score for each household was then calculated as the normalised sum of all assets*rank. Data were controlled for outliers of assets, an example being carpenters, who possessed significantly more furniture than other households as they were able to build it themselves with less outlay. Living conditions (house type, ownership) and level of access to basic services (water supply, latrines, power supply) were ranked, summed and normalised to provide the *services score* for each household.

Questions regarding short-term (monthly) and long-term (annual) food insecurity were constructed employing question formats taken from the Household Hunger Scale; question formats that have been rigorously tested in multiple contexts [35]. Questions included how frequently families had to reduce quantities of food or skip meals, and how often they couldn’t afford to buy nutritious food. The severity and

frequency scores of food insecurity over the past year were normalised and combined to calculate the household relative *food insecurity* score.

A partition model (JMP ver. 12, SAS Inst.) was used to explore the effects of village and household livelihood on relative *asset wealth, income, services, and food security*. A partition model evaluates the optimal split point according to the relationship between X and Y variables using a tree of decision rules, allowing for the comparison of categorical effects on the variation of continuous response variables. This model controls for potential false discovery from multiple tests, and allows for better significance testing using an FDR LogWorth value $-\log_{10}$ (FDR p-Value) [34] where values exceeding 2 are significant at the 0.01 level. Small p-values result in high FDR LogWorth values. To further test for the effects of location on the 4 key variables of assets, income, services, and food security, communities were grouped into upland and coastal villages and compared using Wilcoxon rank sums test.

2.3.3. Livelihood challenges and shocks

Lists of potential shocks likely to be suffered by households on Atauro were created in pre-survey focus groups and survey field testing. Survey respondents ranked the three most significant shocks to livelihoods they had experienced, which served as a shock index for shocks suffered per household. Household shock scores were summed and normalised by livelihood to compare influence of livelihood on shock rankings.

3. Results

3.1. Livelihoods

Five occupations (crop farming, livestock rearing, fishing, formal employment and small-scale business) were the most important source of income for 84% of households. Natural resource-based livelihoods were most common with crop farming, livestock farming and fishing being ranked as the principle source of income by 63% of households (Table 1). Among non-natural resource-based livelihoods, formal government employment was the most common noted by 13.5% of households as the most important source of income. For men, fishing was the most important source of income, while the greatest proportion of women was engaged in rearing livestock. The greatest dichotomies between men's and women's primary sources of income were in crop farming, which was found to be very much a woman's occupation, whereas formal government employment and fishing were dominated

Table 1

The principle source of income for households, and for men and women within those households, on Atauro Island.

Livelihood	Household		Women		Men	
	N	%	N	%	N	%
Farming: crop	105	21.2	73	14.7	17	3.4
Farming: livestock	105	21.2	92	18.6	81	16.4
Fishing	101	20.4	69	13.9	95	19.2
Formal government employment	67	13.5	29	5.9	59	11.9
Small-scale business	37	7.5	39	7.9	37	7.5
Fish trading	23	4.6	8	1.6	17	3.4
Casual work: other	13	2.6	2	0.4	6	1.2
In-country family contribution	13	2.6	10	2.0	9	1.8
Casual work for government	8	1.6	9	1.8	14	2.8
Formal employment: other	7	1.4	4	0.8	6	1.2
Carpenter	4	0.8	0	0.0	1	0.2
Overseas family contribution	4	0.8	1	0.2	0	0.0
Large scale business (owner)	2	0.4	1	0.2	1	0.2
Local NGO	1	0.2	0	0.0	1	0.2
Others	1	0.2	0	0.0	1	0.2
Fish processing	0	0	1	0.2	1	0.2
None/unanswered	4	0.8	157	31.7	149	30.1

	Crops	Livestock	Fishing	Fish trading	Fish processing	Formal employment	Casual employment	Small business	None
Crops	459								
Livestock	424	439							
Fishing	178	156	186						
Fish trading	25	24	19	27					
Fish processing	3	2	0	1	3				
Formal employment	58	62	19	4	0	64			
Casual employment	101	102	64	9	0	17	106		
Small business	398	396	151	18	2	61	98	415	
None	0	0	0	0	0	0	0	2	19

Fig. 2. Composition of livelihoods for 476 households on Atauro Island, Timor-Leste. The intersection of each livelihood pairing (from horizontal and vertical axes) shows the number of households involved in both livelihoods, while total engagement in each livelihood is shown where the same livelihood intersects from the vertical and horizontal axes. Shading highlights common pairings.

by men.

