Modelling household adaptation choices in deltas using a dynamic Bayesian Network model

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Rationale

Deltas and low-lying coastal regions are vulnerable to global sea-level rise, with the potential for mass displacement of exposed populations. At present, deltas are subject to multiple drivers of environmental change and often have high population densities as they are accessible and productive ecosystems: globally about 500 million people live in deltas. Populations in deltas are also highly mobile, with significant urbanization trends. Such migration is believed to be driven primarily by economic opportunity, yet climate and environmental change may play direct and indirect roles in migration trends today and in the future.

The **DECCMA project (Deltas, Vulnerability & Climate Change: Migration & Adaptation)** studies migration as part of a suite of adaptation options available to the coastal populations in the Ganges delta in Bangladesh/India, the Mahanadi delta in India and the Volta delta in Ghana (Fig 1). It aims to develop a holistic framework of analysis that assesses the impact of climate- & environmental change, economics and governance on the migration patterns of these areas. DECCMA uses a hybrid scenario framework that provides consistent endogenous and exogenous scenarios (global to the sub-delta scale) with national shared policy assumptions in detail up to to 2050, and broad trajectories are explored up to 2100 (bio-physical only).

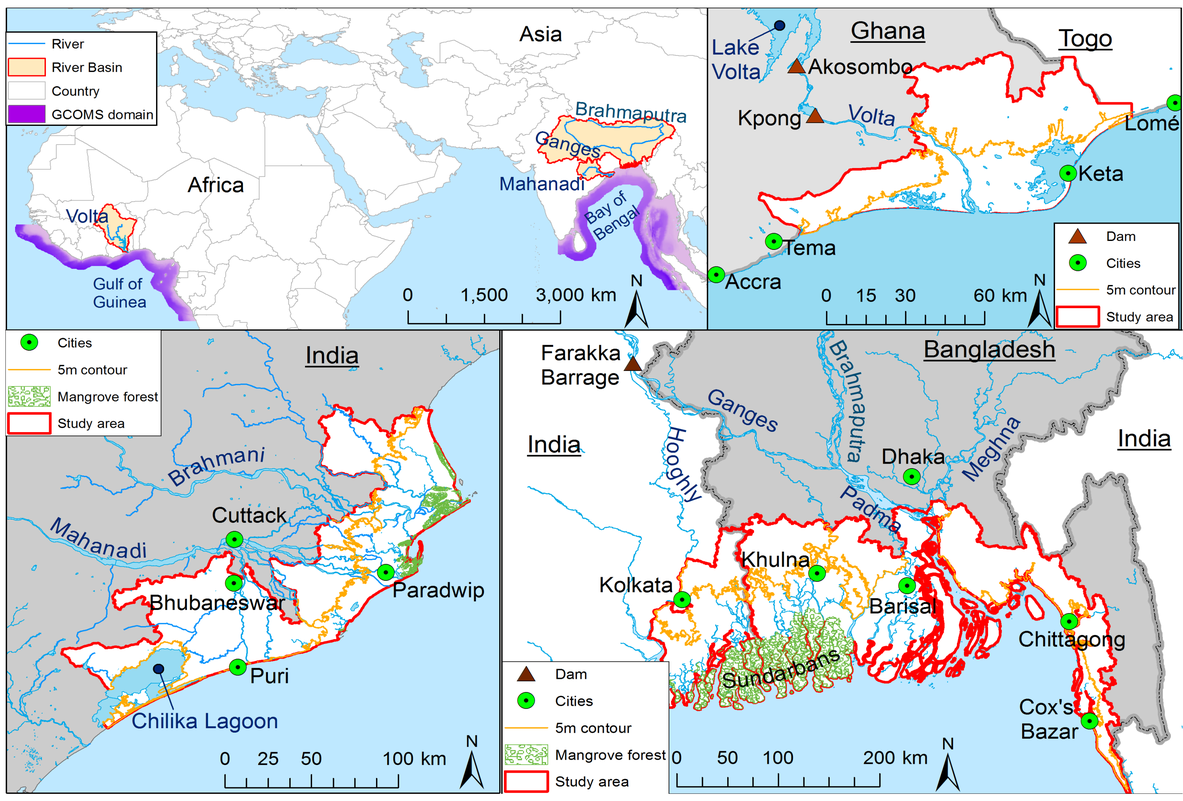

Figure 1: *Study deltas and their catchments*

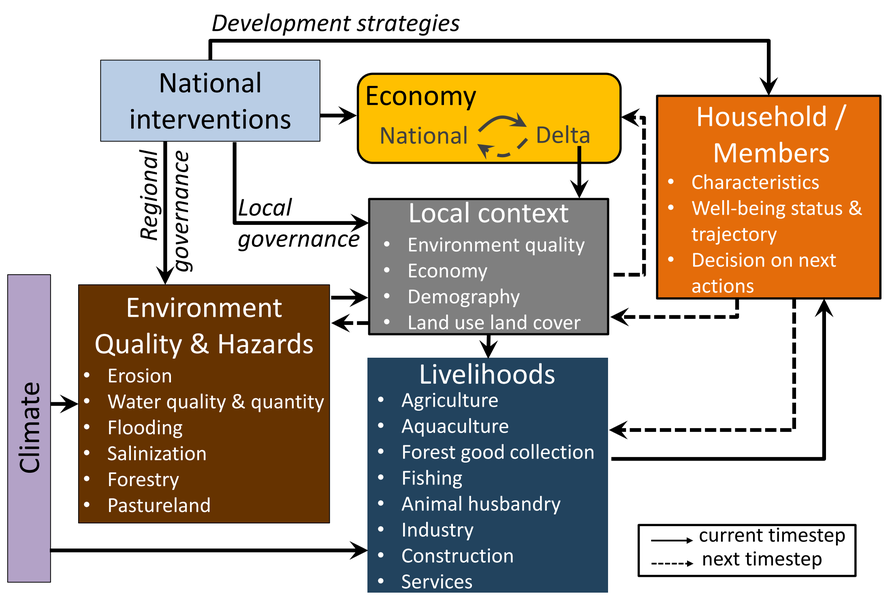

