# Introduction

Climate change threatens the ability of natural resource dependent communities to maintain sustainable livelihoods and achieve development goals ([Yohe et al., 2007](#_ENREF_73)). Climate impacts are compounded by multiple social and environmental stressors, including chronic poverty, population growth and resource depletion ([O'Brien and Leichenko, 2000](#_ENREF_43), [Barnett and Adger, 2007](#_ENREF_7)). Nevertheless, societies have inherent capacities to adapt, even in the absence of deliberate policy decisions to guide actions ([Adger, 2003](#_ENREF_1), [Smit and Pilifosova, 2001](#_ENREF_58)).

Multiple definitions of adaptation exist but there is general acceptance that adaptation involves long-term adjustments within a system (e.g. a subsistence community) to better manage external stress (e.g. [Adger et al., 2005](#_ENREF_2), [Smit and Wandel, 2006](#_ENREF_59)). Examples include changing planting times, or diversifying livelihoods ([Stringer et al., 2009](#_ENREF_62)). Coping strategies are short-term responses to stress, which may create greater pressures in the long-term ([Brown, 2011](#_ENREF_13)). For example, selling assets, eating fewer meals, or removing children from school may make a household more vulnerable to future events. Even when responses to change appear to alleviate external stress, further negative externalities may occur. Some adaptations/coping strategies may compromise long-term socio-economic development goals, exacerbate climate change by increasing greenhouse gas emissions, or increase the vulnerability of other systems, sectors or social groups ([Barnett and O'Neill, 2010; Stringer et al. in press](#_ENREF_8) ). Such responses can be considered ‘mal-adaptations’ ([Barnett and O'Neill, 2010](#_ENREF_8)). Conversely, when adaptation meets both long-term development and mitigation goals, Climate Compatible Development (CCD) is achieved ([Mitchell and Maxwell, 2010](#_ENREF_36)).

CCD fuses together strategies from adaptation, mitigation and development (AMD) and aims to create low emission, climate resilient futures ([Mitchell and Maxwell, 2010](#_ENREF_36)). [Ayers and Huq (2009](#_ENREF_5)) describe a waste-to-compost project in Bangladesh in which reduced methane emissions (mitigation), along with soil improvement in drought-prone areas (adaptation) and poverty reduction (development) occur. Although synergies between AMD exist, trade-offs may also occur. However, evidence-based case studies of trade-offs are rare ([Tompkins et al., 2013](#_ENREF_65)). As such, newly emerging debates around AMD examine whether it is indeed possible to capitalise on natural synergies between the three strategies, or whether the trade-offs are too great [(*ibid*.](#_ENREF_51)).

In this paper, we examine how communities in Zanzibar cope with and adapt to multiple-stressors including climate change, and how these responses affect long-term mitigation and development. We also identify considerations for developing future CCD policy. We address three research questions; (1) what are the multiple-stressors that affect natural-resource dependent communities in Zanzibar? (2) How do community responses (adaptation/coping) affect long-term development and mitigation goals? (3) What are the barriers to maximising AMD synergies in community responses? By exploring day-to-day community and household adaptations to change, opportunities emerge to create CCD policies that are rooted in local realities ([Rojas Blanco, 2006](#_ENREF_53), [Gupta and Hisschemöller, 1997](#_ENREF_26)). Including the local context in policy maximises effectivness ([Amaru and Chhetri, 2013](#_ENREF_3)). The Tanzanian island of Zanzibar is used as a case study country because: (1) the majority of the island’s coastal households depend on natural resources for their livelihoods ([Tobey and Torell, 2006](#_ENREF_64)) and (2) there is a recognised absence of supportive policy for climate adaptation, which means most responses begin at the community and household level ([Mustelin et al., 2010](#_ENREF_38)).

# Coastal livelihoods in Zanzibar

Zanzibar lies in the Indian Ocean, off the coast of Tanzania (Figure 1). At independence from colonial rule in 1963, the island formed a political union with Tanzania. The union, originally based on African socialism, has been blamed for keeping the island politically and economically stagnant ([Cameron and Larsen, 2009](#_ENREF_16)). Some two decades after the first competitive party elections, a sense of nationalism based on the pursuit of a distinct Zanzibari identity has emerged ([Brown, 2010](#_ENREF_12)). However, Zanzibar remains chronically poor and the island’s 1.5 million residents are heavily dependent on a vulnerable marine and terrestrial resource base.

The marine ecosystem underpins economic activity accounting for 30% of GDP ([Lange and Jiddawi, 2009](#_ENREF_30)). Key livelihood activities within the marine socio-ecological system (SES) include artisanal fishing, and aquaculture especially seaweed-farming, which was introduced in the late-1980s. Within the terrestrial SES, agriculture directly employs about 42% of the population, contributing more than a quarter of the island’s GDP ([RGoZ, 2009](#_ENREF_51)). Subsistence farming and forests present economic opportunities through fuelwood collection, growing conifer trees for use as building poles (for tourist infrastructure) and wood for charcoal production ([Fagerholm et al., 2012](#_ENREF_21)). Finally, beach tourism to the island presents some opportunities for local employment ([Gössling, 2003](#_ENREF_24)). Livelihood activities are traditionally gendered. Fishing and farming are undertaken by both males and females, with women carrying out activities nearer to the village. In forestry, men grow commercial species whilst women collect fuelwood. Seaweed-farming is predominantly female, and tourism predominantly male.