Natural resource-based activities were near-ubiquitous in the livelihood mosaic of households. Fig. 2 incorporates all households involved in a given livelihood activity (whether identified by the household head as an important livelihood activity, or listed as an income source) with no weighting applied for importance of that livelihood. For example, almost all households farm crops (89%) and raise livestock (93%). Fishing is less common (41%), and referencing Table 1 suggests that many households involved in fishing (54%) consider this to be their primary livelihood. In contrast, only 23% of crop farming households consider crops their main livelihood. Fish trading is differentiated from selling harvested product – those identifying as fish traders are ‘middlemen’ in value chains who trade in relatively large volumes. Those in casual employment also rely very heavily on crop and livestock farming, but to a lesser extent on fishing. However, one third of fishers also engage in casual employment. Just two households (0.4%) were engaged in only one livelihood.

3.2. Assets, income, services, and food security

In total, information on income was gathered about 800 household members (i.e. household heads and those in the household they spoke for) and the mean household income was USD272 (± 16.3) per month. Median income among all households was USD50 per month, while upland communities (USD30.00) had a substantially lower median income than coastal communities (USD82.50).

Among natural resource-based livelihoods, crop farming provided the lowest income for households, and was correlated with the lowest asset and highest food insecurity score. Earnings in terms of mean monthly income (\pm SE) showed significant differences among fishing (USD133 \pm USD13), livestock rearing (USD103 \pm USD12) and crop farming (USD53 \pm USD14) (ANOVA, $F=8.9191$, $p=0.0002$). Incomes from fishing and livestock farming were significantly higher than crop farming (Tukey-Kramer HSD, $p=0.0001$ and $p=0.0206$ respectively), but themselves did not differ significantly ($p=0.2307$). Households with fisheries as their primary income source had higher asset levels than those with other natural resource-based primary incomes. Effects testing using a least-squares multiple linear model showed that fishing had a significant positive effect on asset wealth ($F=27.3494$, $p<0.0001$), whereas livestock ($p=0.9274$) and crop farming ($p=0.3131$) did not. Livestock farming, while not providing high levels of income or asset wealth, had the lowest food insecurity score among natural resource-based livelihoods.

Forms of paid employment, either government or private enterprise, formal or casual, were the most remunerative among all livelihoods (Fig. 3). However, this outcome is not uniformly reflected in household assets or the food insecurity index. Food insecurity is high for casual

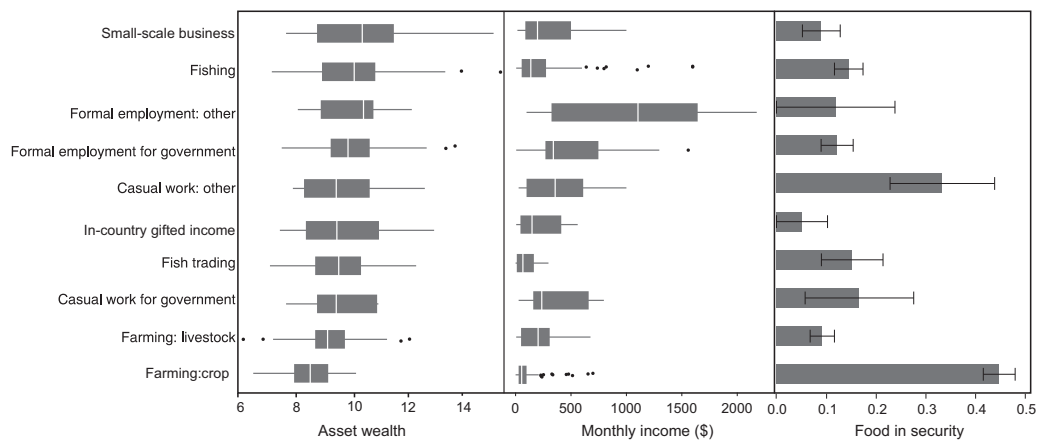


Fig. 3. Asset wealth, recent household monthly income and food insecurity score split by primary livelihood on Atauro Island, Timor-Leste. Asset wealth is an index combining relative value of household assets by respondents. Monthly income (US\$) is based on 14-day recall. Food security questions analysed here used a 1-year timeline to integrate over seasons.

labour, moderate for formal government labour, and low for formal private enterprise labour. Much of the casual employment on the island involves tasks such as road construction work for both government and private developers. This work is available on a ‘day to day’ basis providing very limited longer term security.

