DECCMA

Working Paper

A method to assess migration and adaptation in deltas: A preliminary fast-track assessment

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About DECCMA Working Papers

This series is based on the work of the Deltas, Vulnerability and Climate Change: Migration and Adaptation (DECCMA) project, funded by Canada's International Development Research Centre (IDRC) and the UK's Department for International Development (DFID) through the **Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA)**. CARIAA aims to build the resilience of vulnerable populations and their livelihoods in three climate change hot spots in Africa and Asia. The program supports collaborative research to inform adaptation policy and practice.

Titles in this series are intended to share initial findings and lessons from research studies commissioned by the program. Papers are intended to foster exchange and dialogue within science and policy circles concerned with climate change adaptation in vulnerability hotspots. As an interim output of the DECCMA project, they have not undergone an external review process. Opinions stated are those of the author(s) and do not necessarily reflect the policies or opinions of IDRC, DFID, or partners. Feedback is welcomed as a means to strengthen these works: some may later be revised for peer-reviewed publication.

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1 INTRODUCTION

Deltas contain large populations totalling about 500 million people worldwide. Deltas are extremely fertile and often support high population densities based on agriculture/fisheries. They are thus important for food security. Despite their importance and advantages for agriculture, many of the people living there are poor and reliant on subsistence livelihoods. Even though a range of temporary and permanent migration is already a widespread phenomenon in deltas, the fear is that future sea level rise and sinking land levels coupled with other climate change triggered environmental changes (e.g. drought, flooding, etc.) might mobilise large numbers of people and thus cause mass internal and international migration (e.g., Milliman et al., 1989; Ericson et al., 2006).

The DECCMA project seeks to understand migration within deltas: how climate change and sea-level rise might influence it, and the extent to which it serves as an effective adaptation. Furthermore, it aims to provide better evidence to inform policy makers about the possible futures of deltas, how adaptation can mediate potentially adverse impacts of climate change, and the potential role of migration as an adaptation option.

The focus of DECCMA is on climate change and sea level rise; however, many other drivers such as economic changes or political conflicts can affect migration and other in-situ changes. These various drivers may be mutually reinforcing. Thus, although DECCMA places a special focus on climatic and environmental change, the integration activities have to consider other non-climatic influences to better represent reality and ensure credibility and usefulness to stakeholders. By definition, any response to a climate driver that reduces vulnerability to future climate risk can be considered as an adaptation (Suckall and Vincent 2015, see glossary). DECCMA aims to assess the adaptation options in the study areas (i.e. that reduces vulnerability, including that of households, the local community and the environment) and to identify the unsustainable coping and mal-adaptation strategies (see Glossary). Finally, DECCMA acknowledges that migration can have both negative and positive impacts on social systems. It aims to assess the motives of migration and under what conditions the migration is considered as successful. With this respect, migration can only be successful if both the wellbeing of the household and the migrant is increased. Thus DECCMA aims to provide an insight into not only the larger scale processes, but also to unpack the local community processes and the intra-household dynamics, including how gender roles and relations, are affected by migration and migration-as-an-adaptation. To achieve such an ambitious goal, an integrated assessment framework and an integrated model is proposed as a mechanism to promote integration and discussion across disciplinary boundaries.

The goal is to develop a 'process' understanding of adaptation and migration which is valid to 2050. The results will also inform post-2050 analyses, but it will need to be acknowledged that our understanding of possible future conditions diminishes, especially for the socio-economic system, and our post-2050 analysis becomes more focused on biophysical factors. Hence, a changing approach is envisaged over time and this will be elaborated in the final WP5 methods report. This interim Fast Track output is a key step to outline our provisional ideas and concepts, and promote a shared understanding within the DECCMA Project across the work packages and disciplinary boundaries for Work Package 5 (WP5). The paper outlines the aims and objectives of WP5, considers appropriate and relevant methods, frameworks and theories and proposes a DECCMA conceptual framework.

2 BRIEF DESCRIPTION OF THE STUDY AREAS

The DECCMA project aims to study three deltas: the Ganges Brahmaputra Meghna (GBM), the Mahanadi and the Volta deltas. These deltas face multiple and slightly differing pressures and have different scales. The largest is the GBM, followed by the Mahanadi and the smallest is the Volta delta. Thus, they allow a unique opportunity to consider scale, geographic settings and varying drivers in the analysis of climate change, environmental change, migration and adaptation.

The study area within each delta delineated based on the 5m contour line and administrative boundaries. The 5m contour line is important to focus the attention on the coastal processes and hazards linked to sea-level rise, whereas the administrative boundaries are important for data collation (i.e. defining the spatial scale of the available data) and to ensure that the results will be useful for decision makers.

2.1 The Ganges-Brahmaputra-Meghna delta

The Ganges-Brahmaputra-Meghna (GBM) Basin spans across Bangladesh, Bhutan, Nepal, China and India, and the related delta presents one of the largest estuarine regions of the world. The drainage basin of these three rivers is 1.7 million km^2 and the size of its delta plain is 100,000 km^2. The delta plain is mostly within Bangladesh, with the western extent in India – which brings in part of the Hooghly River estuarine plain. Almost uniquely, DECCMA considers both the Bangladeshi and the Indian sides of the delta plain together in its analysis (Figure 1). Nineteen districts are considered on the Bangladesh side that are officially recognised as the "Coastal Zone of Bangladesh" by the Government of Bangladesh. The Indian side of the study area comprises two large districts.

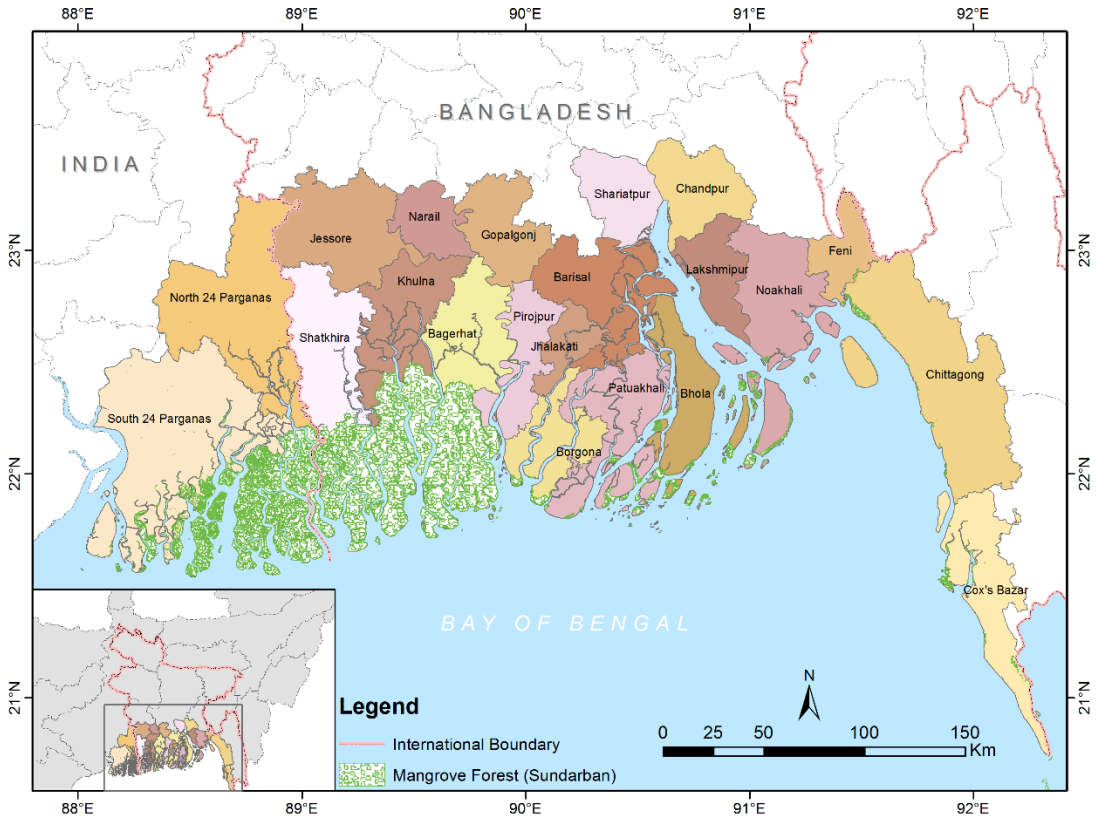


Figure 1: The study area within the GBM delta

The climate of the delta is humid and can be categorized into pre-monsoon (February to May), monsoon (June to September), and post-monsoon (October to January). The total annual rainfall varies across the study area having a range of 1,500 – 2,000 mm in the Western part and 2,000-4,000

mm in the Central and Eastern parts with a maximum in Cox's Bazar receiving 4,285 mm/yr. The average temperature also varies spatially, having an average maximum of 34°C and 31.5°C and having an average minimum of 13.7 and 12.5°C in the Western and Eastern parts, respectively.

According to the 2011 Census, the total population of the study area is about 56.5 million people. 18 million are living in India with a population density of 1900 person/km^2. On the Bangladesh side there are 38 million people with a population density of 750 person/km^2. According to the Household Income Expenditure Survey of Bangladesh (HIES 2010), the average Lower Poverty Line (based on the Cost of \Basic needs method) was BDT 1238 (USD 16) per month and 21 percent of the rural population belonged to this poverty category.

The dominant land use in the study area is agriculture, representing 60% and 48% of the landholdings in Bangladesh and India, respectively. Forest land, entailing natural vegetation and mangrove forest, comprises around 32% percent of the total in India and about 10% of the Coastal Zone of Bangladesh. The majority of the Sunderbans mangrove forest is protected and classified as Reserve Forests. In the study area, agriculture, fisheries, aquaculture (in Bangladesh), and forest resource collection (fuel-wood, honey, etc.) and labouring are the main livelihood types.

The study area is under multiple stresses that make it highly vulnerable to climate change impacts, including:

- high intensity cyclonic storms and tidal surges (Satkhira, Khulna, Barguna, Patuakhali, Bhola, Noakhali, Chittagong and Cox'x Bazar, North and South 24 Parganas);
- sea level rise and high rates of coastal and river erosion (Chandpur, Laksmipur, Bhola and Barisal, North and South 24 Parganas);
- subsidence contributing to relative sea-level rise;
- salinization (Khulna, Bagerhat, Satkhira and Cox's Bazar, North and South 24 Parganas);
- fluvial flooding (Gopalganj, Barisal, Chandpur, Sariatpur, Narail and Jessor), during and after the monsoon; and
- fresh water scarcity during the dry season.