Livelihoods in Zanzibar face a number of drivers of change, including population growth, land pressures, globalisation, tourism and climate change ([Watkiss et al., 2012](#_ENREF_71)). The population has more than doubled in 30 years, from 476,111 in 1978 to 1,211,000 in 2010 ([NBS, 2013](#_ENREF_41)). This creates obvious pressure on resources. For example, the rate of deforestation is approximately 1000 ha per annum ([Watkiss et al., 2012](#_ENREF_71)). Resource pressures are exacerbated by tourism infrastructure ([Käyhkö et al., 2011](#_ENREF_29)). Prior to 1985, tourism was almost non-existent but has rapidly expanded from 50,827 visitors in 1990 to 132,836 in 2010 ([Sharpley and Ussi, 2012](#_ENREF_56)). Large hotels now line the beaches of traditional fishing villages ([Gössling, 2001](#_ENREF_23)). Toursim is a central dimension of globalisation with visitors arriving from around the world, while migrants from mainland Africa move to the island for work in tourist areas ([Gössling and Schulz, 2005](#_ENREF_25)). More recently, increasingly global networks have enabled young Zanzibari men to study Islam abroad and return to challenge the island’s politics. ([Turner, 2009](#_ENREF_69)).

Against this backdrop, the island’s climate is changing. Livelihood activities are likely to be affected by coastal erosion exacerbated by sea-level rise; flooding in low-lying areas; reduced agricultural productivity due to decreased rainfall and higher inland temperatures; and, extreme weather events such as storms ([Watkiss et al., 2012](#_ENREF_71)). For example, erratic rains in 2006/7 significantly reduced agricultural production and also led to widespread malnutrition (*ibid*.). Despite this, locally-specific climate policy is lacking ([Mustelin et al., 2010](#_ENREF_38)) and there are few explicit provisions for Zanzibar in the Tanzanian National Adaptation Programme of Action (NAPA).

# Framework and methods

>Figure 1<

## Research framework

We use the DPSIR (*Drivers – Pressures – States – Impacts – Response*) framework to guide our data collection and analysis. Although we do not set out to demonstrate the framework’s utility for adaptation research, the DPSIR model provides a useful tool to organise complex information relating to both the marine and terrestrial SESs. In the framework, climate change, along with other *Drivers* (such as population growth, economic pressure, poverty, biophysical changes)*,* exerts *Pressures* (such as globalization, emissions, over extraction of resources)*,* and as a consequence *State* changes occur (e.g to livelihoods, to ecological systems). This *Impacts* on environment and society and a *Response* is issued([Turner et al., 1998](#_ENREF_68)). In this research, the *Responses* under scrutiny are the autonomous adaptations and coping strategies undertaken by Zanzibari households engaged in natural resource based livelihood activities. This departs from the traditional application of the framework, which examines policy responses ([Tscherning et al., 2012](#_ENREF_67)).

To explore our first research question ‘what are the multiple-stressors that affect natural-resource dependent households in Zanzibar?’ we explore *Drivers, Pressures, States* and *Impacts* from the perspective of three fishing communities. We present our findings in Section 4, where we recognise the inter-connections between *Drivers, Pressures, States* and *Impacts* ([Mysiak et al., 2005](#_ENREF_39)). As such, we do not attempt to disentangle the categories. To explore our second question ‘how do community responses affect long-term development and mitigation goals?’ we analyse community level data on *Responses* to *Drivers, Pressures, States* and *Impacts*. We present our findings in Section 5, where we assess if *Responses* represent adaptation or coping strategies, as well as assessing the impact of *Responses* on mitigation and development. We explore our third research question ‘what are the barriers to maximising AMD synergies in community responses?’ in Section 6 where we explore barriers to *Responses* that produce AMD benefits, highlighting where policy may intervene to steer communities toward CCD.

## Methods

Our data collection and analysis focuses on community perceptions of the links between *Drivers, Pressures, States* and *Impacts*. The climate change literature notes there is sometimes a mismatch between ‘reality’, for example, as recorded in rainfall data, and community ‘perception’ ([Meze-Hausken, 2004](#_ENREF_35)). However, our focus remains on ‘perceptions’ for two reasons. First, meteorological and socio-economic data do not always present an accurate picture of impacts on the ground. For example, rainfall data does not reveal impacts of erratic rainfall on farmer’s livelihoods and subsequent decision making ([Simelton et al., 2013](#_ENREF_57)). Second, regardless of the ‘reality’ of climate and other changes “*perception* is a necessary prerequisite for adaptation” ([Maddison, 2007:22 [emphasis added]](#_ENREF_32)).

After consultation with local experts from the Institute of Marine Sciences (IMS), University of Dar es Salaam, Zanzibar, three study villages were selected; Paje, Kidoti and Nungwi (Table 1). Site selection considered proximity to the coast, and a livelihood dependence on a mix of fishing, farming, seaweed-farming, forest products and tourism (the key activities identified from the literature). A desk-based literature review and interviews with experts from IMS and the *Sheha* (village leader) provided additional contextual information on livelihoods in each village.