3.3. Spatial distribution of livelihoods and wealth

Primary livelihoods (as identified by household head, not from reported income) showed distinct spatial patterning on the island (Fig. 4a) with fisheries livelihoods concentrated largely in the coastal north, crops through the central regions, and livestock to the south. Relative asset wealth exhibited a distinctly different spatial pattern (Fig. 4b). The highland ‘spine’ of the island and relatively isolated southern coastal areas are characterised by low relative wealth scores, while the mid-section of the island shows higher levels of relative wealth. The influence of livelihood and geographic location (village) on asset wealth and services was tested using partition modelling. Results

show that the main drivers of the wealth and services indicators were geographically linked rather than relating to primary livelihood. Village and primary household livelihood showed significant combined effects on *asset wealth* ($R^2=0.543$, FDR LogWorth=60.42) and *services score* ($R^2=0.439$, FDR LogWorth=40.57) but village had a much stronger effect on both *asset wealth* (FDR Logworth=39.51) and *services score* (37.22) than did primary household livelihood (8.67 and 4.99 respectively). Upland and coastal villages differed significantly across all 4 key variables, with upland communities exhibiting lower asset wealth (Wilcoxon, $Z= -2.59$, $p < 0.0096$), income ($Z= -6.09$, $p < 0.0001$), services score ($Z= -6.51$, $p < 0.0001$), and food security ($Z=4.51$, $p < 0.0001$) than coastal communities.

3.4. Livelihood challenges and shocks

Households were asked to rank the three most significant shocks they had experienced to their livelihoods. Diseases of crops and stock dominated rankings, almost regardless of primary livelihood of the

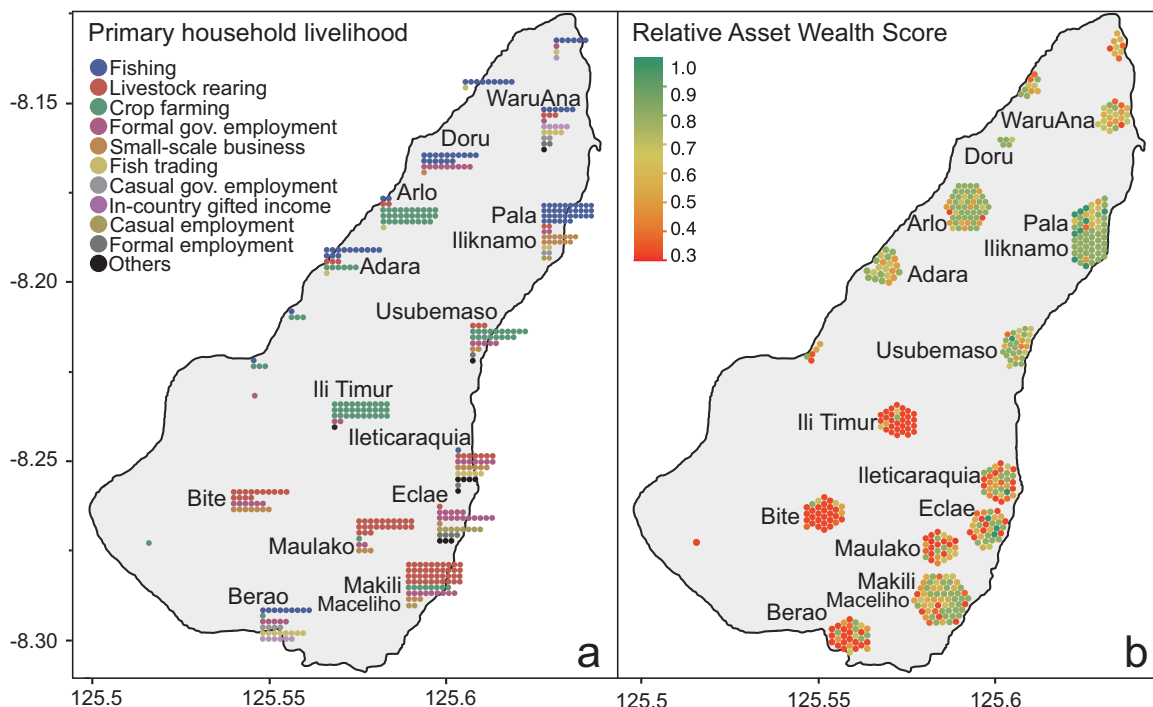


Fig. 4. Livelihood and wealth distribution on Atauro Island, Timor-Leste. Pane a shows the primary household livelihood as identified by the head of household and b shows relative wealth of households calculated by asset ownership.