2.2 The Mahanadi delta

Mahanadi Delta is one of the largest deltas on the east coast of India (Figure 2). The Mahanadi Delta is fed by the network of three major rivers: Mahanadi, Brahmhani and Baitarini into the Bay of Bengal. The coastline of the delta is about 200 km long which stretches from the south near Chilika to the north up to Dharma River.

The Mahanadi delta experiences a tropical with hot and humid monsoonal climate. The delta receives an average annual rainfall of 1,572 mm of which over 70% occurs during the southwest monsoon between middle of June to middle of October. The mean summer temperature of the region varies near 29^{o}C and winter temperatures near 21^{o}C. The high intensity of cyclonic storms, flooding and coastal erosion make the delta vulnerable to climate change impacts.

The Mahanadi Catchment has an extensive area under agricultural use. Forest and agriculture are the mainstay of the people in the interior parts of the basin. The upper part of the delta is highly populated in respect to the lower part of the delta. Devastating floods in the delta regularly bring about some changes in land use pattern. Chilika, the largest coastal lagoon in Asia is situated in the far south of the delta.

Five districts (Puri, Kendrapara, Bhadrak, Jagatsingpur, Khurda) have been taken as the study area based on the 5m and lower elevation zone. As per the 2011 Census the total population is around 6 million with a population density of 491 person/km^2. About 60% of the population of the State fully or partly depend on agricultural sector for their subsistence.

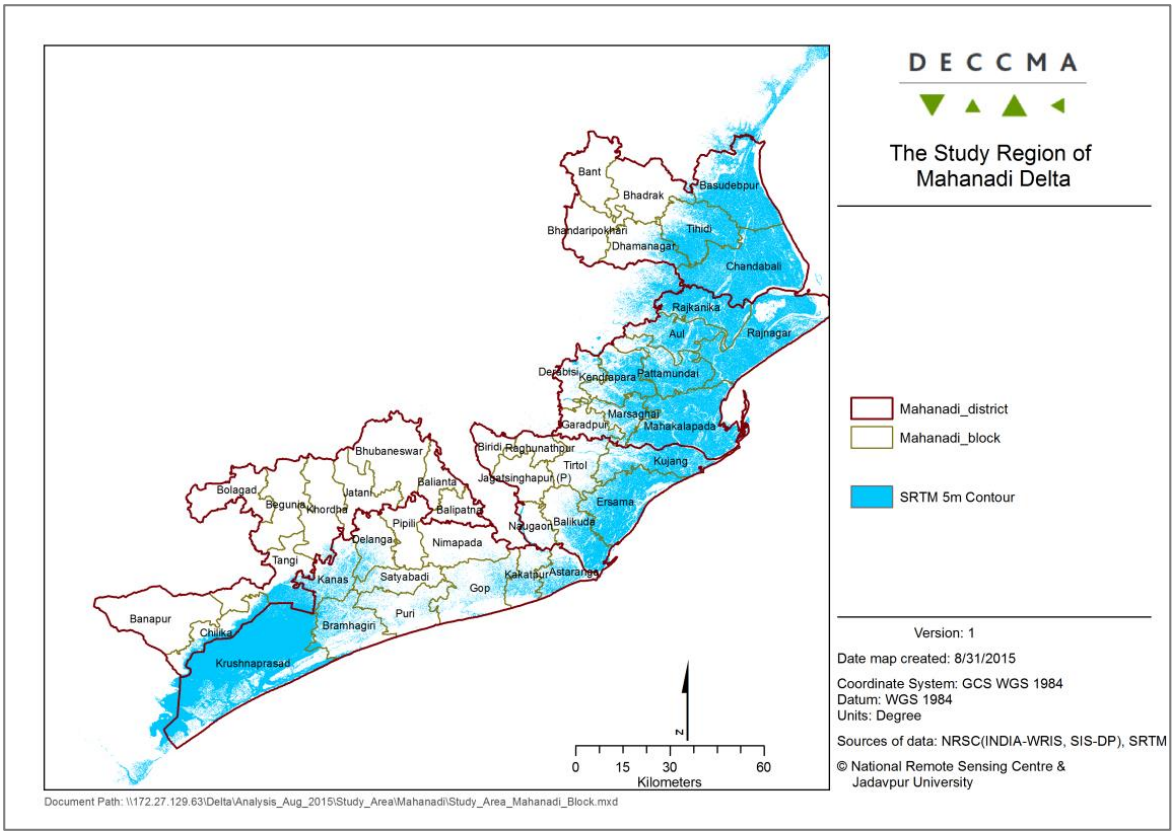


Figure 2: The study area within the Mahanadi Delta

2.3 The Volta delta

The Study area covers a coastal sub-region of the Lower Volta Basin along the Gulf of Guinea in Ghana (West Africa, Figure 3). The main drainage systems in the study area are the Volta Delta, the Keta Lagoon complex and the Songor Lagoon. The study area includes nine administrative districts namely, Ketu South, Ketu North, Keta Municipality, South Tongu, Central Tongu, Ada East, Ada West, Ningo Prapram and Akatsi South. It covers a total area of about 4,553 km^2 with a total population of 965,827 people (Ghana Statistical Service, 2012) and an average population density of 212 people per km^2.

The area falls mostly within the coastal savanna climatic zone which experiences two rainy seasons, the first occurring between March and July and the second, from August to November. The annual precipitation averages vary between 146 and 750mm for the districts. Land cover is predominantly grassland with scattered tress and mangrove.

Coastal erosion is the major natural hazard affecting most of the coast and the region. Coastal erosion varies spatially with a mean of 8 m/year and with a range of 2-17 m/year (Angnuureng et al., 2013; Jayson-Quashigah et al., 2013; Appeaning Addo et al., 2011; Acheampong 2001; Ly, 1980). Apart from erosion, riverine and coastal floods, storm surges and drought were identified by national stakeholders as the major threats in May 2014. Stakeholders did not identify fire and salinisation as key hazards; though they potentially play a role in the coastal processes.

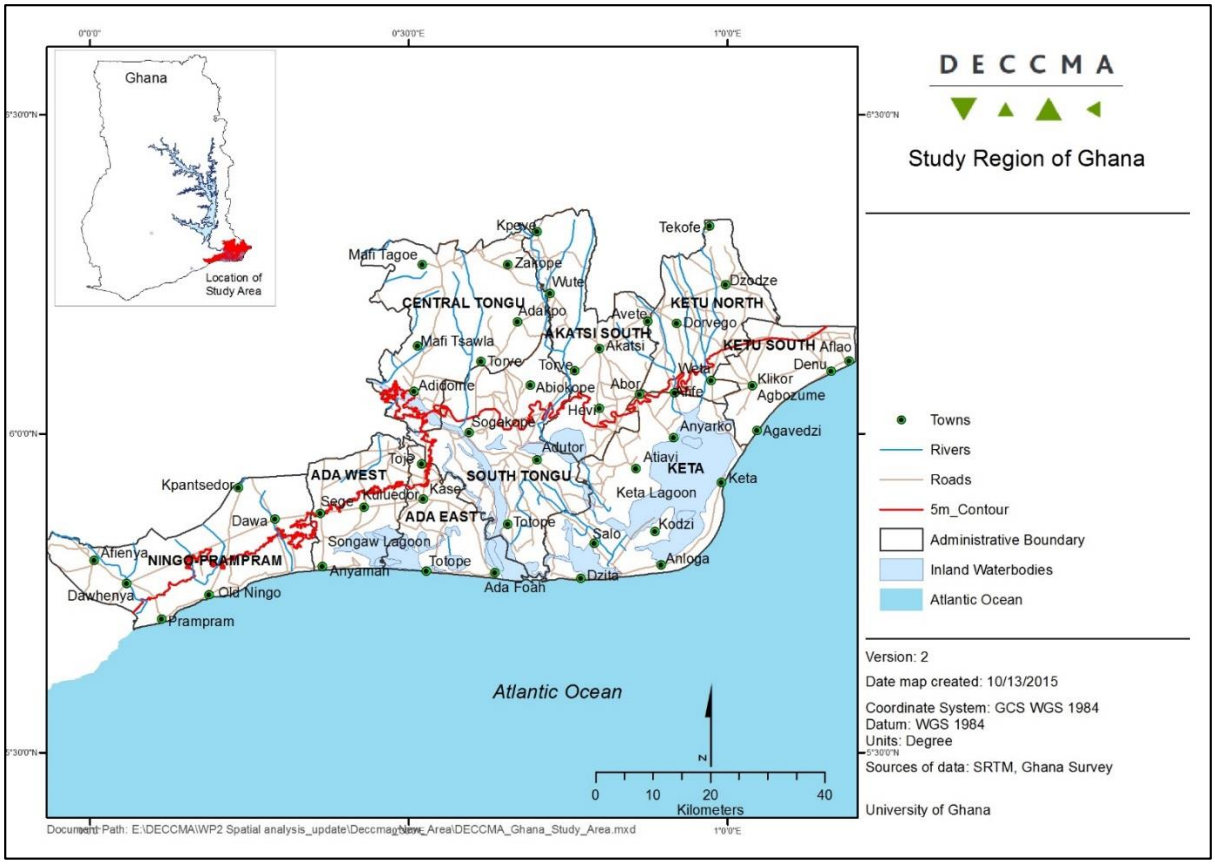


Figure 3: The study area within the Volta Delta

The main economic activities of the inhabitants of the Volta Delta are based on natural resources. The people are mainly engaged in agriculture/fishing/hunting activities. They also engage in salt mining, sand mining, craft and related trades.

Evidence from the 2010 Population and Housing Census indicates that 20-30% of the population in the Volta Delta are living below the national poverty line of GHC 1,314.00 per annum (USD 344 at present exchange rate). The proportion employed among the economically active population is the lowest in highly urbanised Keta Municipality in the entire Volta Region. Access to sanitation services is particularly low in the districts of the Volta Delta.

The Akosombo Dam was built for hydro-power generation in the 1960s. The construction of the dam led to the flooding of some parts of the Volta River Basin, creating Lake Volta. Massive out-migration from the Lower Volta was observed due to the construction of the Akosombo Dam (Tsikata 2006). Although much of this (up to c 80,000 from 740 villages) was forced migration (Tamakloe 1994) the scale of associated non-institutional migration was not quantified. These were mainly farmers and fishing folk. A common destination for migration was towns around the Volta Lake where they could undertake their fishing activities or farming. Other destinations include Tema, Ashaiman and Accra. Lomo, the capital of Togo, is located near to the Volta study area, but cross-border migration has not been researched in Ghana, reflecting Ghana's stronger economy and higher standard of living than its neighbours.