>Table 1 <

To allow for triangulation and verification of results, we use a mixed-method approach to data collection ([Creswell, 2013](#_ENREF_17)). Data collection took place during October-November 2012 and was conducted by local researchers at IMS. Community focus groups were conducted to understand village level *Drivers, Pressures, State* of the environment and *Impact* of changes. Livelihood specific focus groups were then convened to explore the particular issues affecting each livelihood activity as well as *Responses* by those engaged in that activity. All focus groups used a standardized set of questions to elicit information on: (i) physical changes to the environment in which the livelihood activity is carried out; (ii) the impact of the physical change on the livelihood activity; (iii) adaptation to/coping with the change; (iv) obstacles to adaptation. To secure attendance to the groups, an inception meeting took place with each *Sheha* who then facilitated recruitment. Specifically, the *Sheha* disseminated details about the groups across the village. Participants confirmed their attendance with the *Sheha* and in each village, groups were finalised within one week of the inception meeting. Recruitment was generally limited to 8-12 people ([Barbour and Kitzinger, 1998](#_ENREF_6)), although some groups were smaller/larger (Table 2). No participants were turned away. In total, 21 focus groups took place. They were attended by a total of 179 people (72 women and 107 men). Focus groups lasted 1-2 hours, depending on the extent of discussions. Participants were provided with refreshments and a token remuneration, in line with existing local practices.

Sampling for the community level focus group was non-purposive; participants could choose to attend based on their own interest. Sampling for the livelihood focus groups was purposive based on the participants’ main livelihood activity. For example, any villager who generated their main income from agriculture could attend the agriculture focus group, as long as they had not attended the community group. To encourage open discussion and ensure plurality of voices, focus groups were gendered where appropriate (Table 2). This is especially important in a traditionally male-dominated society like Zanzibar where women are often marginalised ([Dean, 2013](#_ENREF_18)), and where males and females have traditionally adopted different livelihood roles. Focus groups were conducted in KiSwahili. Notes were transcribed into English by two Zanzibari research assistants, then coded by the principal researcher and categorised under the key DPSIR headings: *Drivers*, *States, Impacts*, *Pressures* and *Responses*.

Household level quantitative surveys were used to explore household socio-economic conditions, the main livelihood activity of the household, and the household’s portfolio of livelihood activities. Surveys could be completed by any household member and respondents were asked to state the gender of each household member along with their key livelihood activities. Sampling adopted a random approach; research assistants approached every fifth home and asked the resident to participate. Very few people declined to take part in the survey and most were very keen to share their experiences. In total 197 households were surveyed. Surveys took 20 minutes to complete and were conducted in KiSwahili and recorded in English. Analysis took place in Microsoft Excel, using basic descriptive statistics.

>Table 2 <

# Drivers, Pressures, States, and Impacts

In this section, we present data that explores the question ‘what are the multiple-stressors that affect natural-resource dependent communities in Zanzibar?’ Focus groups in all study sites identified three key socio-economic *Drivers* of change in marine and terrestrial SESs: (1) poverty, (2) globalisation including tourism and (3) population increase (Table 3 and Figure 2). In the marine SES, participants noted climate *Drivers*, including coastal inundation, increased wave power and higher sea temperatures. In the terrestrial SES, climate *Drivers* included indistinct seasons along with higher temperatures and more non-rainfall days.

Within the marine SES, participants noted two human-induced environmental *Pressures:* (1) overfishing/use of inappropriate gear; and (2) intertidal zone (ITZ) use change, particularly the expansion of seaweed-farms and tourist activities. A complex combination of *Pressures* along with socio-economic and climate *Drivers* resulted in marine *State* changes. This is illustrated by seaweed farmers who exert *Pressure* by planting seaweed in nutrient-rich water above naturally occurring, sediment fixing sea-grass. In competition for nutrients with farmed seaweed, sea-grasses die off. This leads to a regime shift, or *State* change, resulting in the eventual loss of both grasses and weed. Participants described how seaweed loss was exacerbated by climate *Drivers* including increasingly powerful waves, hotter days combined with a decrease in sea-level (due to sedimentation) that exposes the seaweed to the heat/sun, and an increase in water temperature that kills off the weed. These changes had occurred within the last five years. Further losses occurred as a result of *Pressures* created by tourist activities such as kite-surfing. The overall *Impact* of seaweed loss was reduced income following a poor harvest.

Fishermen were also affected by the complex interactions in the marine SES. Sedimentation resulted in loss of traditional navigational channels used to access fishing grounds. Additionally, habitat loss was reported. A fisherman in Paje explained: *“The sand covers the reef nowadays so nothing can live there: it is even too sandy for octopuses.”* Participants suggested sedimentation was not a problem prior to the mid-1990s. Biodiversity decline, especially amongst benthic species (e.g. octopus and sardine) was exacerbated by socio-economic *Drivers* including population growth and tourist demand for fish, which resulted in *Pressures* from overfishing/use of inappropriate gear (such as circling nets). *Impacts* included loss of income and household food security following a poor catch, and the need to navigate new and more complex routes toward fishing grounds along the reef.