	Pests or diseases caused loss of harvest	Pests or diseases caused loss to crops in storage	Pests or diseases for livestock	Flooding	Death of adult household member	Drought	Adverse weather affecting fishing activities	Seawater intrusion in farm land or household	Destruction of housing	Reduction of fish catch due to other conditions	No market for products	Major accident at sea	Increase in food prices	Theft of cash	Disablement of adult household member	Theft of fish, crops or livestock	Fire outbreak	Taken out land/farm from others
Farming: crop	198	62	53	25	13	11	6	3	2									
Farming: livestock	49	29	38		4		5	5			3	3						
Formal employment for government	35	42	91	3	21	6				1					3	3		
Fishing	21	51	166	8	3	8	63	3		8	6	1						
Fish trading	12	22	27		3	1	14			2	4		1					
Others	7	2	13		4		2			2		2						
Small-scale business (mechanic, handicraft etc.)	6	8	46	1	13				3			1	3	1		3	1	
Casual work: other	6	6	16		6		2		6					1				
In-country family contribution	4	16	26				5			6	4							
Casual work for government		3	23				3	5		2		2						
Formal employment: other		4	4		3		3		4	2								3
Overseas family contribution			3				2	2	1	1	3							
Carpenter		2	3															
Large scale business (owner)		2	3															

Fig. 5. A matrix heat map of shock scores by household primary livelihood on Atauro Island, Timor-Leste. Cell shading and number shows increasing shock severity on a grey scale (light = least severe, dark = most severe).

respondent (Fig. 5). Fishers gave a much higher ranking to diseases of stock than to fishing-related shocks such as adverse weather. Lack of markets was not a concern that fishers identified. Stock farmers ranked crop diseases as a more common challenge than stock disease. We investigated the possibility that this related to different types of livestock farmed by households with different primary livelihoods. Fishers farm more goats than livestock farmers (Wilcoxon, $Z = 2.52296$, $p = 0.0116$), while crop farmers grow more chickens than fishers or livestock farmers (Wilcoxon, $Z = -2.68$, $p = 0.0073$ and Wilcoxon, $Z = -3.06858$, $p = 0.0022$ respectively).

3.5. Fishing seasonality and livelihood diversity

Household monthly rankings of fishing activity (none, low, medium, high) were aggregated to determine how fishing activity varied throughout a calendar year. There were some notable differences in fishing activity between communities in different regions of Atauro (Fig. 6). Geographic orientation (west facing) and features (substantial barrier reef area) allowed fishers to fish throughout the year in three communities, to a greater degree than the other seven communities who were more exposed to the effects of the monsoon. These more stable fishing patterns were correlated with greater specialisation as a fisher (i.e. lower livelihood diversity scores than elsewhere).

East and south coast communities showed a bimodal annual fishing cycle, dissected by very low fishing activities in August and reduced activity in the months immediately prior and following. This coincides with the south-easterly monsoon period when seas are rough on this coast. Conversely, fishing activity in communities on the west coast was more evenly distributed throughout the year, but showed lower levels of activity during the period of the rainy season, and higher activity through the dry season. The exception is Usubemaso on the east coast, where households fished throughout the monsoon period in a similar pattern to west coast communities. Usubemaso is adjacent to the only area of Atauro Island with a protective outer reef, and this may accommodate fishing during the south-west monsoon season. The communities of Ileticaraquia and Ili Timur appear less subject to the influence of the wet season, although reasons for this were not apparent. We note that fishers from Atauro do fish in other areas of

the northern coast of Timor-Leste, and may be able to circumvent rough weather in this way. Fishers in Arlo, Adara and Usubemaso, the three communities that can fish through the south-west monsoon season, exhibited significantly lower livelihood diversity (Wilcoxon $Z = -5.32525$, $p < 0.0001$) than fishers from the other communities examined.

4. Discussion

4.1. Fisheries and livelihood diversity

Fisheries provide opportunities for island communities to generate income and access quality protein and micro-nutrients; frequently in contexts where alternatives are limited. As situations and needs change, people and households can rely more or less on fishing. Multiple disciplines have been interested by the diversity and dynamism of livelihoods in developing island settings. Whilst fisheries are indeed important in many coastal and rural settings across the Asia-Pacific, they often sit alongside a range of other livelihoods that contribute to household food security, income and occupation. Inland fisheries are broadly recognised as one among a complex of household food gathering activities [36,37]. In contrast, the literature on diversity of livelihoods associated with marine fishing is somewhat ambiguous. Marine fisheries are often considered to involve a greater degree of livelihood specialisation [20,38], with limited options for diversification (e.g. [39]). Brugere et al. [40] contest that these perceptions, driven by notions of higher levels of investment in marine fishing assets and higher potential returns, are largely unsupported by empirical evidence.

