espa ecosystem services for poverty alleviation

Tools and Frameworks

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ΔDIEM: Using scenarios to inform pro-poor policy-making

A sophisticated model now being trialled in coastal Bangladesh can help decision-makers in some of the world's most challenging regions meet development and environmental policy targets, benefiting the many millions of poor people whose livelihoods are threatened by climate change.

Key messages

- The Delta Dynamic Integrated Emulator Model (ΔDIEM) incorporates biophysical, socioeconomic and governance processes and data, and tracks change over time to consider a range of plausible futures.
- ΔDIEM offers policy-makers valuable information on how household incomes can be affected by different interventions under a range of scenarios, offering the potential for decision-making that integrates development, environmental and poverty imperatives to better meet national and international targets.
- The model is helping to inform decision-making in Bangladesh, where the livelihoods and wellbeing of tens of millions of people in the Ganges-Brahmaputra-Meghna delta are threatened by ecosystem degradation and climate change.
- In a trial of the ΔDIEM tool, new polders in the south-central district of the delta region resulted in a 24% increase in agricultural production and a 25% reduction in extreme poverty. The polders were the most pro-poor of three development interventions that the team evaluated (assuming other factors remained unchanged).
- ΔDIEM has the potential to be adapted to inform decision-making in other climate-vulnerable regions, where conditions of uncertainty prevail and where there are many drivers of change.

About the research

The context

The vast Ganges-Brahmaputra-Meghna delta covers most of Bangladesh and parts of West Bengal in India. Of the tens of millions of people living in the delta, the Ecosystem Services for Poverty Alleviation (ESPA) programme's Deltas study area has a population of 14 million. This is a densely populated and fertile region, but there is significant and widespread poverty. Rural livelihoods are inextricably linked with the natural ecosystems, particularly agriculture and fisheries. However, these ecosystems are endangered by long-term environmental change including rising salinity, subsidence, rising sea-levels and storm surges. The Bangladesh Delta Plan 2100 (BDP2100)[1] has been developed over recent years to strategically plan the development of Bangladesh and protect its people and environment in six hotspot areas, of which one is the coastal zone.

A remodelled embankment with a protective shield provided by the Government of Bangladesh in preparation for the monsoon season.

Photo credit: United States Agency for International Development (USAID)

The approach

The ESPA Deltas project worked in the seaward part of the delta in Bangladesh, south of Khulna and west of the Meghna River to the Indian border, within the coastal hotspot of the BDP2100. Researchers undertook an ambitious, transdisciplinary study of the lives of the population here and of the ecosystems on which they depend. This included analysing climate change, biophysical changes and the socioeconomic and livelihood situations of the population.

The team studied specific ecosystem services, such as fisheries and agriculture, in relation to livelihoods, wellbeing and poverty, and developed scenarios for how these would be affected by different climate and development trajectories. The views and priorities of a range of stakeholders, including community members, were considered using participatory approaches and these too informed the scenario development process.

The ΔDIEM model

The sectoral project results were integrated into the Delta Dynamic Integrated Emulator Model (ΔDIEM). ΔDIEM is unique in linking biophysical, socioeconomic and governance processes to consider a range of plausible futures. Given a particular development trajectory and series of interventions, it can assess the resulting range of impacts over time on the livelihoods and wellbeing of the people of the Ganges-Brahmaputra-Meghna delta. It can do this from a regional level down to the Union level (the lowest administrative tier, of some 21,000 people), annually to 2050 (and longer for more exploratory analysis). The model can consider a wide range of environmental changes, natural hazards and climate change, as well as policy interventions, in varying permutations.

Farmers harvesting shrimps; their livelihoods are at risk from long-term changes to ecosystems.

Photo credit: Yousuf Tushar for WorldFish

The scenarios

The ESPA Deltas team worked with the Planning Commission of the Government of Bangladesh in a pilot study to use the ΔDIEM tool. The Government of Bangladesh selected three alternative development options to be assessed:

- A new coastal 'greenbelt' buffer along the southern exposed coast.
- A new sea wall to protect against cyclones.
- A new network of polders to enhance agriculture.