>Table 3 <

In the terrestrial SES, three key *Pressures* were identified: (1) land conversion (for tourist infrastructure, commercial and local farms, and cattle grazing); (2) water abstraction, for hotel and agricultural use; and (3) fuelwood collection. These *Pressures* along with socio-economic and climate *Drivers* resulted in terrestrial *State* changes. For example, *Pressures* are created when land conversion of local forest takes place. In Kidoti, 400 acres of forest had been lost to a commercial chilli farm. At the same time, local fuelwood collection is increasing as a result of socio-economic *Drivers* that include poverty (specifically, a lack of energy alternatives) and population increase. Climate *Drivers*, specifically high temperatures and lack of rainfall, led to *State* changes such as the regular occurrence of forest fires. Furthermore, forest users reported a loss of biodiversity, including native tree species, insects, birds and mammals, such as Ader's Duiker (*Cephalophus adersi*) – a critically endangered small antelope. Farmers reported a similar situation whereby *Drivers* and *Pressures*, especially population growth and land conversion for tourist infrastructure, led to *State* changes that included loss of local soil fertility and water shortages. Terrestrial livelihood *Impacts* include loss of locally available fuelwood, loss of income following poor harvests, and threats to food security. Focus group respondents described that these changes had taken place within the last 30 years.

The application of the DPSIR framework indicates that specific *Drivers* cannot be isolated. Multiple-factors lead directly to the loss of navigation channels, decline in reef health, seaweed die-off, increased soil infertility, loss of fuelwood, and other impacts in Zanzibar’s SESs. The following section considers the spectrum of *Responses* being undertaken by local communities in the absence of clear policy guidance.

>Figure 2 <

# Responses: Relocation/Extensification, Intensification and Diversification

In this section we present data that explores the question ‘how do community responses affect long-term development and mitigation goals?’ We assess if *Responses* represent adaptation or coping strategies, as well as assessing the impact of *Responses* on mitigation and development. This enables us to develop a picture of on the ground trade-offs and synergies within AMD. Three *Responses* to the multiple stressors including climate change were elicited from focus group discussions. These are: (1) relocation/extensification (moving to a new area, usually outside the village, to conduct the livelihood activity, and expanding the size of the area in which the livelihood activity is carried out); (2) intensification (spending longer or working harder on the activity to maintain the same returns); and (3) diversification (taking on additional livelihood activities whilst retaining the previous ones, thus expanding the livelihood portfolio). As this section identifies, *Responses* to change resemble coping strategies rather than effective adaptations that can create long-term solutions to stressors. This has implications for both development and mitigation.

## Relocation/ Extensification

Relocation of terrestrial SES livelihood activities beyond village boundaries occurred particularly in Paje and Nungwi. Although all land is officially state-owned, insecurity of tenure and lack of demarcation of customary boundaries have prompted *de facto* open access use with some villagers using forest and farmland far from their homes. In Paje and Nungwi, forest users noted journey times of over an hour on foot (c. three miles) for fuelwood collection. Similarly, respondents in Nungwi bought fuelwood from the neighbouring island of Pemba. Motivated by fertility decline in local soils, farmers in Paje travelled over 30 minutes (c. 15 miles) by car to reach fertile farmland in the island’s interior. In Nungwi, farmers walked for four miles to farmland. This behaviour had emerged over the last 30 years and coincided with the introduction of tourism and motorised vehicles. Extensification of existing farm plots occurred alongside relocation in both Paje and Nungwi;

*“We have moved to new land away from the village and increased our plot size so we have a bigger area to grow our crops – then at least we have more chance to get a harvest.”*

(Focus group, Oct 2012: female farmer, Paje)

Relocation/ extensification in the marine SES included moving seaweed farms to deeper water to ensure seaweed remained covered during low tide on hot, dry days. At the same time, seaweed farmers expanded the size of their plots to guarantee a minimum harvest. This had been particularly common over the last five years. In Kidoti, respondents reported fourfold expansion of seaweed plots. Fishing activities moved out of village waters as local stocks declined, an issue which respondents felt was not as severe in their ‘father’s time’ (around 30 years ago). Artisanal fishing is open access; anyone with a fishing licence can fish in any water ([Jiddawi and Öhman, 2002](#_ENREF_27)). Although some customary fishing rights exist on the island (*ibid*.), these were not reported during focus groups or interviews. Instead, in all three sites, focus group participants noted that ‘outsiders’ had begun to fish in waters around the village. Female fishers in Paje also reported long walks across the sediment-affected ITZ to find pools deep enough to collect benthic species.

### Impacts of relocation/extensification on mitigation

Within the terrestrial SES, this *Response* created two negative impacts on mitigation. First is the use of motorised vehicles to transport farmers to inland farms. In Paje, a daily 30 mile round-trip in a diesel engine car with a fuel efficiency of 30MPG produces around 5.6 tonnes CO2/year (climatecare.org, 2013). Given these assumptions, if 30 farmers per village adopt this adaptation the annual increase in emissions would be 152.1 tonnes CO2/year. Second, relocation/ extensification of farming and forest activities results in the depletion of above and below ground carbon sinks ([Palm et al., 2004](#_ENREF_45)). Farmers in Zanzibar use slash-and-burn methods to clear and prepare land. The burning that follows forest clearing immediately converts aboveground biomass into CO2 (*ibid*.) Collection of fuelwood places further pressure on aboveground carbon stocks. The total emissions from land use conversion and forest use in Zanzibar are c. 221 tonnes CO2/year ([Watkiss et al., 2012](#_ENREF_71)). Below ground carbon is lost when traditional farming practices (e.g. intensive tilling) expose soil ([Roose and Barthes, 2001](#_ENREF_54)). No estimates of below-ground carbon loss have been made yet ([Watkiss et al., 2012](#_ENREF_71)).