On Atauro Island, fishing is the principal source of income for a high percentage of the households engaged in fishing activities (54% for fisheries compared with 22% of crop farming households that derive their primary income from crops). However, almost all households that fish are engaged in multiple livelihood activities (e.g. 95% in crop farming; 84% in livestock; 34% in casual employment). Seasonality in access to fishing appears to be a driver of livelihood diversity. Fishing grounds that are sheltered from monsoonal winds provide better year-round access to fish resources, and those who can fish year-round chose

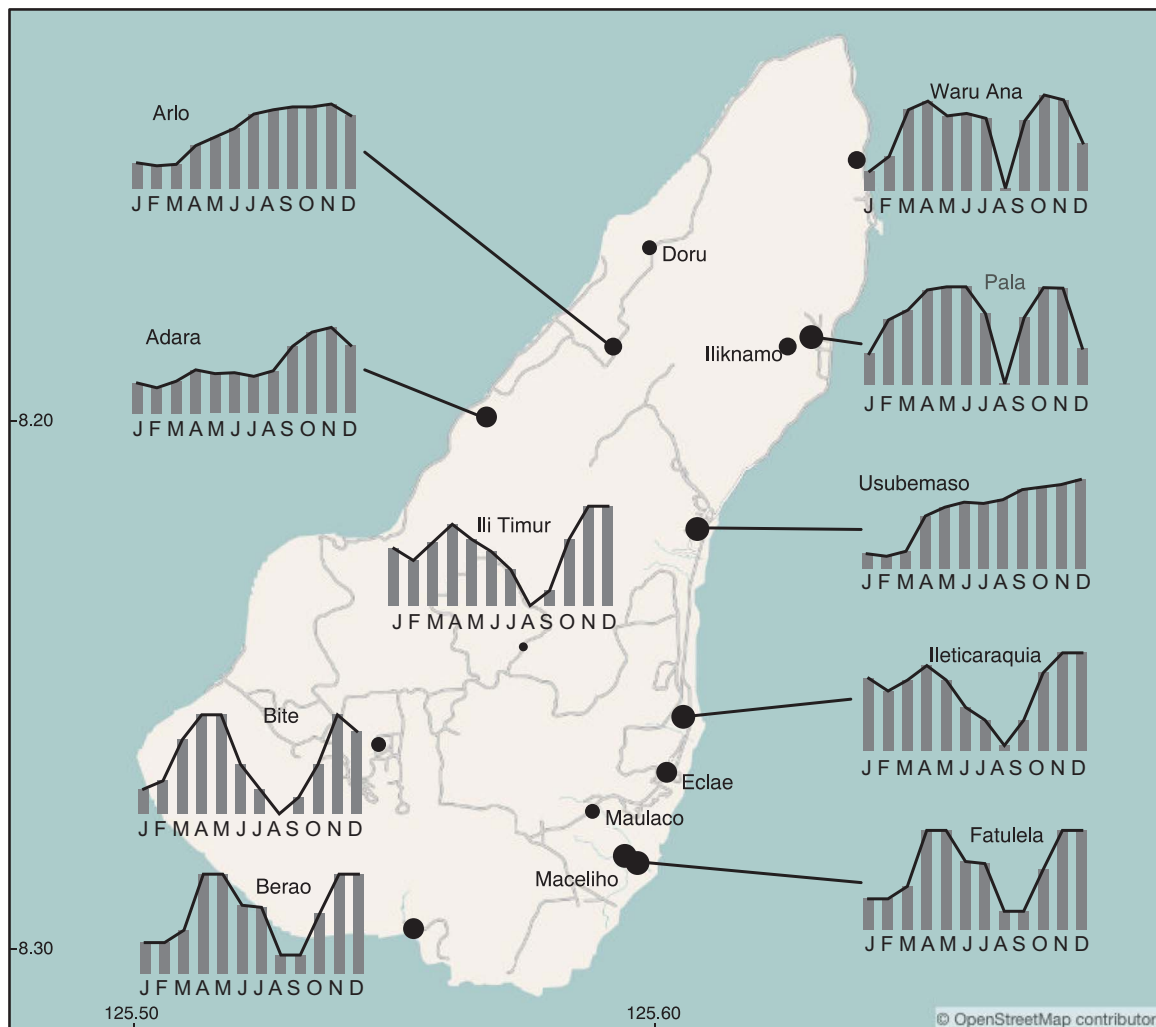


Fig. 6. Annual variation in the intensity of fishing activity using combined rankings (none, low, medium, high) of all households in 10 communities in Atauro Island, Timor-Leste.