3 WP5 AIMS AND OBJECTIVES

WP5 provides the conceptual underpinning as well as the methodological tools for integration between the DECCMA work packages. As such, WP5 heavily relies not only on the research outputs and timely delivery of the other WPs, but also on the cross-discipline discussions within the project team. Integration will occur through the application of an integrated assessment approach to evaluating adaptation and migration. The specific research questions of WP5 are formulated to answer the high level DECCMA questions:

1) Which socio-economic, climatic-related environmental stresses and governance factors are most important in explaining migration of men and women in the delta?

2) What are climate-resilient and successful adaptations for men and women in deltas?

3) What are the advantages and disadvantages of migration as an adaptation to climate stress compared with in situ resilient responses for men and women in the delta?

4) How can government policy promote more climate-resilient and successful outcomes for men and women in the delta?

These WP5 questions and the following Methods section focus on exploring the plausible behaviour of these deltaic systems to 2050. Our understanding of the socio-economic drivers and processes diminishes over time. Thus, the analysis of post-2050 futures are likely to be limited to the assessment of the status and trajectories of biophysical environment and will be defined in the final WP5 methods report.

4 METHODS

To answer the four WP5 high-level questions in a useful way for stakeholders, the development of both an innovative integrated analysis of historical data and a quantitative tool are envisaged. Question 1 is likely to be addressed mostly based on data analysis with no need of an integration model, but rather an integrated analysis. To evaluate adaptation and migration options (Question 2 and 3) and to answer the future trends related questions (Question 4), however, requires an integrated model. In addition to an integrated framework and model, the development of future scenarios is also required. This section outlines the methods and the steps needed to answer each of the WP5 research questions.

4.1 Question 1: Which socio-economic, climatic-related environmental stresses and governance factors are most important in explaining migration of men and women in the delta?

This question aims to explore the recent past and current migration patterns in the three deltas and to refine the DECCMA conceptual framework on migration. Here, only the existing data is used to learn about migration (sending/receiving areas, factors associated with migration, etc.).

The question will be answered with an integrated analysis of historical and present day data collected and collated in WP1, WP2, WP3 and WP4. This exercise aims to establish the associations/links between elements of the system by using regression models, PCA (Principal Component Analysis) and possibly using the Bayesian Geo-additive Semi-parametric (BGS) regression method. The focus will be on census years and other accessible survey years and the analysis should examine the changes between these time slices: what environmental, economic, other changes

could have driven the observed migration magnitudes, patterns and change (e.g. sending and receiving community locations). The analysis will not only look at variables pairwise, but also in conjunction (i.e. many or all together). This analysis will:

a) Examine **the various drivers of migration (including non-climate-related factors)** using secondary data sources: population growth / environment / climate / livelihood / economy / environmental shocks versus number of migrants. In addition to the associations, this analysis is likely to provide hot spot information (identifying the important sending and receiving areas).
b) Examine **the more detailed patterns of migration** using household survey data**:** gender / age of migrants, circumstances of migration (livelihood, personality, past-migration experience, satisfaction with location, age, number of children, local social network, migrant networks, place attachment, attitudes to risk, levels of exposure to information on other places, location of sending and receiving communities). The aim is not only to identify the decision thought process of migration, but also to identify possible **thresholds** for migration, and to **evaluate the outcome** of the migration (successful or unsuccessful: i.e. has the migrant and/or sending household achieved its migration aims?). Although the DECCMA research is primarily focusing on internal migration, this analysis should also consider international migration.
c) Refine **the DECCMA conceptual framework** (outlined in Section 6), and if possible, to calculate threshold and create equations and rules for the subsequent model development tasks.

4.2 Question 2: What are climate-resilient and successful adaptations for men and women in deltas?

This question aims to assess the potential of each identified adaptation and assess which ones allow the community / individual to maintain their position and with ones allow an improvement in wellbeing and status. Migration as an option here is ignored.

The aim is to identify successful, climate-resilient adaptations. This question requires an integrated analysis, thought experiments, and possibly some modelling, using toy models to consider the casual loops in the system. The aim is to gain an understanding of the impact of the different adaptation options on the livelihood of the coastal population. This understanding has to be established for different time-scales: immediate, short-term, medium-term and long-term. Thus, to answer this question, the following tasks have to be carried out by the DECCMA team:

a) The **catalogue of coping, adaptation options** that might complement migration. Some development options might be included in this work, but these are not the primary focus of this research. WP5 and WP6 will work together to conceptualise successful adaptation options for modelling purposes: simplify the adaptation option list to a distilled list of choices (i.e. a typology of adaptations).
b) Using thought experiments and the literature, assess each of these adaptation options and **identify their effect** on different livelihood types, and on the environment by considering different time-scales. It is essential to know where/when/how they are used, and what are the implications (present and future), including maintenance and further investment requirements.
c) The development of **robust evaluation criteria of adaptation options** is essential to be able to test the successfulness.
d) **Parametrisation** of the decisions around each in-situ adaptation options and their effects is also needed. This will be based on the results of the above thought experiments and the DECCMA household survey results.
e) **Future (climate and development) scenarios** have to be developed.

f) Finally, using **toy models**, the sensitivity and uncertainty of the catalogued adaptation options will have to be tested. This modelling activity will focus on individual adaptation options and these toy models will not be that same as the models developed to answer Question 3 and 4. These models are unlikely to be spatially-specific. The models will be designed based on the outcome of the thought experiments.

4.3 Question 3: What are the advantages and disadvantages of migration as an adaptation to climate stress compared with in situ responses for men and women in the delta?

This question aims to look at both migration and adaptation together in a model framework. Through a sensitivity analysis, the conditions under which the migration is going to be a success is assessed.

To answer this question, an integrated modelling framework is needed. The development requires multiple steps:

a) The implementation of the conceptual framework is envisaged to be done by using multiple modelling techniques with different complexities and by using a tiered, building-block approach. The **Systems and Bayesian Network models** will include relations and casual loops without being spatially-explicit (general behaviour modelling). The environmental (including land use), social and economic conditions are input scenarios in this case, and the model will inform us if migration or certain adaptation could be the result of the circumstances. These toy models should describe household archetypes including household structure and gender. The **Agent-Based Model (ABM)** will have the same scope, but will be spatially-specific. The early version of these models will consider land use as an input time-series, but the aim is that the land use will be an emergent property of the ABM model defined by household-level decisions. These decisions are expected to be based on the WP3 household survey results, the WP2 GAEZ/NAEZ (Global- and National Agri-Ecological Zone) assessment, the literature and expert knowledge.
b) The development of **robust evaluation criteria of migration** is essential to test the pros and cons of migration.
c) Finally, **a sensitivity and uncertainty analysis** of the implemented integrated model is carried out by using the previously developed future scenarios.

4.4 Question 4: How can government policy promote more climate-resilient and successful outcomes for men and women in the delta?

Under this task, the plausible futures of these deltas are explored by considering appropriate adaptation options for multiple scales (community, household and individual levels) including gender and wellbeing. The aim is to test rigorously a set of pre-defined adaptation pathway scenarios with different complexity level models (i.e. tiered approach) and with different modelling techniques (i.e. systems, Bayesian, agent-based). The outputs of these model runs are then analysed to identify the successful development pathways and their uncertainties. This requires:

a) The analysis of possible pathways of the three deltas (10-years window of analysis?). This is likely to be a desk study assessing the literature and using expert knowledge.
b) These identified adaptation pathways are then assessed by using the plausible future scenarios developed under Question 2, and the models developed under Question 3.

5 BRIEF LITERATURE REVIEW OF MIGRATION AND ADAPTATION

5.1 Migration theory

Mortreux and Adams (2015) have reviewed the migration theory literature and found four types of theory: (i) Neoclassical economic theory, (ii) Structuralist approaches, (iii) Livelihood approaches and (iv) Decision making theory. They concluded that although these theories capture well the different aspects of migration, the literature is currently lacking in an overarching migration theory that brings all these aspects together. Thus, the DECCMA project should not prioritise any one of these theories above the others. Rather, a pluralist theoretical approach should be developed and applied in the project. The approach must consider multiple drivers, such as economic, political, social, environmental and demographic drivers, and must capture the multiple scales of migration: macro- (i.e. global), meso- (i.e. national) and micro- (i.e. household and individual) levels.

5.2 Literature review of migration conceptual frameworks

Several conceptual frameworks of migration exist in the published literature. One of the most comprehensive frameworks is developed by Black et al (2011) emerging from the UK Government's Foresight Report on Migration and Global Environmental Change. The report highlighted that the link between environmental change and migration should be explored from the perspective of how these environmental changes might influence the drivers of migration (Figure 4). They identified five dimensions of drivers of migration (i.e. environmental, social, political, economic, demographic), and four different categories in relation to migration status: two migrant categories (forced, voluntary) and two non-migrant categories (trapped and voluntary). While this conceptual framework is useful, it has four limitations (from the perspective of DECCMA): (1) it provides little insight about how people make decisions; (2) the role of in-situ adaptation strategies to tackle climate or non-climate drivers is not clearly stated; (3) it doesn't say anything about whether or not the migration is a success; and (4) gender differences are not considered.