Within the marine SES, this *Response* had very little impact on mitigation as most households do not have access to carbon emitting technology for marine activities. Only 10.8% of surveyed fishing households own or use a fuel powered boat. The majority of fishermen rely on traditional sail boats (*dhows).* Extending seaweed farms is likely to have an indirect negative effect on mitigation as wooden poles cut from the forest are used on seaweed farms. Focus group respondents in Paje noted that a seaweed-farmer uses between 200 - 800 poles on a single plot. Poles are replaced every four months.

### Impacts of relocation and extensification on development

When *Responses* lead to conflict they are counter-productive and can be classed as maladadaptive ([Tänzler et al., 2010](#_ENREF_63)). Focus group discussions reveal instances of conflict between and within villages as a result of relocation/extensification. In the terrestrial SES in Paje, female forest users described recent tensions with a village six miles to the west;

*“[the other village] want to use the same forest as we do. Because of poverty and because we have no alternative livelihood we all have to use the forest. It causes conflict, we argue about who takes what.”*

(Focus group, Oct 12: female forest user, Paje).

Similarly, in the marine SES, the potential for conflict between villages was noted by fishermen in all three study sites;

*“Outsiders come from villages in the north. These are the ones who use the mtando* [circling net]*. They should be punished.*”

(Focus group, Nov 12: male fisher, Kidoti)

Conflicts within village boundaries were particularly problematic in the marine SES. In Paje, seaweed farmers, fishers and tourists operated in the same space along the ITZ. Conflicts between fishermen and seaweed-farmers occur when boats navigating a route out to sea are obstructed by seaweed farms. This sometimes results in seaweed damage. Conflict also occurs between seaweed farmers and tourists as the latter swim and kite-surf along the ITZ causing damage to seaweed beds. Although informal arrangements for sharing the ITZ have been promoted by a local hotel, this is not enforced.

## Intensification

Agricultural intensification is a common strategy to increase output where land is limited ([Scoones, 1998](#_ENREF_55)). Brookfield‘s ([1972: 31](#_ENREF_11)) classic economic definition of agricultural intensification states “the primary purpose of intensification is the substitution of these inputs [capital, labour and skills] for land, so as to gain more production from a given area, use it more frequently, and hence make possible a greater concentration of production”. When a farmer can mobilise enough inputs (including labour) to meet their requirements, intensification takes place ([Mortimore and Adams, 2001](#_ENREF_37)). Conversely, when inputs are not available, extensification takes palace.

Intensification is often viewed as a positive alternative to extensification as no new land is needed. However, in Zanzibar, intensification is labour-led as it occurs in the absence of new capital, such as tools to increase productivity. Labour-led intensification is characterised by increased time and effort ([Reardon et al., 1999](#_ENREF_49)). This includes more days spent on the farm and more hours spent farming each day, and a decrease in the length of the fallow period. Zanzibari farmers traditionally allowed fields to fallow for 20-25 years following cultivation ([Masoud, 1991](#_ENREF_33)) but household survey evidence suggests a fallow period of fewer than three years is now commonplace. Focus groups suggest that this had occurred over the past 30 years, around the same time as farmers relocated to outside of the village. Cassava cultivation had become almost permanent with an average fallow period of only 7.4 months following cultivation reported across the three sites;

“*Nowadays we just have to work harder at farming and taking care of the crops. We don’t do anything different like grow new crops, or use more inputs, we just work harder and longer. We can’t leave the land to recover for too long; we need it for crops”*.

(Focus group, Nov 12: male farmer, Nungwi)

Intensification also occurs in the marine SES. Fishermen in all three sites reported spending more hours at sea to ensure they returned with a decent catch. In Paje, male fishermen reported that boats were at sea for eight hours to secure the same catch that had taken four hours ten years before. In Kidoti, fishermen reported being at sea all night (>eight hours) sometimes returning with no catch. Fisherwomen reported similar issues. In Nungwi, focus group participants described returning from a day’s work with three or four octopuses where a catch of 20 had been normal ten years earlier. To secure a steady income, women spend more days per year on the beach, further contributing to species decline through over-fishing. Finally, seaweed farmers in Kidoti noted that as part of efforts to increase on-farm labour, children contributed to both seaweed farming and local fishing. All focus group participants noted that this was becoming more common.

### Impacts of intensification on mitigation

Within the marine SES, this *Response* has little impact on mitigation due to the lack of carbon emitting technology. Within the terrestrial SES, increasing yields through intensification prevents carbon loss from forest and shrub land in a way that relocation/extensification does not ([Burney et al., 2010](#_ENREF_15)). However, given the drastically reduced fallow period, trees are unable to colonize and mature following harvests ([Tschakert et al., 2007](#_ENREF_66)). The absence of secondary forest development significantly reduces the potential for above ground carbon storage by as much as 90% ([Bruun et al., 2009](#_ENREF_14)). Furthermore, soil organic carbon rapidly declines with continuous cultivation of crops ([Bationo et al., 1995](#_ENREF_9)).

### Impacts of intensification on development

Agricultural intensification is usually seen as a positive contribution to development ([Reardon et al., 1999](#_ENREF_49)). However, opportunities for intensification are limited by a lack of resources (e.g. machinery, inputs). Although farmers work harder, harvests cannot be guaranteed. As one female farmer in Nungwi complained *“We put in a lot of effort now but we still have a low harvest.”* It is possible that this is partly a result of the drastically reduced fallow periods that have been link to reduced long-term yield ([Mertz, 2002](#_ENREF_34)). If this is so, reducing the fallow period is maladaptive.