Figure 2: *Schematics of the integrated assessment model*

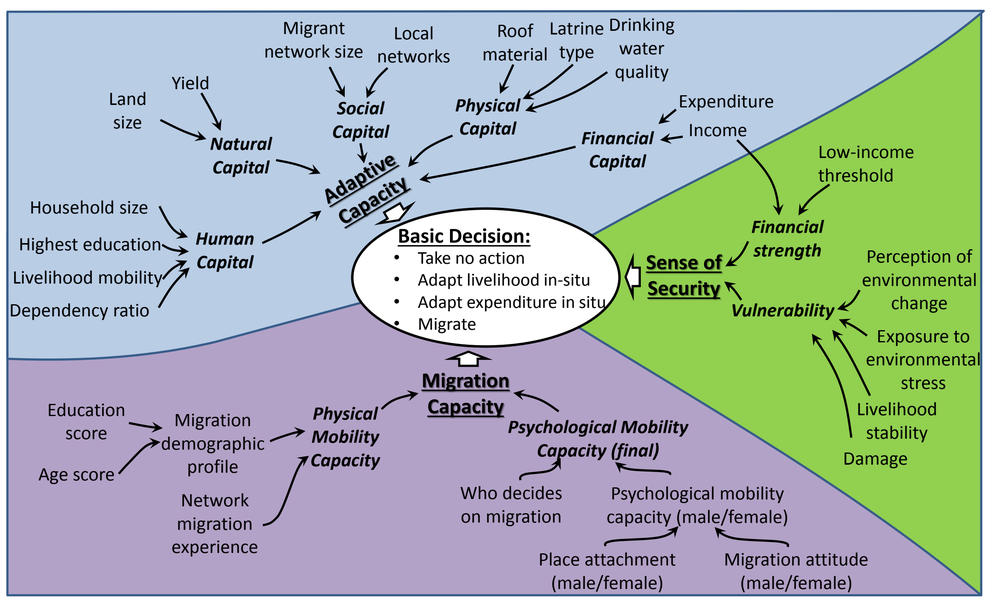

Figure 3: *The Household decision component*

The integrated assessment model

The integrated model of the DECCMA project (Fig 2) formally combines the project elements in a fully coupled, quantitative assessment framework. The household decision component (Fig 3) uses a dynamic Bayesian Network model based on a bespoke household survey dataset (N = 1500 per study site). The aim of the integrative modelling is to identify the drivers and to approximate the benefits and disbenefits of migration as an adaptation option. Finally, the model aims to quantify the attribution of climate change on migration patterns.

Sensitivity analysis

Importance of the household component variables was assessed by using: (1) a variance reduction method ([4] local), (2) a Pearson correlation method ([1] global), (3) a standard regression coefficient method ([2] global), and (4) a Kolgomorov-Smirnov method ([4] global). The results using all data are similar across all methods (Table 1). The most sensitive variables relate to Financial Capital and Environmental Vulnerability. The Network Migration Experience is also very important (Physical Mobility). Other sensitive variables are Yield Potential and quality of Local Networks. The local sensitivity analysis also showed weak sensitivities to Psychological Mobility variables. Sensitivities of inputs are delta- and decision-specific (e.g. Fig 4). Interaction of drivers are more important than individual settings. The sensitivity of the component variables might change when archetypes of households are investigated.