to do so, relying less on other livelihoods. This is unsurprising given that we also found there to be higher financial rewards from fishing when compared to other natural resource-based livelihoods. Clearly among those with the assets and access to engage, fishing is important in structuring livelihoods; however, there is little evidence of specialisation. The relatively low levels of capitalisation seen in Timor-Leste's fisheries, with the nation's fleet overwhelmingly dominated by small, unpowered craft, may be either a symptom (small investments across multiple livelihoods) or a driver (small vessels constrain returns from fishing, promoting diversification) of this diversity.

4.2. Livelihoods and vulnerability

Among natural resource-based livelihoods, fisheries show attributes of relative stability and lower levels of vulnerability. Fishing was highlighted as being less subject to shocks than crop or livestock farming, and in three communities where fishing was a dominant livelihood, offered a year-round source of food and income. Notably, fishers highlighted disease among livestock as their greatest livelihood vulnerability, reflecting the high levels of co-involvement of fishing and stock farming among households, the vulnerability of livestock to disease, and the substantial direct loss of capital incurred through livestock losses. Problems with selling catch received a low ranking for shocks experienced by fishers, likely reflecting the demand-driven nature of fisheries in Timor-Leste [28]. This is perhaps aided by a degree of 'brand recognition' and accessibility for Atauro Island fish

among the Dili-based middle class, who are prominent among buyers at a well-attended weekend market on Atauro Island. This is not reflected in other fishing communities in Timor-Leste, where access to markets (and therefore unsold or difficult to sell product) can be a major constraint to fisheries livelihoods [18].

While fishers highlighted livestock disease as their biggest vulnerability, livestock farmers nominated crop losses as theirs. This study investigated whether this was driven by differences in types of livestock held by fishers and farmers, paying particular attention to numbers of chickens owned per household. Vulnerability of chickens to Newcastle Disease in Timor-Leste is a major food security issue [41] that would likely contribute substantially to this indicator. Finding no significant difference in chicken holdings, it is possible instead that specialist knowledge among livestock farmers reduces the incidence of disease, or that having greater means to produce their own meat for household consumption, crops become a more dominant concern.

In contrast to fishing and livestock farming, crop farming households were notable for low asset scores, low income, low food security, and high livelihood vulnerability (people described shocks from crop losses both in cultivation and storage). Poor soil fertility in Timor-Leste [42] leads to substantial yield gaps for staple crops, creating a potential poverty trap [43]. Post-harvest maize losses as high as 63% due to weevil attack have been reported in Timor-Leste [44], and substantial aid efforts to provide improved storage systems are ongoing. Beyond our survey results on vulnerabilities, land tenure issues in Timor-Leste are fraught, with multiple overlaid and often conflicting systems from

different governance periods (Portuguese, Indonesian, independence) [45]. Rather than fisheries being a livelihood of the landless, it is apparent that on Atauro Island it is more appropriate to describe crop farming as the fall-back option for those who don't readily have access to the sea, whether that is related to skills, assets (such as boats and fishing gear), physical or socio-cultural determinants. Households further from the sea certainly had the worst outcomes for wellbeing indicators.

4.3. Livelihoods and wellbeing outcomes

Small-scale fishing in less developed countries has been characterised as a livelihood of last resort, an occupation of the landless poor and even a poverty trap (see reviews [46,47]). In contrast, this research revealed that fisheries on Atauro Island play a positive role in securing wellbeing outcomes. Rather than operating as the 'safety net' (sensu [46]) fishing (relative to other natural resource-based livelihoods) had a clear positive influence on asset wealth, and a positive effect on income and food security (i.e. higher than for crop farmers, but similar to livestock farmers).