The Government is considering these interventions as part of the BDP2100 based on their potential to provide protection against flooding, reduce poverty and boost the economy.

Bangladesh scientists and policy-makers visited the University of Southampton for extended periods to assure the quality and accuracy of the ΔDIEM simulations. At the request of the Government of Bangladesh, worst-case scenarios were considered; specifically, a 148cm relative sea-level rise by the end of the century (including 2.5 mm/year subsidence), a 4.1˚C temperature rise above pre-industrial levels by 2100, and increased levels of monsoon rainfall (see Table 1).[2]

Results

Greenbelt

The greenbelt development option considered creating a 1km-wide mixed mangrove and forest strip seaward of the polders. Such a greenbelt would displace agricultural land predominantly used by the poorest residents and the intervention shows a *small increase* in poverty due to change in livelihood types (around 20-30 households per union in the affected

Table 1: Parameters considered in the ΔDIEM model

Parameter	Value
Relative sea-level rise	148cm over the period 2000-2100 (61cm by 2050)
Temperature rise	4.1°C above pre-industrial levels by 2100 (2.8°C by 2050)
Hydrological climate change scenario	The wettest of three climate scenarios, increasing rainfall intensity (+5%) and river discharge (+18%)
Land-use change	Land-use change continues on current trajectories
Exogenous economic growth	Economic growth continues on current trajectories until 2030, after which it becomes constant
Population growth	Population remains constant
Farraka treaty[3]	Current treaty agreements continue

districts – where a union is the smallest unit of local government). The analysis also shows that while the greenbelt would not substantially reduce flooding, it would offer protection to the landward dykes, substantially reducing the risk of breaching during cyclones. Some potential benefits of the greenbelt, such as increased fisheries (crabs and fish nursery), tourism and non-timber forest products (e.g. honey collection), have yet to be tested.

Sea wall

The sea wall scenario considered strengthening and enhancing existing coastal-facing dykes to create a sea wall 3m higher than existing dykes. In the time frame of the analysis (to 2050), however, the wall would give minimal additional protection against cyclones and their surges compared to the existing structures. The wall would have no impact on poverty rates. Beyond 2050, with continued rising sea levels and the possibility of more intense cyclones, the benefits are likely to be much larger.

South-central polders

Polders are low-lying tracts of land enclosed by earthen embankments with drainage. They are the traditional means to keep back annual river flooding and storm surges. The south-central scenario considered the effects of the proposed polders in Barisal and Jhalokati district, enclosing most of the last open area of agriculture in south-west coastal Bangladesh where river flooding is expected to be exacerbated by a more intense monsoon and sea-level rise over the coming decades.

The model estimates a 24% increase in agriculture production and a 25% reduction in extreme poverty within the poldered area when it is completed. This assumes that the residents of these areas remain the same. (Changing land ownership and farm size may lead to different outcomes.)

Under the conditions in which the scenario was tested, the benefits are realised if the polders are well maintained. Deteriorating polders would lead to poorer outcomes than no polders. This is true for all polders in the study region where, historically, maintenance has not received sufficient attention.

In addition, in this scenario some risk would be transferred outside the south-central polders, with a potential risk of flooding downstream, mainly to the south and west. Such a trade-off is associated with a 3% *increase* of people in poverty in these areas. Such information is significant as it provides input for the scale, location and even temporal context for consideration of compensation or other mitigation measures (e.g. financial compensation, flood proofing, training, etc.). This demonstrates how ΔDIEM supports better understanding of winners and losers and resulting trade offs.

Floods can devastate coastal communities' assets, as shown here.
Photo credit: WorldFish

Next steps

Of the three scenarios considered, the new polders are most beneficial, both in terms of enhancing incomes and removing people from poverty. However, issues of trade-offs with neighbouring regions due to displaced flooding need to be investigated and evaluated. Further investigation is also required for the other two scenarios of the wider greenbelts, and on sea wall and dyke breaching during cyclones.