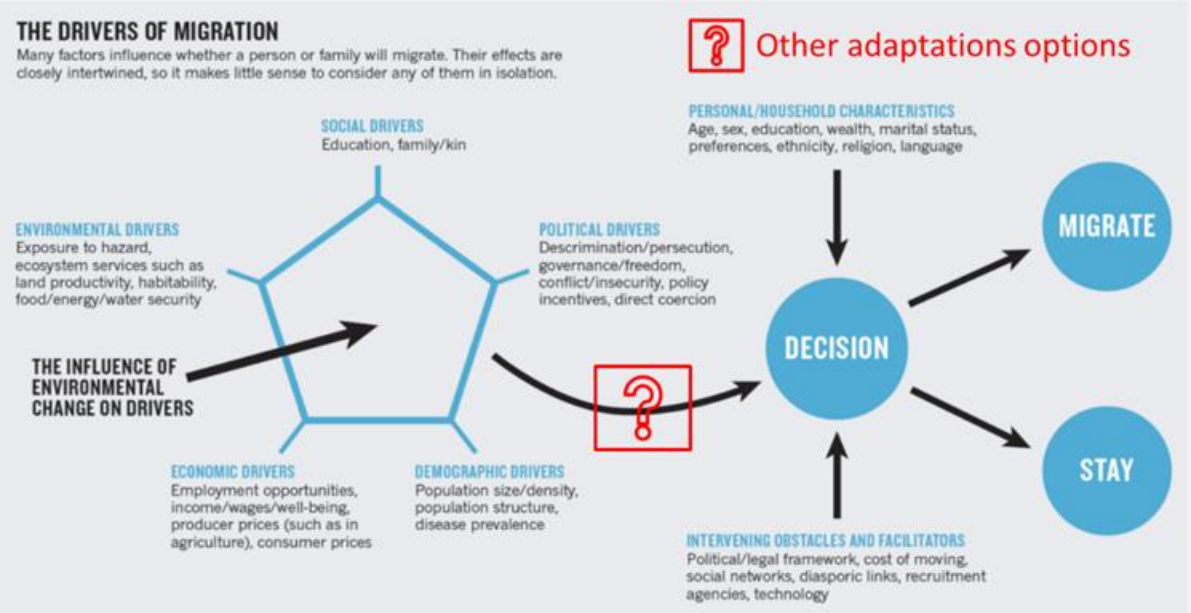
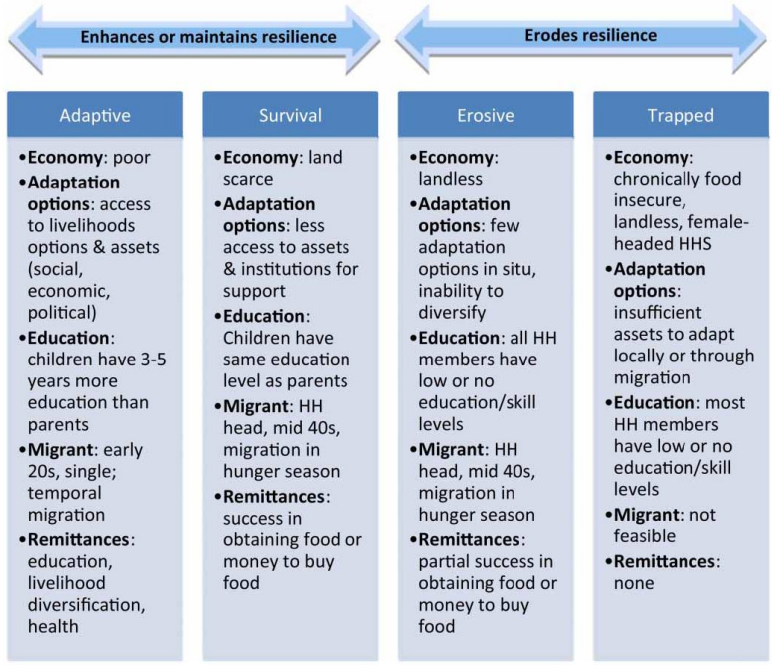


Figure 4: Foresight project conceptual diagram and its limitations (adapted from Black et al., 2011)

Murphy (2014) built on the work of Warner and Afifi (2013) and investigated the links between rainfall, migration and wellbeing in dryland areas, where rainfall is the main environmental hazard. They created four typologies which represented the ways in which mobility and immobility can be

both positive and negative forms of adaption to climate change at the individual and household levels depending on the household context. Four different typologies of individual/household were proposed as shown in Figure 5 (upper panel). While these four categories might be contested or expanded, this approach can provide some of the missing insights regarding how decision-making is done at the household level (see Figure 5, lower panel).



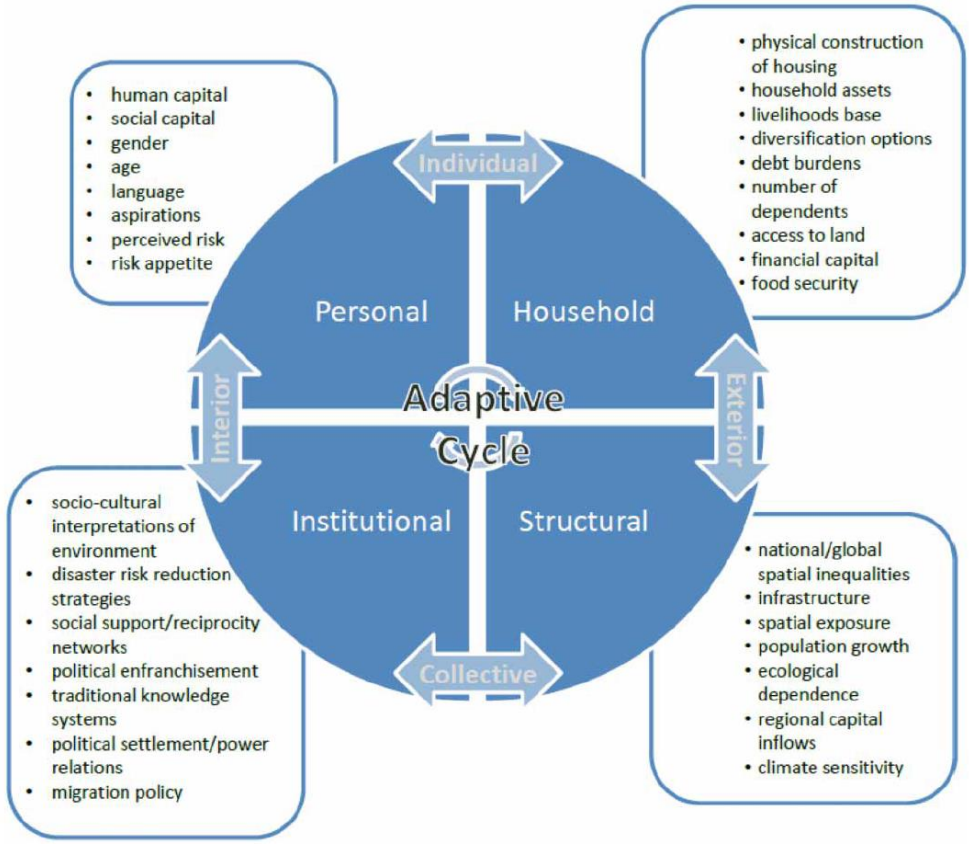


Figure 5: Household profiles of (im)mobility (upper panel) and heuristic model outlining factors related to human (im)mobility in a context of environmental change (from Murphy, 2014)

Haas (2010) reviewed the migration literature and developed a pessimistic, an optimistic and a pluralist framework. His focus was on development and not on climate or environmental change induced migration, but the elements he summarized are still similar to those used by other conceptual frameworks. While Haas attempted to link macro- and micro level migration, the scope of these frameworks are limited to the economic aspects of migration and thus do not fully capture the DECCMA objectives.

One of the most comprehensive conceptual frameworks is developed by Smith (2014) (Figure 6). This framework builds on the concept of Black et al (2011), and successfully incorporates different scales of migration. Although the framework is fairly comprehensive and useful, it still has shortcomings from the DECCMA perspectives: considers only one driver (i.e. rainfall) without any short duration hazards (e.g. flooding). The scale of the sending community, the wellbeing of the migrant, and other adaptation options of the households (i.e. not agriculture-related) are not included. Yet, this framework and the published ABM model are very useful to inform the DECCMA conceptual framework and model development activities.

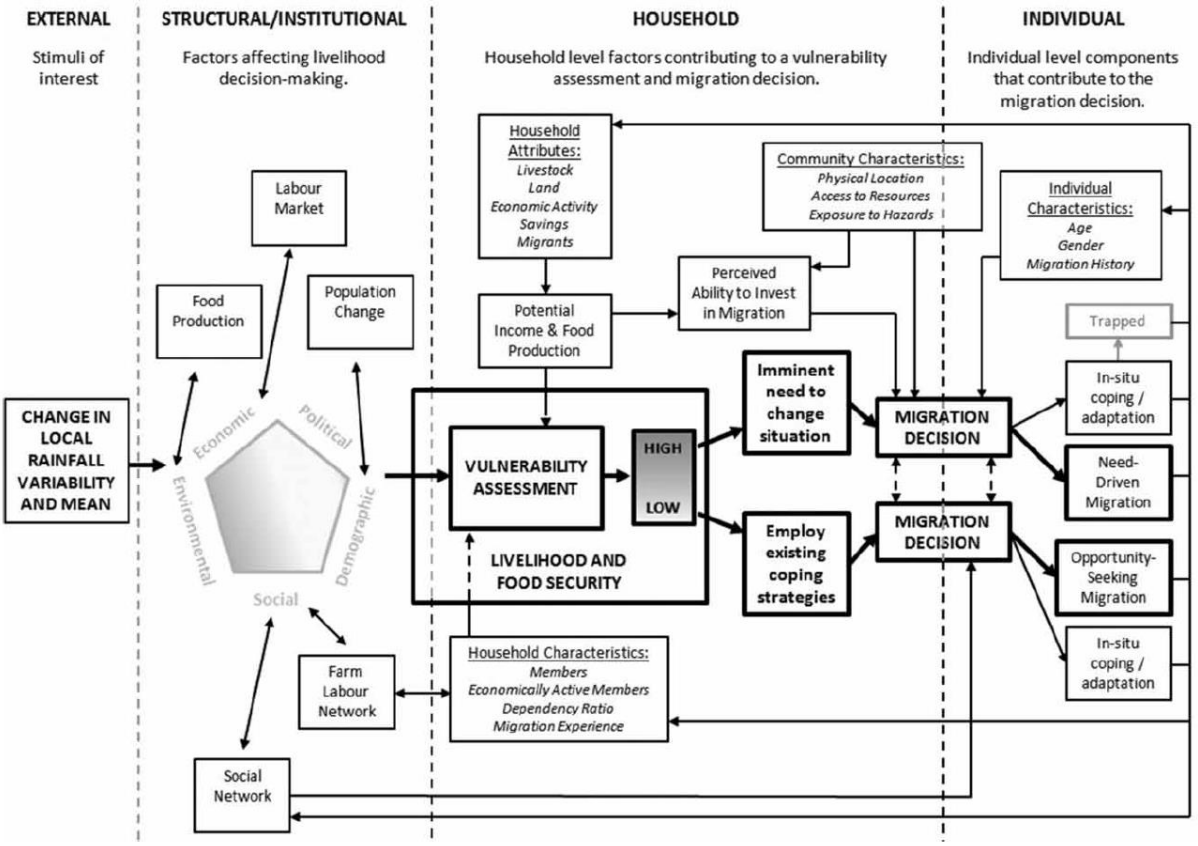


Figure 6: Rainfalls Agent-Based Migration Model (from Smith 2014)

5.3 Migration as one of the Adaptation options

In situ changes (see Glossary) can happen in response to multiple drivers. WP6 categorised in-situ changes into five categories (Suckall and Vincent 2015): adaptation, coping strategy, maladaptation, development and serendipitous adaptation. Adaptation refers to adjustments that reduce vulnerability to climate variability and change (see Glossary). Climate-related drivers can have a

slow-onset characteristic (e.g. salinization) or can be a fast-onset event (e.g. sea flooding during cyclones). Adaptation may also occur serendipitously as a result of changes made for other reasons. Adaptation can occur at different scales with different actors: local (Individual, Community), regional (Private sector, NGO), and national (Government). The key aspects of adaptation are:

- **Driver(s)**: why is the adaptation being undertaken, what is triggering the adaptation?
- **Provider /beneficiary**: who is providing the adaptation and who is benefiting from it?
- **Timing**: is the adaptation occurring in response to or in anticipation of climate change?
- **Temporal scope**: does the adaptation aim to provide long term or short term benefits?
- **Spatial scope**: who are the beneficiaries, are they localised or does the adaptation affect many people?
- **Function / effects**: what is the broad aim of the adaptation in terms of its contribution to risk reduction, vulnerability reduction or strengthening resilience?
- **Form**: what does the adaptation look like?
- **Performance**: can the adaptation be considered a success?