While more men earned income from fishing than women, the dichotomy is certainly not as clear as that seen in many cultures in the region or globally [21]. Women engage in many types of fishing, including gleaning (notably for octopus, crabs and shellfish), gillnetting from boats, and spear fishing. Indeed, the cultural significance and unique nature of fishing to women on the Island was highlighted in the award-winning ethnographic video 'Wawata Topu – Mermaids of Timor-Leste' [48]. In other cases (e.g. [49]), the engagement of women in fishing is linked to an increase in the direct use of catch and income for basic household needs thus leading to directly improved household food security; this would require further research to establish for the households in Atauro, and Timor-Leste more broadly. As a follow-on to this study, a broad-based survey of gleaning fisheries and women's fishing in Timor-Leste has been initiated.

Livestock farming is notable for the highest food security outcome among natural resource-based livelihoods (lowest food insecurity score), as well as a relatively high capacity to generate income. Población [18] notes that elsewhere in Timor-Leste livestock provide a much stronger income base than fisheries, and as a result fishers are reluctant to invest in scaling up fishing operations, preferring to invest in livestock. Livestock are readily traded or sold due to their central importance in rituals and ritual exchange in Timorese traditional culture. This was not reflected in our income indicator on Atauro Island, with fisheries showing a higher average income than livestock farming. A plausible driver for this discrepancy is differing religious observance relating to meat consumption and use. Población et al. [50] and Bicca [51] highlight that Catholic practice, as is dominant throughout most of mainland Timor-Leste, has developed to accommodate components of indigenous, animistic ritual practices, and meat consumption is mainly restricted to ritual and celebratory observance. In contrast, Atauro Island is predominantly Protestant, and a stricter adherence to new moral codes as introduced by the Assemblies of God church sees livestock with a reduced role in ritual. Livestock then potentially sits alongside fish with a predominant role in food security. Focus group participants on Atauro Island (unpublished data) suggested livestock play an important buffer role to food security and income, being sold during the lean season when income and food from fishing or crops is scarce. Participants also noted livestock prices tended to drop at such times due to an increase in market supply.

While there were clear differences in wellbeing indicators among households based on primary livelihood, geographic location (village or coastal compared to upland households) ultimately proved a stronger predictor for wellbeing outcomes. Mean household income (USD272) was similar to that found in the 2011 Timor-Leste Household Income and Expenditure Survey (USD292)[52], while median incomes from upland households on Atauro Island (USD30) were the same as for rural

households in the national survey and substantially lower than those for coastal households (USD80) in the present study. The striking geographic differences observed relate to diverse and likely interacting geographically linked structural, socio-political or physical constraints to development. Carter and Barrett [53] promote the use of asset-based measures to quantify persistent or *structural* poverty, while noting that the more frequently used metrics of income and food security highlight stochastic elements of poverty. Poverty is in part transient: whereby households can move in and out of a state of poverty through short-term changes in drivers such as employment availability, seasonal access to resources, rainfall etc.; and part structural. Asset based scores, including the services score used here, provide a better predictor of long-term poverty. In the present study we find a close agreement between stochastic and structural measures of poverty, both showing substantial geographic differentiation in poverty scores (We note, however, that this agreement between diverse indicators may not hold if a longer term study including multiple measurements of stochastic poverty were conducted). Mills et al. [54] found similarly that household vulnerabilities in an inland African fishing community were largely independent of livelihood, but instead related to systemic issues (health services, clean water, transport, education) within the community that influenced their ability to meet basic human needs. While the survey in this study did not look at vulnerabilities beyond those directly linked to livelihoods, it is likely that similar processes are in play here. On Atauro Island, the communities in the elevated centre of the Island are disadvantaged in terms of isolation from services including infrastructure, health, education and transport systems and this was reflected in the service scores. This study shows that access to ocean-based livelihoods contributes to lower poverty in coastal areas. The interdependence of a community's ability to meet basic human needs, and the governability of fisheries and other natural resources has been emphasised by others [55], and this highlights the importance of broad institutional collaboration across service sectors in formulating governance approaches.

4.4. The hopes and limits of a diverse livelihood portfolio

Within developing and rural settings there are structural (geographic, economic and social) realities that constrain the diversity of livelihoods that households can viably pursue. As economic development increases, the degree to which livelihoods rely directly on local natural resources will decrease, as new opportunities are presented through diversifying economies and improved infrastructure [4]. Given the development status of Timor-Leste, and the rural and relatively remote nature of Atauro Island, it was unsurprising that natural resource-based livelihoods were found to be pervasive.