The findings from these early runs of the ΔDIEM model are valuable but represent a proof of concept. They only consider one set of assumptions about how the world may change. These interventions need to be tested over a wide range of assumptions about the future, drawing on the best science and stakeholder inputs and questions. Other potential development interventions could be tested, again over a range of plausible futures, and this is an obvious next step.

Overall, this pilot project demonstrates how an inclusive, consultative and partnership approach with government and civil society partners, including affected communities, has resulted in a tool to help policy-makers meet development, environmental and poverty objectives in challenging circumstances. More specifically, the scenarios run on the ΔDIEM model demonstrate its potential value in informing the BDP2100, helping the Government of Bangladesh to meet its international and national policy objectives in terms of both protecting ecosystems and reducing poverty.

About the project

Assessing health, livelihoods, ecosystem services and poverty alleviation in populous deltas – or the ESPA Deltas project (project code NE/J002755-1) – included scientists from the United Kingdom, Bangladesh and India. The pilot study was conducted by the University of Southampton (UK) and the Institute of Water and Flood Management, Bangladesh University of Engineering and Technology (Bangladesh) in close collaboration with the General Economic Division of the Planning Commission, Government of Bangladesh. The ESPA Deltas project and the continuation, pilot study were funded by ESPA. For more information visit www.espadeltas.net

Further reading

Nicholls, R.J., C.W. Hutton, A.N. Lázár, A. Allan, W.N. Adger, H. Adams, J. Wolff, M. Rahman and M. Salehin (2016) 'Integrated assessment of social and environmental sustainability dynamics in the Ganges-Brahmaputra-Meghna delta, Bangladesh', *Estuarine, Coastal and Shelf Science* 183(B): 370-381. DOI: 10.1016/j.ecss.2016.08.017.

Lázár, A.N., D. Clarke, H. Adams, A.R. Akanda, S. Szabo, R.J. Nicholls, Z. Matthews, D. Begum, A.F.M. Saleh, M.A. Abedin, A. Payo, P.K. Streatfield, C. Hutton, M.S. Mondal and A.Z.M. Moslehuddin (2015) 'Agricultural livelihoods in coastal Bangladesh under climate and environmental change: A model framework', *Environmental Science: Processes and Impacts* 17: 1018-1031. DOI: 10.1039/c4em00600c

Nicholls, R.J., C.W. Hutton, W.N. Adger, S.E. Hanson, M. Rahman and M. Salehin (eds) (2018) *Ecosystem services for wellbeing in deltas: Integrated assessment for policy analysis*. London: Palgrave.

Credit

This publication was written by the ESPA Directorate based on information provided by the Deltas project team.

About the ESPA Programme

ESPA is a nine-year global development research programme established in 2009 with funding from the Department for International Development (DFID), the Natural Environment Research Council (NERC) and the Economic and Social Research Council (ESRC). ESPA is one of the most comprehensive research programmes on linkages between ecosystem services and human wellbeing, aiming to provide world-class research evidence on how ecosystem services can reduce poverty and enhance wellbeing for the world's poor.

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Importantly, the value of an integrated socio-ecological model for informing policy has been demonstrated. The adaptation of the ΔDIEM tool and its application in other areas characterised by conditions of uncertainty and where there are many drivers of change is another potentially valuable next step. The fact that ΔDIEM is based upon a model approach means that it can operate at any spatial or temporal scale. Hence, the approach could be expanded within Bangladesh and/or applied in other vulnerable deltas.

Endnotes

1. www.bangladeshdeltaplan2100.org
2. Nicholls, R.J., S.E. Hanson, J.A. Lowe, R.A. Warrick, X. Lu and A. J. Long (2014) 'Sea-level scenarios for evaluating coastal impacts', *WIREs Climate Change* 5 (1). DOI: 10.1002/wcc.253.
3. A treaty signed in December 1996 by the Government of India and the Government of Bangladesh on the sharing of waters between the Ganga/Ganges waters at Farraka (www.ssvk.org/koshi/reports/treaty_on_farakka_india_bangladesh_4_ganga_river_water.pdf).

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