Labour intensification in both marine and terrestrial SESs increase time burdens. This disproportionately affects women as they already bear the greatest burdens in their roles as fuelwood/water collectors, housekeepers and child-carers ([Blackden and Wodon, 2006](#_ENREF_10)). Female time burdens generally decline with agricultural intensification, but where the key input is labour, female contributions will not decline ([Quisumbing and Pandolfelli, 2010](#_ENREF_48)). Intensification of an activity through child labour, as is the case in Kidoti, has implications for achieving universal primary education. Lack of education is already problematic in Kidoti where 34% of the survey respondents reported having no formal education, compared with the national average of 29.6% ([RGoZ, 2007](#_ENREF_50)).

## Diversification

Livelihood diversification occurred in all study sites, although options for diversification outside of the activities described in Section 2 were limited. Survey data showed that households had an average of 4.5, 4.4 and 3.0 livelihood activities in Paje, Kidoti and Nungwi respectively. The more limited livelihood portfolios in Nungwi can be explained by the dominance of fishing and the physical barriers to seaweed farming (i.e. strong waves that have always been a feature of the village);

*“We can’t always get money from fishing, so we have tried to do other things, like plant seaweed to get extra income. But the seaweed is taken by the strong waves so it is hard to make money this way.”*

(Focus group, Nov 12: female fisher, Nungwi)

Exceptions to the lack of livelihood diversification options are the opportunities presented by tourism. Indirect opportunities include growing conifer trees for use as building poles in hotels. Poles are grown on cleared forest or agricultural land and are harvested and sold after four years of growth. Surveys revealed that 12.6% of households in Paje, 26.5% in Kidoti and 6.1% in Nungwi were engaged in pole growing. Direct opportunities in tourism include employment by tourist establishments (e.g. as guards, cleaners and gardeners), and informal interactions with tourists (e.g. selling goods and services on the beach). Survey data show that in Paje, Kidoti and Nungwi, 40.5%, 15.8% and 26.1% of households respectively, generated some income from direct and indirect tourism. Focus group respondents linked tourism involvement to declining opportunities in traditional sectors, especially farming;

*“When tourism first came to Zanzibar the Sheha told us not to get involved as it was morally wrong. He said we would see alcohol and bad morals from the tourists. But our farms were not working and we were poor. People from the village went to get jobs anyway because we had no choice. Then the Sheha saw we could make money and still keep our own morals.”*

(Focus group, Nov 12: male tourism worker, Kidoti)

An important feature of livelihood diversification is male engagement in traditionally female activities, such as fishing for benthic species (e.g. octopus) and seaweed farming. For example, 16.1% of the households interviewed in Paje and Kidoti use male labour in seaweed farming, which is traditionally exclusively female, and over half of surveyed households use male labour for octopus collection.

### Impacts of diversification on mitigation

Options for diversification are limited to the livelihood activities described in Section 2, all of which produce minimal emissions. The exception to this is pole growing. It is estimated that conifer plantations in Africa sequester 6.4-10.0 tonnes CO2/hectare ([Nilsson and Schopfhauser, 1995](#_ENREF_42)). In reality, sequestration is likely to be much lower, or even negative, as these figures assume intensive management including fertilizer use, and do not take into account rotational patterns of harvest ([Nabuurs et al., 2007](#_ENREF_40)). Furthermore, since building poles are harvested at an immature stage they have yet to become carbon sinks. For this reason growing building poles has been discontinued in two Tanzanian mainland villages that are part of the United Nations’ ‘Reducing Emissions from Deforestation and Forest Degradation’ (REDD+ ) programme ([Zahabu and Malimbwi, 2011](#_ENREF_74)).

Diversification into tourism activities has little direct impact on mitigation, however, the indirect impact in the form of embedded carbon should be acknowledged. Gossling ([2010](#_ENREF_22)) estimates that each guest in a Zanzibari 4\* hotel produces 73kg CO2/ night. Similarly, a return flight to Zanzibar from Rome, Italy - where the majority of tourists originate ([Anderson, 2013](#_ENREF_4)) - produces around 1.27 tonnes CO2/flight (carbonneutralcalculator.com, 2013). How nations account for carbon emissions from international travel remains unresolved. Depending on the outcome of this debate, becoming dependent on carbon heavy activities may be a maladaptive strategy.

### Impacts of diversification on development

Instead of easing women’s time burdens whilst maintaining the overall income of the household, the use of male labour for traditionally female tasks was viewed negatively by focus group respondents. Women felt their ability to secure and manage their own income was threatened;

*“The women should collect fish and octopus and the men should go further out to fish. Men are the source of our problems. They take our fish.”*

(Focus group, Oct 12: female fisher, Nungwi)

The changing gender dynamics of livelihood activities was also recognised by men who attributed the change to a lack of alternatives;

*“Things are bad and these days even men will engage in octopus collection. They work like women, or they take the octopus from the reef on their way back from fishing. It used to be only women who did this, but because men don’t catch enough fish, we do this as well now.”*

 (Focus group, Oct 12: male fisher, Nungwi)

## Synthesis

Based on this analysis three key points emerge. First, *Response* strategies resemble coping strategies that provide short-term relief to stress but in the long-term may negatively affect development goals. Related to this is the second point, which is that each *Response* generates a trade-off between adaptation, mitigation and development. For example, when farmers respond to low productivity by spending longer on the farm, there is a development trade-off as time burdens are increased, and a mitigation trade-off as secondary forest cannot be established. However, it is not yet possible to identify which livelihood strategies generate the largest gains in terms of adaptation, mitigation and development. Third, it is clear that communities’ *Responses* are constrained due to a number of barriers.

