

Valuing adverse health outcomes against storm damages given the presence of private defensive strategies, public programs, and natural barriers: Evidence from Bangladesh coastal areas

Sakib Mahmud

University of Wisconsin-Superior, USA

Edward B. Barbier

University of Wyoming, USA

Recent studies indicate that as a result of global climate change coastal areas with high population densities and abject poverty might experience more damage to life and property as a result of cyclone and storm surge events [1;2]. A coastal household vulnerable to cyclone and storm surges may also face significant adverse health outcomes from exposure to such storms [1;2]. To protect the health status of its members, a household might decide to invest time and money in different private defensive strategies. However, the incentives to increase private actions to reduce storm-inflicted health outcomes might differ among households because of the expectation of public protective programs [3;4], and the location of the household relative to the coast and natural coastal barriers [5;6].

Given the possible influence of public programs and mangroves on private defensive strategies, our paper is about specific private actions to reduce: a) the likelihood (probability or risk) that a household will face adverse health impacts from a major storm, and b) the adverse impacts, or severity, of any such health outcomes if they occur. The paper is also about whether exogenous influences, such as post-disaster government rehabilitation and relief programs, or the presence of mangroves and human-made embankments, affect these private defensive strategies of a household. To examine these issues, we classified a household's private defensive expenditures into two categories: (1) *self-protection expenditures*, which are actions that reduce the likelihood of storm-inflicted health risks, a form of *ex-ante* prevention *before* the storm event; and, (2) *mitigating activities and treatments expenditures*, which are actions to reduce the severity or magnitude of storm-inflicted injuries or diseases, a form of *ex-post* adaptation *after* the storm event.

To fulfill the research objective, this paper combines a health production function and an endogenous risk framework that allows the estimation of a household's valuation of different health outcomes from severe cyclone-induced storms in the presence of public programs and mangroves. The model is applied empirically to a case study of households' choices on self-protection and on mitigation and treatments to protect against storm-inflicted health problems in southwest coastal areas of Bangladesh, a low-lying densely populated nation most vulnerable to climate change [1;2]. The case study is based on a household survey data comprising 500 households among 35 villages focusing on the aftermath of Cyclone Sidr, which made landfall on 15th November 2007.

Results from the theoretical model leads to possible estimation methods to derive households' marginal willingness to pay for reducing the likelihood and the severity of adverse health outcomes as a result of improved access to public programs and storm protection services of mangroves. One of the novel contributions of our paper in the health and the endogenous risk literature is to show that these marginal willingness-to-pay measures can be derived without the expected utility terms, i.e., they are function of only prices and technological parameters. As a result, the theoretical model can be tested empirically to measure the marginal willingness-to-pay estimates using household survey data.

The empirical results on the full sample of the case study area reveal important findings. First, households that spend more on self-protection are also likely to face more health-related problems. This confounding result might indicate that either there is inefficiency regarding the ways the households reallocate their resources for self-protection or they are simply unlucky by falling directly into the path of Cyclone Sidr. Second, there is a U-shaped relationship between the probability of a household member facing storm-inflicted health problems and its income. This finding suggests that the low-income and higher-income households are more vulnerable to storm-inflicted health risks compared to the middle-income households. Third, the results reaffirm the possible influence of mangroves in saving lives or reducing storm-inflicted injuries. Fourth, there is an inverted U-shaped relationship between the post-Cyclone Sidr income and medical expenditures due to storm-inflicted health problems. This finding implies that once a household member is exposed to a storm-inflicted health problem, the

middle-income households invest more in medical expenses compared to low-income and higher-income households. Fifth, for *ex-ante* public programs, results reveal that the probability of experiencing more adverse health problems from a major storm is higher for those households that live inside the embankment. This outcome is possible since breaches in embankments are common in the study area. Sixth, for *ex-post* public programs, households that received government assistance through public disaster relief programs are more likely to incur storm-inflicted injuries. This finding is logically consistent with the fact that the government usually targets those households that are deemed most vulnerable to natural disasters. Finally, demographic characteristics such as age, and the numbers of females and children in the household have considerable influence on the likelihood of a household facing storm-inflicted health risks, but not on medical expenditures due to storm-inflicted injuries.

Regarding marginal willingness to pay measures for reducing health risks, results reveal that households are willing to pay the highest for improved access to storm protection services of mangroves. This is followed by households' marginal willingness to pay for *ex-ante* public programs such as access to embankments and *ex-post* public programs such as access to public sponsored disaster relief programs. These results are not surprising considering the descriptive analyses of the study which show that storm-inflicted health-related problems are lower in the mangrove-protected areas. It seems from the marginal willingness to pay estimates, households acknowledge this fact based on their past experiences and hence they are willing to pay more for better storm protection services from mangroves. For public programs, we argue that households prefer access to *ex-ante* embankments over *ex-post* disaster relief programs because they put more weight on reducing the likelihood rather than the severity to storm-inflicted health-related problems.

Regarding policy implications, we suggest that the government should collaborate with the local stakeholders to come up with an efficient tree plantation program involving mangroves that can play a significant storm protection role in saving lives and reducing storm-inflicted health-related problems. Moreover, the government should also consider the combination of having both mangroves and embankments in order to protect the latter from breaches as a result of a major storm event. Such a program might have the capacity to save more lives and reduce other storm-inflicted health-related risks. However, considering the uncertainties surrounding the extent of the storm protection role of mangroves from

tidal waves that are too extreme in magnitude [7] and the government's own capacity to protect the coastal communities from intense storm events [2], we think it is justifiable for the government to encourage more collective and individual participation in private storm protection actions. The government should also ensure that these programs are sustainable in the long run taking into account the widespread poverty and limited insurance markets facing the Bangladesh coastal communities.

References

- [1] IPCC (2007), 'Climate Change 2007: Impacts, Adaptation and Vulnerability', Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.
- [2] The World Bank (2010), 'Natural Hazards, Unnatural Disasters: The Economics of Effective Protection', The World Bank Publications, November 1, 2010.
- [3] Lewis, T. and D. Nickerson (1989), 'Self-insurance against natural disasters', *Journal of Environmental Economics and Management* **16.3**: 209–223.
- [4] Raschky, P.A. and H. Weck-Hannemann, H. (2007), 'Charity Hazard – A real hazard to natural disaster insurance?', *Environmental Hazard*, 7:321-329.
- [5] Barbier, E. B. (2007), 'Valuing Ecosystem Services as Productive Inputs', *Economic Policy*, **22.49**: 177-229.
- [6] Das, S. and J. R. Vincent (2009), 'Mangroves protected villages and reduced death toll during Indian super cyclone', *PNAS* **106.18**: 7357-7360.
- [7] Alongi, D.M. (2008), "Mangrove Forests: Resilience, Protection from Tsunamis, and responses to Global Climate Change", *Estuarine, Coastal and Shelf Science*, Vol. 76, pp. 1-13.