Although DECCMA project focuses on adaptations, it also recognises that households make changes that are not necessarily adaptation. Thus, DECCMA also collects some information on the other changes in household activities, and all these catalogued in-situ options are going to the considered in the WP5 activities.

Migration is a separate, yet interlinked issue with adaptation. Migration can happen in the absence of a climate driver, for example due to economic, social, cultural, political or environmental reasons (for example rural to urban migration). However, climate drivers might influence the process of migration. Following the DECCMA definition, adaptation, on the other hand, can only happen in the presence of a climate driver or in the presence of climate-related stresses. If a household responds to a climate driver and this reduces their future vulnerability to climate risks, they have adapted. It is also the case that migration occurring in response to economic, social, cultural, political or environmental reasons (i.e. not climate) can enable adaptation to climate change (serendipitous adaptation). Thus, there must be a change in practice and/or behaviour to be able to call it adaptation. Migration is only one way in which households may adapt to climate change. Adaptation can also happen at community/regional level, for example, building engineering structures (e.g. an embankment) to protect the village.

Migration can take multiple forms: temporary, circular (e.g. seasonal) and permanent. In addition to the drivers of migration, DECCMA needs to investigate:

- the **threshold** at which the decision is taken to migrate for climate change-related reasons rather than adapting locally;
- the influence of **non-climate change related drivers** on migration and adaptation.

6 THE DECCMA CONCEPTUAL FRAMEWORK

6.1 The original DECCMA vision

Drawing on the published literature, the first attempt to develop the DECCMA conceptual framework is shown on Figure 7. In this framework the linkages with receiving communities, other adaptation strategies and the minimum of the key concepts regarding migration-decision making (i.e. dynamic thresholds) are explicitly included. The conceptual diagram works on multiple scales.

The global/national scale is represented by the “National/Regional Strategic Adaptation” and “Supra community / Scenarios of drivers” boxes. The former represents the high level decisions and push factors, whereas the latter highlights the five domains of drivers that influence the community responses and ultimately the migration patterns. Changes in these domains influence the “Local (Sending) community” characteristics that ultimately filter down to the “Household and personal” levels. The “Household and personal characteristics” will allow the Gender specific evaluation and classification of the population (welfare, wellbeing, poverty,…). The project aims to identify “Gender-specific and dynamic thresholds” that might trigger a household level decision on whether in-situ adaptation or a form of migration (or both) is necessary for the survival well-being of the household. These dynamic thresholds are recognised to be spatially, and temporally-explicit, and probably different for each household type. The decision is not binary, in-situ adaptation can both increase and decrease the resilience (see glossary for definition) depending on the selected adaptation option, but it is mostly expected that as a result of the adaptation, capacities of both the households and local community are increased and the environmental risks are also reduced. When temporary or permanent migration of one more members of the household occurs, the migrants may provide remittances, improved social networks and improved innovations for both the household and for the local community through transfer of skills and knowledge. However, this may lead to demographic changes within the sending region, the modification of the community structure and a reduction of the skill-pool of the local community. In return, the sending household is hypothesised to provide a safety-net for the migrant by providing money, moral support and backup, if the well-being of the migrant is threatened. Migrants are however not only affecting the sending household and community, but also the receiving community. Both sending and receiving communities might potentially influence the governance and planning processes at national level through the regular governance channels and grassroots initiatives.

The above paragraphs explained the logic behind the formation of the initial version of our conceptual framework. Although this framework captures an overarching migration theory, the supra community processes, the community and household adaptation and migration decisions are under-developed within this conceptual framework. Since the development of this framework, it has subsequently been modified, but is presented here to show the evolution in our thinking.

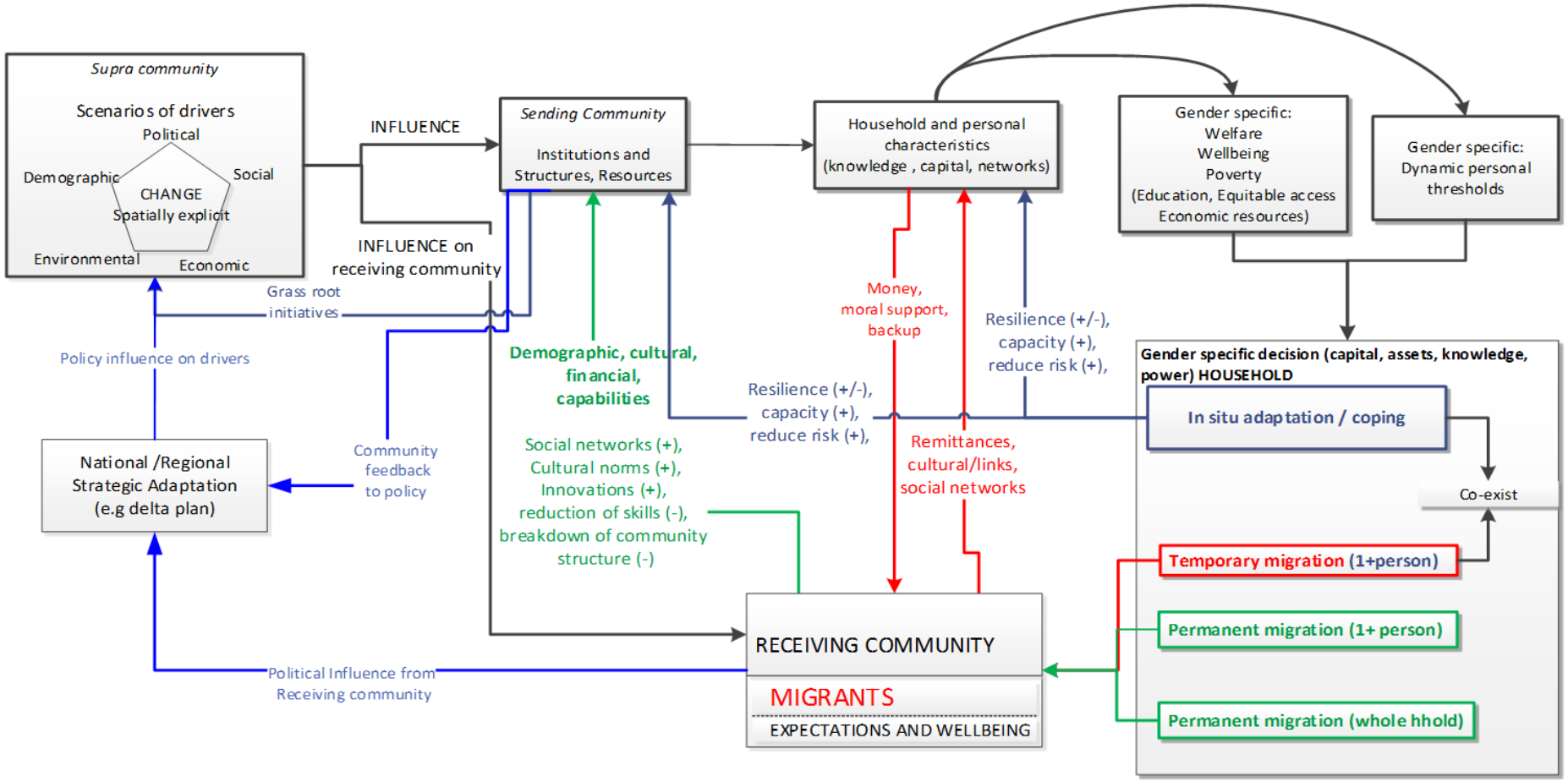


Figure 7: DECCMA Conceptual framework - version 1 (16 December 2014)

6.2 Revised DECCMA conceptual framework

The original conceptual model (Figure 7) is a good start, but many of the needed variables and linkages are not explicitly shown. Furthermore, considering the likely output delivery times of the DECCMA WPs, the original conceptual framework is revised and a tiered version of the diagram is prepared. The first steps of the model development will focus on the household processes. This is the least understood element of the system, thus, spending sufficient time on this aspect is critical. Furthermore, the WP3 household survey will be completed by the summer of 2016; thus all relevant data on the households and local communities will be available very quickly. On the other hand, the WP2 biophysical activities and WP4 economic activities are likely to produce their first results later. Thus, in this report, the conceptual framework development focuses on the smaller-scale social aspects, and the detailed representation of the biophysical and economic system elements are going to be drafted at a later stage. To be able to progressively develop the complexity in the DECCMA framework, the following model framework development steps (i.e. building blocks) are suggested (Figure 8):

Tier 1: A simple household migration framework (Figure 9).
Tier 2: A simple household migration-adaptation framework (Figure 10).
Tier 3: A household migration-adaptation framework including the migrant (Figure 11).
Tier 4: A household-community framework of migration and adaptation (Figure 12).
Tier 5+: A spatially explicit, process-based migration-adaptation framework including governance, economics and dynamic modelling of environmental quality (Figure 13).

The timeline of implementation is drafted in Section 7.