# Barriers to maximising AMD synergies in *Responses*

To explore the question, ‘what are the barriers to maximising AMD synergies in community responses?’ we present focus group data on community perceptions of barriers. Following Pinkse and Kolk ([2012](#_ENREF_47)) and Dyer et al ([2013](#_ENREF_20)) we categorise barriers into four groups. These are resource, regulatory, learning and governance barriers (Figure 3).

>Figure 3 about here <

## Resource barriers

The capacity of individuals to adapt to climate change is determined by their access to resources ([Smit and Wandel, 2006](#_ENREF_59)). In Zanzibar, lack of access to land and capital present significant barriers to *Response* strategies that could incorporate AMD. In the marine SES, households’ ownership of fishing equipment was low. In Paje, 11.7% of surveyed fishing households owned a boat and 15.7% did so in Kidoti. In Nungwi, where the majority (77%) of households engaged in fishing, less than half (41.8%) owned a boat. Instead, individuals rent fishing gear, or use equipment provided by a trader subject to an agreement to sell catch back at an agreed (usually below market) price. In all sites, the lack of engine driven boats meant that fishermen lack the capability to sail far beyond the reef, thus constraining opportunities to extend the fishing ground. This was exacerbated by the loss of traditional navigational channels and unpredictable weather;

*“The weather is too unpredictable, so if we go too far and try to come back late, we will get stuck. We can only go about only 600m outward from the reef these days.”*

(Focus group, Oct 12: male fisher, Paje)

Similarly, seaweed-farming and female fishing groups reported how a lack of basic equipment such as protective footwear prevented access to parts of the ITZ. A lack of post-catch resources such as fridges and processing equipment emerged as a further resource barrier. Only 14.6% of households owned a freezer with the remainder renting space in a freezer;

*“If someone comes in late from collecting fish they cannot sell their catch immediately and they have to pay 300 shillings to store it. This means we are limited in what we can catch.”*

(Focus group, Nov 12: female fisher, Nungwi)

In the terrestrial SES a similar picture emerged. For example, in Nungwi only 15.6% of surveyed farming households use any form of fertilizer;

*“Our biggest challenge is insufficient equipment. Right now, the main item we use is an iron rod, and we don’t have much else apart from this. We don’t use fertilizer we just work hard.”*

(Focus group, Nov 12: male farmer, Nungwi)

Interviews with IMS experts revealed that a preference for foreign/mainland labour was related to poor education/foreign language skills amongst the local population.

If access to inputs was facilitated through farming/fishing cooperatives there would be clear production benefits and consequently development benefits for the community ([Ortmann and King, 2007](#_ENREF_44)). However this may have consequences for long-term adaptation. For example, modern equipment, including motorised boats, may lead to unsustainability through overfishing. A negative mitigation impact would occur unless regulation sought to control emissions by encouraging cleaner fuel e.g. marine biodiesel has been shown to reduce CO2 emissions ([Lin and Huang, 2012](#_ENREF_31)).

## Regulatory barriers

Regulation could help communities utilise resources more efficiently whist minimising trade-offs between AMD. However, a lack of regulation emerges as a current barrier to AMD compatible *Responses*. For example, as outlined in section 6.1 over-fishing undermines adaptation by creating greater pressures in the long-term and is exacerbated by the absence of measures that reduce capacity utilization, such as catch quotas or limits to days at sea;

*“There is nothing we can do to help ourselves because in this village we have poor management and a lack of enforcement of rules and regulation around fishing.”*

(Focus group, Nov 12: male fisher, Nungwi)

Overfishing is further exacerbated by lack of enforcement that extends throughout Zanzibar’s Exclusive Economic Zone (EEZ) – a range of 200 miles from the shoreline. Local boats are usually incapable of traversing long distances so cannot adapt by extending their range hence large parts of the EEZ are used by foreign fishing boats that pay a permit fee ([Wilson, 2004](#_ENREF_72)). Due to ineffective revenue collection, the national benefit of foreign fishing is insignificant (*ibid*.). As such, revenue that could have been directed toward community development is lost. Similar ‘leakage’ of potential income is present in the tourism industry, an increasingly important source of foreign revenue on Zanzibar ([Steck et al., 2010](#_ENREF_61)). Focus group respondents in all sites described the impact of poor regulation on the ability of local communities to access income generating opportunities;

*“Immigrants from the mainland [Tanzania and Kenya] come into Nungwi to get money from tourists. In the past villagers worked in tourism but now foreigners take the chances. The hotels won’t employ us locals – they prefer foreigners. There should be rules to stop the foreigners taking our chances because we are left with nothing.”*

(Focus group, Nov 12: male tourism worker, Nungwi)

Regulation could ensure that the local community benefits from local resources, including tourism. Access to local employment opportunities could be secured though government supported local employment schemes, for example, placements that lead to full time work. Whilst engaging in tourism would generate immediate development benefits, adaption benefits may not be as long-term. Tourism would need to be ‘climate-proofed’ to protect the environment attributes that attract visitors ([Uyarra et al., 2005](#_ENREF_70)).