As found in this study, and despite the structural realities that might constrain options, people in rural developing country settings often hold relatively diverse livelihood portfolios [56,57]. Researchers suggest livelihood diversity is correlated with higher adaptive capacity (e.g. [15,58]) in that this diversity provides households with some ability to shift efforts away from livelihoods that suffer environmental and economic shocks, thereby buffering against impacts on food security or income [57]. However, households in rural economies rarely hold the ultimate ability to switch their efforts from, for example, one poorly performing livelihood to one that reaps wonderful rewards [59]. A gendered study in the Solomon Islands highlights that 'diversity' may not necessarily be a favourable attribute in the shorter term given the high transaction costs in keeping options available. Livelihood opportunities for women in one Solomon Islands community became greater as socio-cultural norms relaxed, however the outcome that women experienced was a greater labour burden i.e. greater costs in the short term, irrespective of whether their capacity to adapt might benefit sometime in the future [60]. This highlights that where interventions seek to increase the opportunities available to people, it will be important to consider how that livelihood might interact with others

in a person or household's portfolio. The fact that new livelihoods might be added, rather than substituted, has implications for resource management: livelihood diversification projects may not, in themselves have the capacity to reduce resource exploitation rates and in many instances have failed to do so [61].

Several authors note also that the capacity to cope and spread risks through a diverse livelihood portfolio is, in some situations, only going to be sufficient if households can shift away from one 'vulnerability domain' to an un-connected, less vulnerable domain [62,63]. For example, different livelihoods that are dependent on the same ecosystem may well be subject to the same ecological shocks, while co-located livelihoods may be subject to the same geophysical shocks (e.g. natural disasters). Yet, this ability to switch between broader contexts will invariably be constrained by capacity to invest or relocate, often leaving poorer households exposed and potentially caught in a poverty trap [64]. Accessibility of alternatives to the most vulnerable in communities must be of prime consideration when designing livelihood interventions.

This study illustrates clearly that the utility of livelihood interventions to improve the wellbeing of households will to a degree be constrained by the drivers of longer-term, structural components of poverty. Longer-term investments in improving assets and services at the household and community level will build resilience of communities to diverse shocks, enabling or expediting recovery from shocks and transformations away from persistent poverty. This does not, however, downplay the importance of supporting diversified sustainable livelihood portfolios to build the resilience of household incomes and food supply. Within the above-mentioned constraints, stochastic components of poverty play a crucial role in wellbeing of household members, and in avoiding poverty traps [53].

5. Conclusions

This research highlights that even if governance and livelihood interventions are focused on fisheries, interactions with other livelihoods must be considered. That is, if interventions were to work with people who rely principally on fishing, they would only be focused on a fraction of the population that derive benefit from fisheries resources; they would overlook the greatest vulnerabilities fishers (and broader coastal communities) face and, in the case of Atauro Island, they would be focused on the most food and income secure sector of the natural resource dependent population.

Livelihood diversity is a feature of these and indeed many rural coastal communities. Livelihood diversity can be a positive attribute where it allows households to cope or adapt to shocks or economic or environmental changes. With this in mind, policies that promote fishers to specialise (i.e. by privatising resources, monetising the right to fish and increasing capital entry requirements) will make it harder for fishers to switch and adapt if resource abundance or other shocks face the fishery [16,57,65,66]. Caution is recommended against interventions that rely on livelihood diversification as a sole means of reducing resource pressure. The potentially additive nature of livelihoods highlights that livelihood programs which seek to reduce pressure on resources should go hand-in-hand with reforms that improve resource governance (see also [67]). Where a reduction in fishing pressure is deemed necessary, such coordinated programs may be effective in improving resource status without negatively impacting fisher households. It is also found that structural realities faced by communities, which cannot be overcome through local or livelihood based interventions, can be a powerful determinant of wellbeing outcomes emphasising the need for cross-sector engagements in policy development and intervention planning. This study's results emphasise that if policies are to be formulated that strive to improve both resource status and the wellbeing of resource dependent households, they must be built on an in-depth and locally contextualised understanding of livelihood structures, drivers and vulnerabilities.

Funding

This work was supported by an Australian Centre for International Agricultural Research grant (FIS/2010/097) – *Exploring options for improving livelihoods and resource management in Timor-Leste's coastal communities*.

Acknowledgements

We are very grateful to the communities in which we worked for their support and participation in this research. We are also grateful to the Roman Luan management and survey team for their invaluable role with data collection, and the Ministry of Agriculture and Fisheries, Timor-Leste for their critical partnership with WorldFish in Timor-Leste.

Appendix A. Supplementary information

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.marpol.2017.04.021>.

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