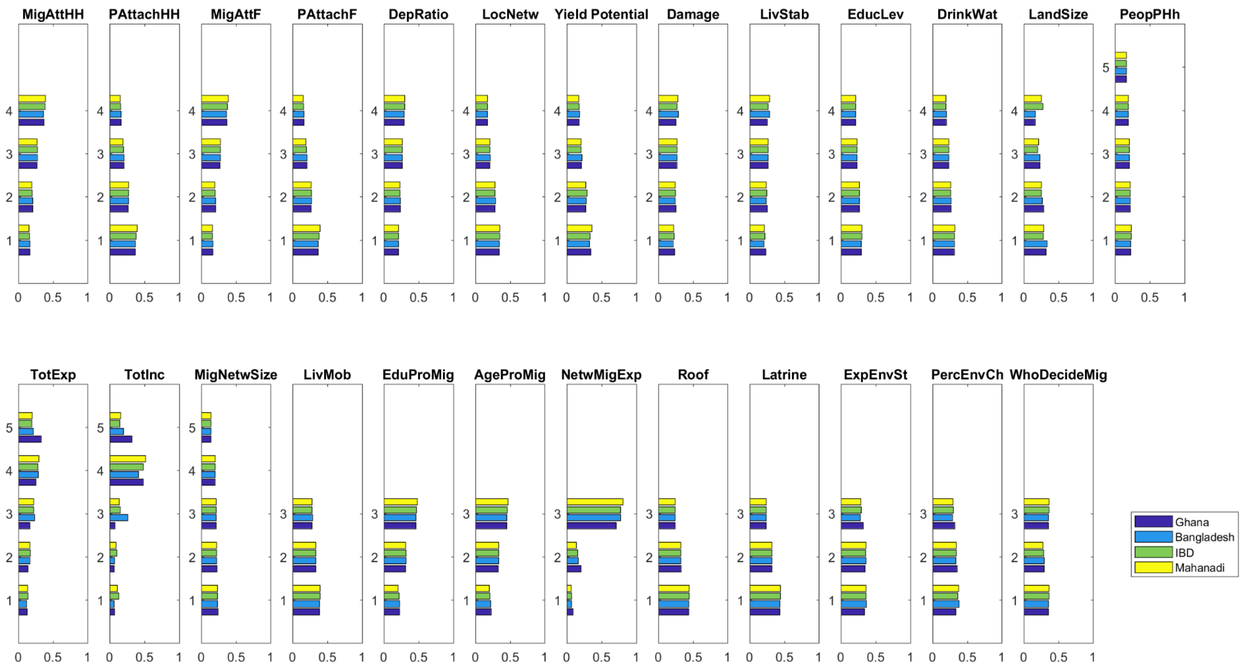

Figure 4: *Parameter value frequencies for the decision of 'Migrate'*

Table 1: *Summary of the sensitivity analysis*

	Parameter name	Variance Reduction (Netica)	Pearson Correlation Coefficient	Squared Standard Regression Coefficient	Kolmogorov –Smirnov
Human Capital	People Per Household				
	Dependency Ratio				
	Highest Education Level				
	Livelihood Mobility				
Natural Capital	Land Size	+			
	Yield potential	+	+		+
Social capital	Migrant Network Size	+			
	Local Networks	+	+		+
Physical Capital	Roof	+			+
	Drinking Water				
	Latrine	+			+
Financial Capital	Total Expenditure		++	+	++
	Income Total	++	++	+	++
Physical Mobility	Pro-Migration Score (age)				
	Pro-Migration Score (Education)				
	Network Migration Experience	++	++		+
Psycho-logical mobility	Migration Attitude (Hhead)	+			
	Place Attachment (Hhead)	+			
	Migration Attitude (Female)	+			
	Place Attachment (Female)	+			
	Who Decide On Migration	+			
Vulnera-bility	Perception Of Env. Change	++	++	++	++
	Exposure To Env. Stress	++	+	++	
	Livelihood Stability	++	++	++	+
	Damage	++	++	++	

Note: *+ sensitive* *++ very sensitive*

Conclusions and next steps

Migration and adaptation decisions in deltas are complex, spatially specific, and poorly understood. The DECCMA project aims to shed additional insight on these decisions using an integrated assessment framework and model that will be fully operational by end of 2017. The research is participatory involving relevant stakeholders and aims to promote dialogue about adaptation and migration issues in deltas rather than seeing the model as "the answer".

References: **[1]** IOOSS, B. & LEMAITRE, P. 2015. A review on global sensitivity analysis methods. In: MELONI, C. & DELLINO, G. (eds.) Uncertainty management in Simulation-Optimization of Complex Systems: Algorithms and Applications. Springer. **[2]** NEUMANN, M. B. 2012. Comparison of sensitivity analysis methods for pollutant degradation modelling: A case study from drinking water treatment. Science of The Total Environment, 433, 530-537. **[3]** Norsys Software Corp. "Netica 5.24" 64-bit for Windows 7 to 10. **[4]** SPEAR, R. C. & HORNBERGER, G. M. 1980. Eutrophication in peel inlet—II. Identification of critical uncertainties via generalized sensitivity analysis. Water Research, 14, 43-49.

CARIAA Collaborative Adaptation Research Initiative in Africa and Asia

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