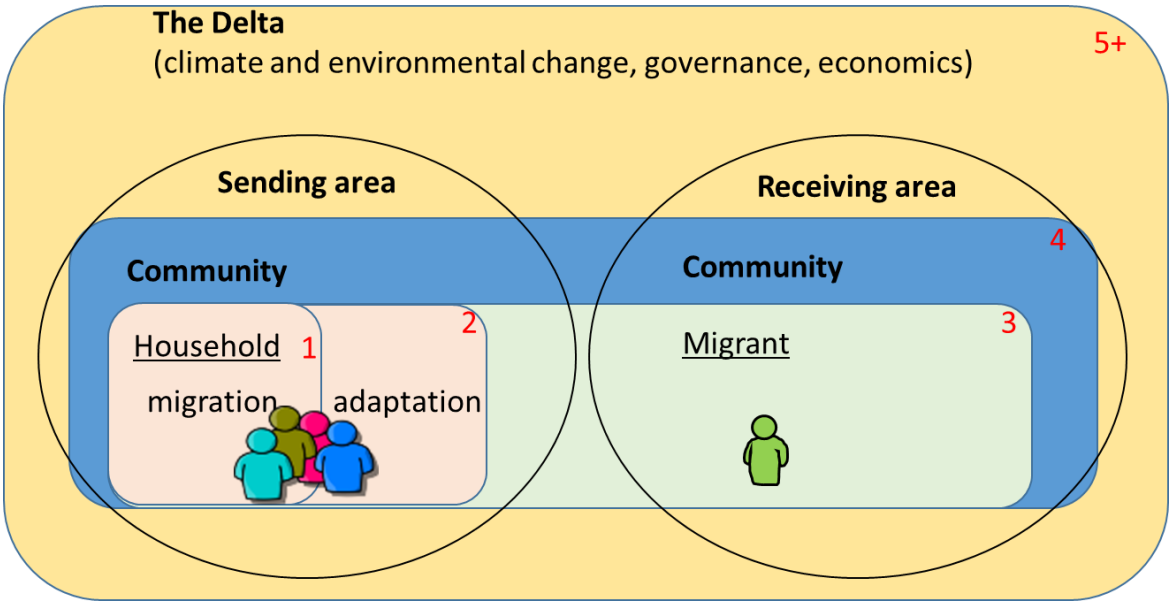


Figure 8: The building blocks of model framework development (each box represents a phase of the model development)

Tier 1: A simple household migration conceptual framework

The decision of the household to migrate (one or more household members), depends on its monetary status and vulnerability to environmental stresses and other economic changes. Perception of household status in terms of relative wealth is not constant. Hence further thought a are needed on how to measure and apply in the model framework the changes of these thresholds over time. Livelihood income might affect the vulnerability of the household to climate stresses and the perceptions of environmental change. Depending on these, the household changes their tolerance (i.e. thresholds) to change its behaviour. If things go well and the household is resilient, this threshold is high and we assume that they would not migrate. If things go badly, the household might decide to make changes and thus lower the threshold for migration. The migration decision is, however, mediated by a number of other factors, such as their financial capital, place attachment (i.e. some people can be so attached or immobile that they refuse to leave even if would be essential to leave) and the nature of gender roles, relations and other pull factors. Migrant social networks ease the decision by providing helpers in receiving areas. These variables are going to be measured in the household survey, but will need further thought as to how they will be applied in the model framework. Gender is not explicitly shown on the diagram, but the DECCMA integrated model will handle men and women separately during the model runs. This separation in the model will be based on the DECCMA household survey results. The model aims to keep track of the changing family structure, size and family mobility. Other pull factors such as changing aspirations and changing opportunities are much more difficult to capture in a numerical model, and thus these need further thought. The key outputs will be monetary wealth, number of migrants, and gender of migrants.

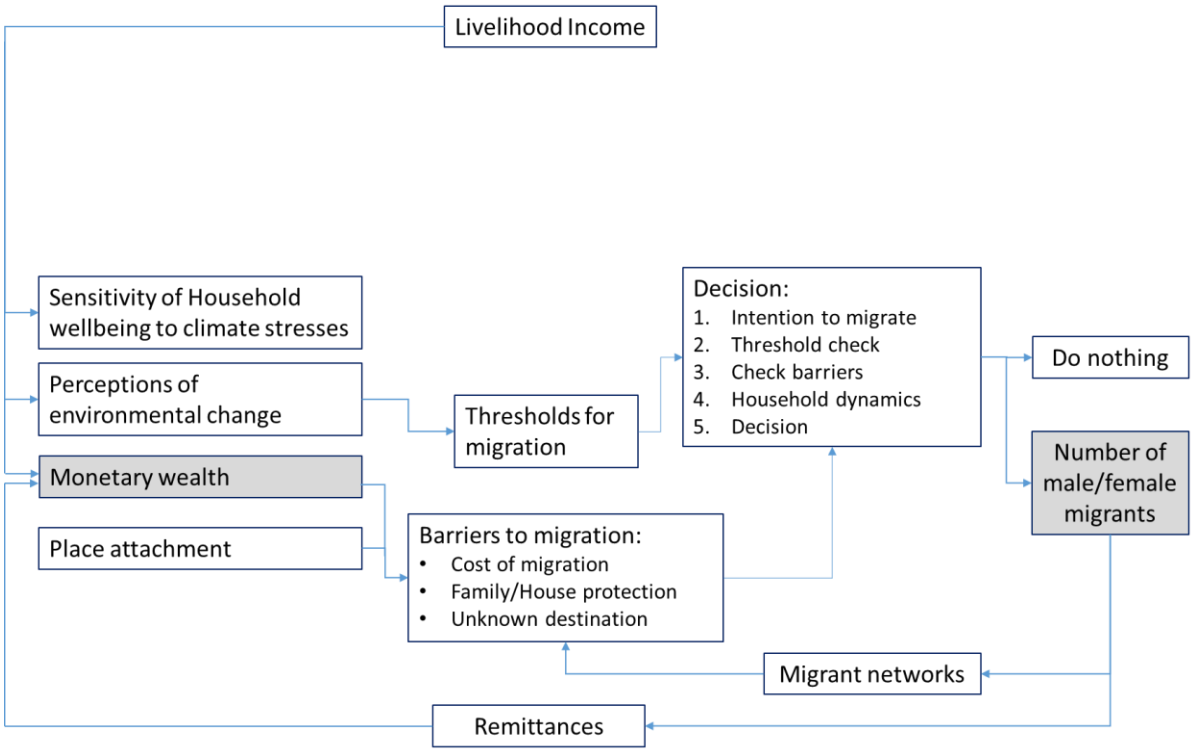


Figure 9: A simple household migration conceptual framework (Tier 1)

Tier 2: A simple household migration-adaptation framework

Building on the household migration model, the next step is to add the adaptation aspect of the household decisions. Similarly to migration, adaptation has also barriers such as money, knowledge and access to physical assets such as land that are mediated by the household characteristics (i.e. adaptive capacity). The threshold for adaptation is based on vulnerability to climate-related stresses and shocks and perceived trajectory of environmental change. This latter one is envisaged to be a function of income of the household and 'wealth' of peers in the local community. The decision on whether to in-situ adapt or migrate is sometimes sequential (i.e. in-situ adaptation is preferred to migration), but not always. The exact mechanism of the decision will be designed on the basis of the household survey results. The key outputs are the livelihoods of the households, the adaptive capacity, monetary wealth, and number/gender of migrants. Success of the households are not yet 'estimated' at this point of the model development.

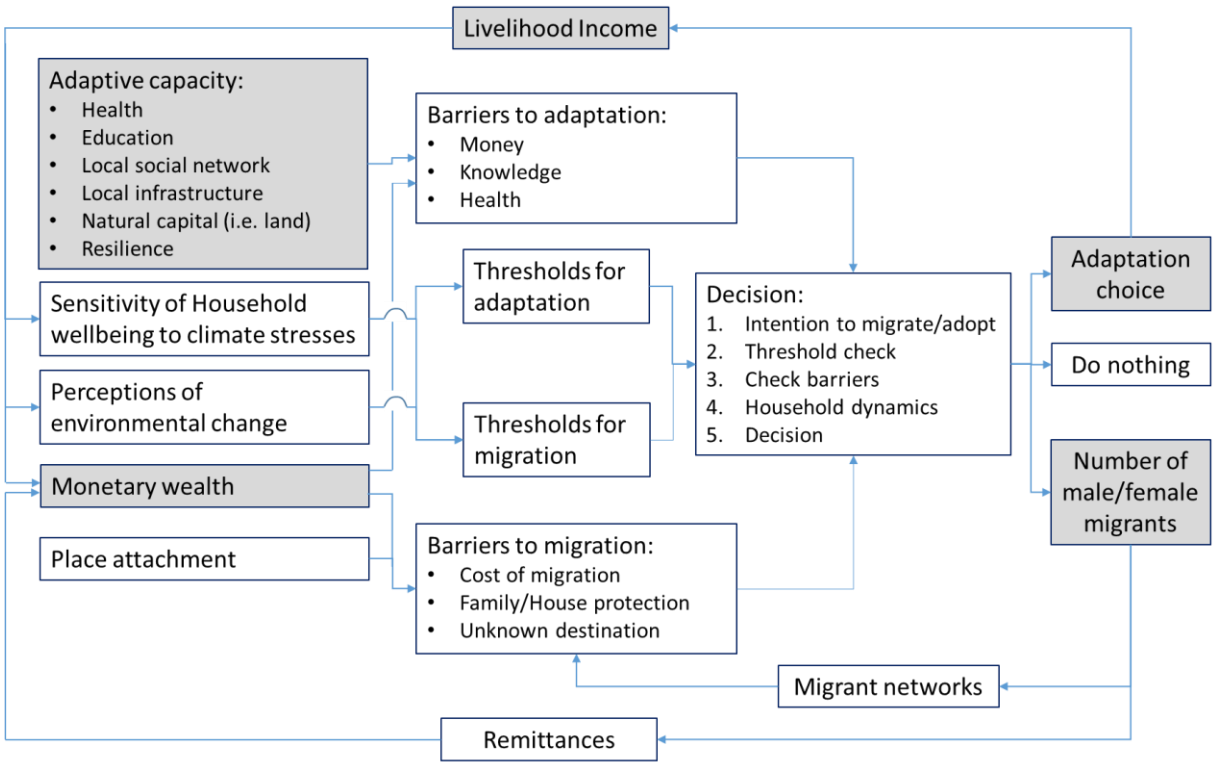


Figure 10: A simple household migration-adaptation framework (Tier 2)

Tier 3: A household migration-adaptation framework including the migrant

DECCMA only considers migration to be successful, if the both the wellbeing of the household and the migrant is increased. Thus, the conceptual framework has to be extended to include the migrating member(s). Further thoughts and discussions are needed to establish a definition and a measure for 'success' and 'wellbeing'.

The employment opportunities and thus the income of the migrant strongly depend on the type of migration, the length of migration (i.e. time spent), and the available social networks. It is assumed that the longer the migrant is away, the better employment opportunities he/she can find in the receiving community. This assumption will need testing based on the DECCMA survey results. The social networks only help at the beginning of the migration to ensure a 'safe' location and provide an initial job opportunity, but these jobs are generally lower paid than those that the migrant can find at later stages. However, social networks provide an additional safety net that might increase the adaptive capacity of the migrant. The wellbeing of the migrant depends on a number of factors: sensitivity to risk, employment opportunities, social networks and the potential to return home. This latter one strongly depends on the financial situation of the migrant. The household might support financially the migrant in desperate times, and they might also set expectations to the migrant depending on their monetary or other status. Thus the return thresholds of the migrant will be influenced by the wellbeing of the migrant and the sending household. Further thoughts are needed on how to measure this in the survey and in the model framework. The success of the migration has to be evaluated based on both the wellbeing of the sending household and the wellbeing of the migrant. The key outputs are the wellbeing of the migrant, the stay/return decision and the success/ failure of the migration.