## Learning barriers

For the community to benefit from tourism and other opportunities it is important to overcome learning gaps, which include a lack of new knowledge, practice and technologies ([Pinkse and Kolk, 2012](#_ENREF_47)). Local people struggle to find formal employment opportunities that are not based on natural resources because of limited English and maths skills ([Mustelin et al., 2010](#_ENREF_38)). Educational attainment on Zanzibar has been ‘alarmingly’ low, and although some progress has been made, competencies in skills such as maths remain poor ([SACMEQ, 2011](#_ENREF_60)). In Paje, a lack of appropriate knowledge of modern farming techniques and alternative crop varieties was a critical barrier to behavioural change;

*“We still grow the same crops, like cassava and yams. We have not changed the timing or the season that we plant in, or the methods we use. These are just how we farm and we won’t change.”*

(Focus group, Oct 12: female farmer, Paje)

Similarly, focus group respondents in all three sites revealed how a lack of knowledge around agroforestry was a barrier to new methods of planting that have been shown by a number of authors to have AMD benefits at the community level. ([e.g.Kalame et al., 2011](#_ENREF_28))

*“We don’t replant trees around the farm because we would lose cultivatable land. It would never work to plant trees on our farms because crops would be shaded out. Even if we did plant trees near the farms, the livestock would destroy them as seedlings.”*

(Focus group, Nov 12: male forest user, Nungwi)

## Governance barriers

To ensure resource, regulatory and learning barriers are surmountable, effective governance that facilitates cooperation and communication between communities, tourism and government is needed. In all villages, lack of communication between community and government was highlighted by the absence of extension workers who have a role in teaching farmers new skills in land management;

*“They don’t do anything! The extension officer should be visible, with a clearly defined role. The community is only aware of ideas for change from the radio or newspaper. Extension officers are rarely seen in this village.”*

(Community focus group, Oct 12: male farmer, Paje)

Local institutions have been shown to enhance local adaptive capacity in mainland Tanzania ([Rodima-Taylor, 2012](#_ENREF_52)). However, in Zanzibar, a lack of resource governance, including local institutions to mitigate conflict within and between communities was evident. Intra-community conflict was particularly evident in Paje where seaweed-farmers, fishers and tourists operated in the same space along the ITZ. During focus groups, seaweed farmers conveyed a sense of ‘helplessness’ and a perception that they had the least leverage over the space;

*“There is nothing we can do to change what is happening in the ocean. It is out of our control. If we make our farms bigger or move them, the windsurfers and fishermen can still destroy them”*

(Focus group, Oct 12: female seaweed-farmer, Paje)

Similarly, women in Nungwi described how they were marginalised by more powerful male fishers;

*“The women would like a female-only fisheries committee and we would like to be involved in the men’s fisheries committee. Now men make all the decisions about fishing and we have to live with it. We would zone the ITZ and make sure the men respected our decisions”*

(Focus group, Nov 12: female fisher, Nungwi)

Local institutions, including committees and cooperatives could assist farmers in accessing local markets. Farming focus groups described hotels’ preferences for foreign rather than local goods. Interviews with IMS experts revealed that this was related to fears over quality and consistency of supply. Research from South Africa also reveals that where hotels’ are keen to buy local produce, there is a lack of awareness around potential suppliers ([Pillay and Rogerson, 2012](#_ENREF_46)). This limits income opportunities from agricultural. In Kidoti where most (96.6%) surveyed households engage in subsistence farming, only a third (35.1%) generate an income from selling agricultural produce, and only 1.6% supply hotels. This disconnect between local farmers and the tourist industry is well-recognised;

*“Some of the crops grow well, like lemons, but we need to find a market for them. Then we can make some money. If we could sell lemons to the hotels we would have money.”*

(Focus group, Oct 12: female farmer, Paje)

# **Discussion and Conclusion**

Our findings highlight the importance of applying an AMD lens to focus our research. By using this lens we suggest that in responding to multiple-stressors, including climate change, communities in Zanzibar create trade-offs between AMD. More specifically, we suggest that instead of being long-term adaptations, *Responses* may often actually be maladaptive coping strategies. These coping strategies generate worsening development conditions that serve to undermine long-term socio-economic development in the island. Furthermore, many of the *Responses* also lead to high carbon pathways. Barriers to *Responses* that generate positive AMD benefits occur due to a lack of resources, regulation (or inadequate regulation), knowledge/skills, and governance to facilitate communication and cooperation.

A range of small changes to overcome these barriers and that are supported by a policy commitment could help guide adaptation. For example, resources barriers could be overcome by creating policy that supports access to credit, or facilitates the creation of cooperatives, thus enabling communities to access inputs and markets. A farmers’ cooperative could ensure better quality and quantity of supply than an individual farmer could produce. However, regulation is needed to ensure that increased access to resources, including inputs and markets, supports long-term adaptation and mitigation considerations. Overcoming learning barriers by improving knowledge products could support more effective adaptation by improving access to opportunities, whether in the form of guidance communicated through agricultural extension workers, or through other locally accepted methods. Finally, effective governance is needed to manage the process. Governance barriers could be overcome by introducing coastal zoning policy that takes into account different users’ needs, thus reducing conflicting coastal uses. There is interest within both government and local communities to explore how community-based management approaches, which build from customary practices, can be effectively used to address resource use. Community-based management, where communities actively participate in defining and implementing management measures, is seen as a promising approach and has been used successfully in other contexts ([Dougill et al., 2012](#_ENREF_19)).

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