What are ecological and societal benefits of coastal nature-based measures? A quantification of ecosystem services

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1. INTRODUCTION

Mainstreaming nature-based measures into coastal management and policy making requires an in depth understanding of the coastal flood defence contribution of such measures as well as their additional societal benefits. This study investigated which nature-based measures can be used along the Belgian coast to ensure coastal defences and additionally create a multitude of ecosystem services. We investigated six nature-based coastal measures (foreshore/beach/dune nourishments, dune-in- front-of-dike, biogenic reefs and green dikes) compared with a hard reference scenario with a grey dike. The aim was to demonstrate the added value of nature-based measures in the land-sea interaction zone by estimating the coastal defence contribution (part i), quantifying the additional ecosystem services (part ii), and detect local needs (and resistance) for nature-based measures (part iii).

2. METHOD AND RESULTS

i. Coastal defence: Six theoretical scenarios with different nature-based measures where compared to a grey reference scenario (dike heightening/storm wall). The coastal Safety Tool, developed by IMDC, was applied to assess the magnitude of each measure required to protect against a sea level rise of +1.5m. Overall, an important observation is that many of the soft measures do not in themselves provide a fully-fledged coastal defence. In the scenarios those measures were combined with a hard measure (raising the dykes) to meet the coastal safety requirements. The combination of soft and hard solutions can result in a reduction of the required dike height. One specific finding, is that, in order to protect against the same rise in sea level of +1,5m, the required dune height is lower than the required dike height (only +1m above the existing seawall for dunes compared to +2m above the existing seawall for dikes; Figure 1).

Figure 1: Estimated height required to protect the coast in the future against a sea level rise of +1.5m: for a dune-in-front-of-dike (left) and for a reference hard dike (right).

ii. Ecosystem services (ES): For each scenario, a series of ecological and cultural services were considered besides coastal safety. The ES of the Flemish coast are described in the report ecosystem vision for the Flemish coast[1]. This is further supplemented with more recent studies for biogenic reefs[2] and dunes[3]. The ES analysis (Table 1) shows the added value of all nature-based measures compared to the hard reference dike, with moderate added benefits for sand measures (nourishments) and the highest gains for measures with plants and animal species (dune vegetation, reef species). However, based on the ES analysis, it is not obvious to say that one measure is better or worse. The purpose of this analysis is therefore primarily to make the multitude of effects specific, rather than to make an overall assessment in favour or against a particular measure.

Category	Ecosystem services (Highest values / Mid values / Lowest values)	Unit	S1.1 Ref dike	S1.2 Beach nourishm.	S1.3 Dune nourishm.	S1.4 Dune-ifo-dike	S2.1 Ref dike	S2.2 Reef	S2.3 Foreshore nourishm.	S2.4 Green dike
Provisioning services	Fisheries production	score*ha	6,7	6,4	6,4	6,4	7,7	8,3	7,7	7,7
	Drinking water production	score*ha	0,0	0,0	0,5	0,5	0,0	0,0	0,0	0,0
Regulating services	Air quality regulation	Ton fine dust/ha/y	0,0	0,0	7,4	7,4	0,0	0,0	0,0	2,7
	Sediment retention	Score	3,0	3,0	4,0	4,0	3,0	4,2	3,0	3,8
	Coastal safety, flood prevention	Score	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
	Climate regulation: carbon sequestration	kgC/ha/y	17,2	17,2	206,0	206,0	18,9	-203,5	18,9	111,6
	Water retention	m^3/ha	0,9	1,6	2,3	2,3	1,2	1,2	1,2	1,2
	Water quality regulation: N-retention	kg N/ha/y	8,3	8,3	17,4	17,4	9,2	8,7	9,2	10,6
	Water quality regulation: P-retention	kg P/ha/y	0,6	0,6	3,6	3,6	0,6	0,6	0,6	1,1
	Water quality regulation: denitrification	kg N/ha/y	292,8	281,2	294,2	294,2	336,4	588,3	336,4	339,1
Cultural services	Recreation (ecotourism, outdoor sports activities..)	score*ha	0,6	1,1	1,0	1,0	0,9	0,9	0,9	1,1
	Cultural and natural heritage (archeology, paleontology)	score*ha	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0
	Landscape experience – nature/green/dune	score*ha	0,2	0,5	0,8	0,8	0,4	0,4	0,4	0,6
	Landscape experience – sea view	score*ha	0,6	1,1	0,9	0,9	0,9	0,9	0,9	0,9
	Economic potential, employment	score*ha	0,7	1,2	0,9	0,9	1,0	1,0	1,0	1,0
	Development and transfer of knowledge and research	score*ha	0,0	0,0	0,6	0,6	0,0	1,2	0,0	0,1
Supporting services	Hydrodynamic changes (waves)	score*ha	7,0	7,0	7,2	7,2	8,2	8,4	8,2	8,2
	Habitat biodiversity	score*ha	21,9	21,3	21,8	21,8	25,6	28,4	25,6	25,7

Table 1: Ecosystem services (ES) analysis per scenario, grouped for two different locations with their respective coastal safety assessment (S1.1-S1.4 and S2.1-S2.4).

iii. Reflections from local governments - Our evaluation was presented to local governments to start a discussion about their (practical) considerations or even resistance for implementing nature-based measures. They showed an overall willingness to rethink today's coastline but only if all current user functions are integrated. They raised practical points of attention such as accessibility for elderly/wheelchairs/strollers and necessity for adaptive infrastructure to avoid regular maintenance needs, but also proposed creative solutions such as arranging catering on roof terraces. In addition to the more practical considerations, the local governments also stressed the needs for communication and raising awareness. It is crucial to show equivalent future alternatives (e.g. figure 1) and avoid comparison with today's situation (situations with different coastal safety risk). It was also recommended to focus in public communication on the direct benefits that are of interest to people such as greenery, health and recreation, rather than on policy reasons (safety and risk management) for which there is in general low public attention.

3. DISCUSSION AND CONCLUSIONS

We developed and illustrated a framework to make ecological and social aspects explicit in addition to the technical evaluation (coastal safety requirement). The main purpose was to inform local governments and start a discussion on the practical implementation of nature-based measures. Some remarks; the scenario's and coastal safety assessment were purely theoretical and not intended as a concrete plan of action for a particular location. The ES assessment is not all-embracing and is not giving an exclusive interpretation that one measure is better or worse, but provides the explicit overview of the variety of ecological and societal effects. This provides relevant input for further integrated multi-criteria assessment including investment costs, maintenance costs and other local considerations. This allows for a full economic-ecologic-societal evaluation of nature-based measures.

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