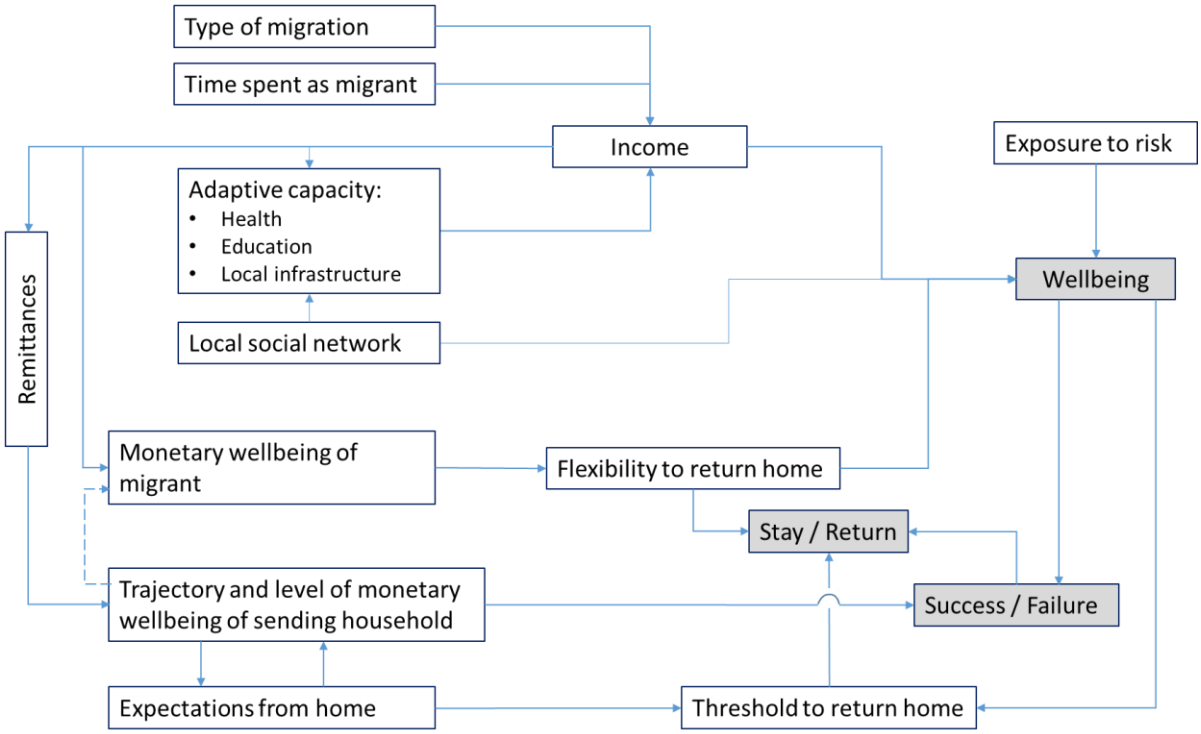


Figure 11: A household migration-adaptation framework including the migrant (Tier 3)

Tier 4: A household-community framework of migration and adaptation

The household and migrant processes have important consequences to the sending community and receiving community. The receiving community benefits from cheap labour and innovation, but the population growth might put a pressure on the infrastructure and services. Similarly, the sending community might experience both positive and negative changes. Because of the new ideas of the migrants, community practices and norms might change to the better or worse. Capturing community practices and norms in the model require further thoughts. Environmental quality is expected to increase, because migration results in lower population number, and thus the pressure on the environment decreases. The structural changes on the population causes negative effects on the social cohesion and inequality might increase (only few migrants) or decrease (many migrants). Other societal changes, such as loss of talent and expertise are much more difficult to capture and represent in the model framework. These need further thoughts. It is hypothesised that more migrants make a better social network that has a positive feedback on the number of migrants from the sending community. This will be tested based on the DECCMA survey results.

Climate and environmental change are normally associated with negative environmental impacts, even though changes until the end of century are not uni-directional and there are large uncertainties around individual future projections (Caesar et al 2015). This affects the associated livelihoods positively or negatively. Shocks (rapid onset changes) also play an important role in the livelihoods, resilience and thus adaptive capacity of the households, which are in turn impact on their migration and adaptation decisions. At this stage, changes in climate and environmental quality might only be considered as static hot spot maps developed by WP2.

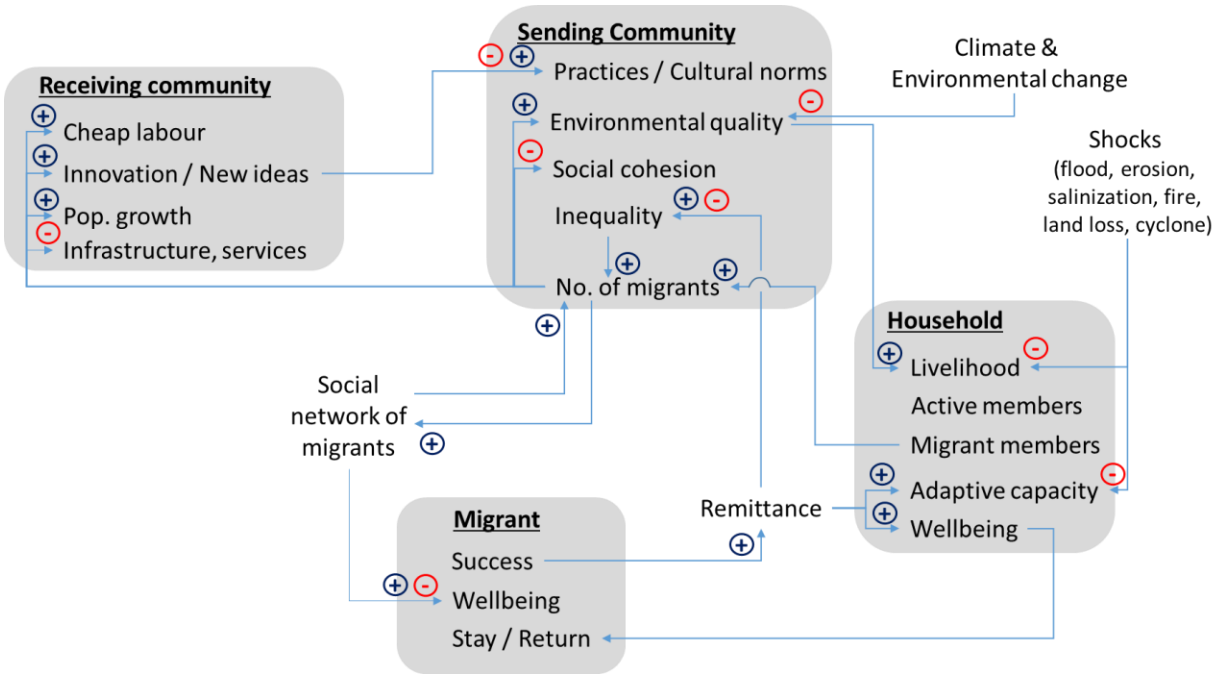


Figure 12: A household-community framework of migration and adaptation (Tier 4)

Tier 5: Governance, macro-economics and dynamic modelling of environmental quality

After building a robust individual, household and community component model, the scope has to be expanded to consider spatial variations, climate, environmental, land cover, land use, economic and governance (policies, subsidies, political unrest) changes. The importance of these drivers will be assessed while answering Question 1 and will be added to the social component model in a tiered fashion. At this point it will be worth considering if a dynamic simulation of the environment is necessary based on different narratives of climatic and socio-economic changes. If so, a coupled model chain has to be developed (like ΔDIEM in the ESPA Deltas project) that is capable of approximating the effect of natural and governance change on environmental quality. Land use and land cover are important adaptation-related elements. At the beginning, these will be handled as pre-fixed scenarios, but if time allows, it might be changed to a dynamic model component, where land cover and land use depend on the decisions of the simulated households, and thus become emergent properties of the system. One potential (final) conceptual framework of the entire system is shown on Figure 13 as an illustration. This will be revisited in 2016.

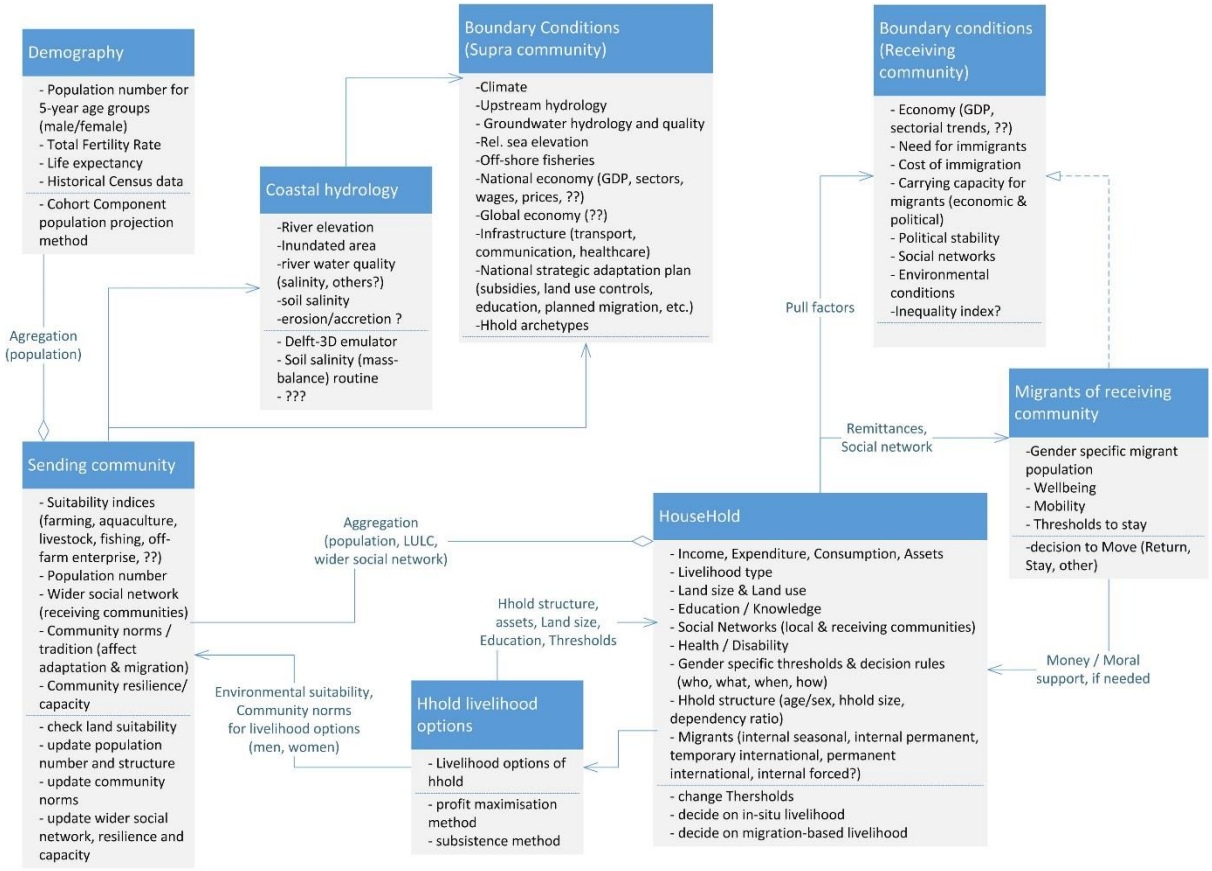
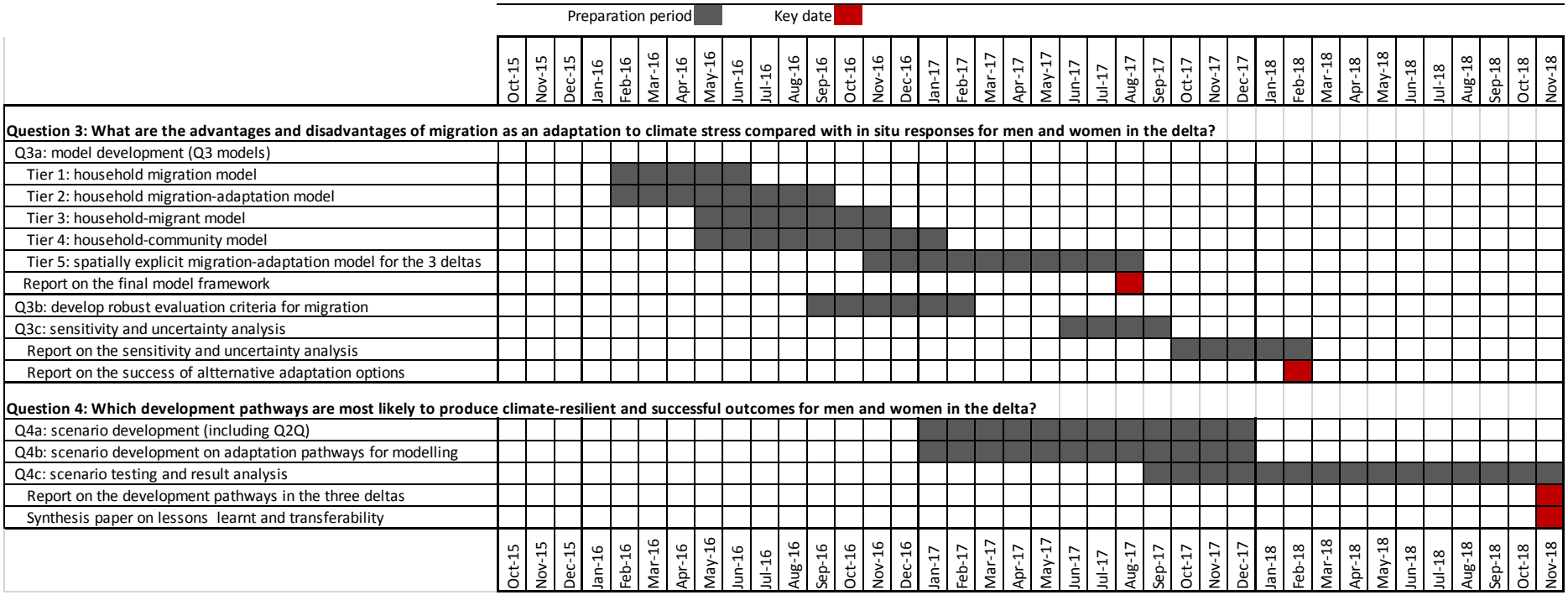


Figure 13: A UML-type conceptual framework of the coupled environmental and socio-economic system (Tier 5)

7 TIMELINE

Preparation period Key date

	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18
WP5 Fast track report is completed															?																							
Hotspot maps from WP2 (historical and future)																?																						
Available secondary data received from WP1,2,4								?																													
Modelled data is received form WP2,4														?																							
Sending area data is received from WP3/6																																					
Receiving area data is received from WP3/6																																					
Receiving the future climate and socio-economic nattarives from WP1																?																						
Question 1: What socio-economic, climatic and governance factors are most important in explaining migration of men and women in the delta?																																					
Q1a: general associations with migration																																					
Q1b: more detailed patterns of migration																																					
Report on migration associations and patterns																																					
Q1c: development of the conceptual framework																																					
Stakeholder validation of the conceptual framework/model																																					
Final report on the conceptual framework and model (D5.2)																																					
Question 2: What are climate resilient and successful adaptations for men and women in deltas?																																					
Q2a: catalogue of coping, adaptation and development options																																					
Q2b: thought experiments on the effects of catalogued options																																					
Q2c: develop robust evaluation criteria of adaptation options																																					
Q2d: toy model development and parameterisation																																					
Q2e: scenario testing with Q2 toy models																																					
Report on the modelled success of alternative adaptation options (WT6.5)																																					
	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18


Preparation period
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Nov-18
Question 3: What are the advantages and disadvantages of migration as an adaptation to climate stress compared with in situ responses for men and women in the delta?
Q3a: model development (Q3 models)
Tier 1: household migration model
Tier 2: household migration-adaptation model
Tier 3: household-migrant model
Tier 4: household-community model
Tier 5: spatially explicit migration-adaptation model for the 3 deltas
Report on the final model framework
Q3b: develop robust evaluation criteria for migration
Q3c: sensitivity and uncertainty analysis
Report on the sensitivity and uncertainty analysis
Report on the success of altternative adaptation options
Question 4: Which development pathways are most likely to produce climate-resilient and successful outcomes for men and women in the delta?
Q4a: scenario development (including Q2Q)
Q4b: scenario development on adaptation pathways for modelling
Q4c: scenario testing and result analysis
Report on the development pathways in the three deltas
Synthesis paper on lessons learnt and transferability

8 NEXT STEPS

Building on the Fast Track Approach outlined here, we will continue to outline and develop the DECCMA approach to integration. Beyond these conceptual questions, there are three important and detailed questions which need to be answered.

- Which data types are needed for the analysis and what are their availability in the study deltas?
- What software template harmonisation is required across the study deltas? The aim is to have only one piece of software for each modelling method (i.e., Systems, Bayesian Network, Agent-Based Models) that can be parameterised to all three study deltas. If data/information is limited in some countries, maybe only the simpler, Systems and Bayesian Network models are applied that are not spatially distributed.
- How do we address post-2050 changes? The above methods aim to investigate the system to 2050. Further developments are needed to analyse the post-2050 situation.

9 ACKNOWLEDGEMENT

This work is carried out under the Deltas, vulnerability and Climate Change: Migration and Adaptation (DECCMA) project under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) programme with financial support from the UK Government's Department for international Development (DFID) and the International Development Research Centre (IDRC), Canada. The views expressed in this work are those of the creators and do not necessarily represent those of DFID and IDRC or its Boards of Governors.

10 GLOSSARY OF KEY TERMS USED IN WP5

Adaptation: Adaptation refers to adjustments that reduce vulnerability to climate variability and change. These adjustments may be in response to, or in anticipation of, real or perceived climate stressors. These stressors may be exposure to sudden onset shocks, such as floods; and/or to slow-onset incremental stresses, for example in temperature and rainfall patterns, or sea level rise.

Adaptive capacity: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC, 2014).

Agent based model (ABM): Agent-based models aim to simulate the actions and interactions of autonomous agents (e.g. individuals, households, communities, etc.) with a view to assessing their effects on the system as a whole. ABMs are bottom up approaches, where the system status emerges as the cumulative effect of all the action of the simulated individuals.

Bayesian network model: Bayesian network, Bayes network, or belief network models are graphical statistical models that describe the probabilistic relationships between system variables.

Conceptual framework: A conceptual framework is a not fully developed theory. In a conceptual framework, the concepts are not linked to one another in a logically ordered deductive system as in a fully developed theory. It provides an explicit explanation why the issue/phenomenon under study exists by showing how the variables are related to each other. Much of the conceptual work in social sciences is more rightfully described as conceptual schemes than theories.

Conceptual model: A conceptual model for modellers is the equivalent of a conceptual framework for social scientists. It is software-independent and, similarly to a conceptual framework, resides in the expert knowledge domain. It is used to guide and inform the computer model design. Standard diagram conventions have been proposed to represent conceptual models, such as the Unified Modelling Language (UML).

Coping is an immediate, short-term reaction to a climatic stress or shock. Unlike adaptation, coping does not address underlying vulnerability and may even exacerbate the negative impacts of climate change.

Development increases the life expectancy, adult literacy, access to education, as well as people's average income, which is a necessary condition of their freedom of choice. Development may reduce the immediate vulnerability, but if climate risk has not been considered, a development is not an adaptation.

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2014).

In-situ changes: Changes in human behaviour, land management or local infrastructure aiming to tackle the effects of climate or non-climate drivers.

Maladaptation is an "action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of, other systems, sectors or social groups" (Barnett and O'Neill 2010).

Migration: Migration is the process by which individuals or whole households leave their usual place of residence for another geographic location, usually crossing an administrative or national border and remaining for at least six months, usually as a result of a change in the relative attractiveness, real or perceived, of the usual place of residence with respect to the destination.

Resilience: The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation (IPCC, 2014).

Serendipitous adaptation happens when a development activity also reduce climate vulnerability.

Systems model: Systems models, or system dynamic models aim to understand the nonlinear behaviour of complex systems over time using stocks and flows, internal feedback loops and time delays.

Theory: Classically defined, a theory is an abstract generalization that systematically explains the relationships among phenomena. The basic components of a theory are concepts. It consists of a set of statements, each of which expresses a relationship among the concepts. The statements are arranged in a logically interrelated system that permits new statements to be derived from them.

Uncertainty analysis: Uncertainty analysis is the process of assessing the effect of (i) the selected model framework, (ii) the selected parameter values, (iii) the propagation of error within the simulation error and (iv) the plausible future climatic, environmental and socio-economic conditions on the simulation results.

Validation: Validation is the process of assessing the simulation model and its associated data whether they provide an accurate or acceptable representation of the observed system.

Verification: Verification is the process of determining if the implemented model accurately represents the designed conceptual framework and its specifications, thus there are no errors in the computer code.

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014).

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