

# Chapter 32

## A Nature-Based Solution for Coastal Foredune Restoration: The Case Study of Maghery, County Donegal, Ireland



Paul Lawlor and Derek W. T. Jackson

**Significance Statement** Climate change has many negative impacts on coastal areas with sea level rise and more frequent and intense storms leading to higher rates of coastal flooding and erosion. Natural coastal features such as beaches and sand dune systems can boost resilience to climate change and provide an effective buffer against negative impacts. This case study from Maghery in Ireland demonstrates how a partnership of stakeholders comprising Local Government, Ulster University and the coastal community implemented a Nature-based Solution to regenerate a coastal foredune system in a Special Area of Conservation. The Nature-based Solution also proved to be a more effective and a more appropriate adaptation response than constructing a hard engineering scheme to protect the coastline.

**Keywords** Coastal marine environments · Climate adaptation · Ireland · Nature-based solutions · Beach and dune regeneration · Coastal communities

### 1 Introduction

Coastal areas change naturally over time through various environmental forcing factors (Masselink et al., 2016; Jackson et al., 2019a; Dodet et al., 2019; Jackson & Short, 2020; Short & Jackson, 2021) but indications of recent climate changes may be showing human-influenced acceleration of this (Jackson & Cooper, 2011; Jackson et al., 2019b). Recent rapid climate change is expected to have a wide

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P. Lawlor (✉)

School of Transport Engineering, Environment & Planning, TU Dublin, Dublin, Ireland

e-mail: [paul.lawlor@tudublin.ie](mailto:paul.lawlor@tudublin.ie)

D. W. T. Jackson

School of Geography and Environmental Sciences, Ulster University, Coleraine, Northern Ireland, UK

School of Agriculture, Environment & Earth Sciences, University of KwaZulu-Natal, Durban, South Africa

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range of impacts on Ireland's landscapes, society and economy through changes to its managed and natural ecosystems, water resources, agriculture and food security, human health and coastal zones. While the observed scale and rate of change are in line with regional and global trends, the changes are expected to continue and increase in the years ahead (DoCCA, 2017, p. 7). The most immediate risks to Ireland from climate change are those arising from changes in extremes – particularly those from floods, precipitation and storms (DoCCA, 2018, p. 7) and the need to adapt to these risks is urgent and essential (DoCCA, 2019, p. 142).

The 5800 km coastline in the Republic of Ireland (Falaleeva et al., 2011, p. 787) is considered to be particularly susceptible to climate change impacts that include inundation, more extreme storm activity and an increase in coastal erosion (EPA, 2013, p. 3). It is estimated that 20–25% of the entire coastline is at risk of coastal erosion with heightened rates of erosion taking place during stormy years (Flannery et al., 2015, p. 162). However, the distribution of these impacts is uneven with environmental modelling indicating that coastal areas to the west and north west are most at risk (Guisado-Pintado & Jackson, 2018, 2019) particularly when sea level rise and a higher number of winter storms are taken into account (Devoy, 2008, p. 330). These risks are recognised in Ireland's National Planning Framework which includes an objective to '*...address the effects of sea level changes and coastal flooding and erosion and to support the implementation of adaptation responses in vulnerable areas*' (DoHP & LG, 2018, p. 103). However, there is no overarching national level coastal management policy (Falaleeva et al., 2011, p. 787) or guidance for engaging in proactive planning for coastal areas and many Local Authorities lack the required capacity or information for doing so (Flannery et al., 2015, p. 163). The lack of coastal guidance may be about to change. At the time of writing, a national coastal management strategy steering committee has been assigned the task of considering the development of an integrated coastal change strategy.

With no clear national level policy, Irish coastal management has proceeded in an *ad hoc* fashion (O'Hagan & Ballinger, 2010, p. 751). Coastal adaptation projects that respond to climate impacts have often been reactionary (or short-term) in nature, rather than mainstreamed with long-term strategic planning. Despite their reactive approach, the responses of Irish coastal Local Authorities to coastal risks are strikingly similar as they often rely on publicly-funded engineered solutions (Flannery et al., 2015, p. 168) such as groynes, sea walls and rock revetments (O'Hagan & Cooper, 2002, p. 545). Also known as 'grey infrastructure', these costly works are highly visible and can have a reassuring effect on receiving communities even though they can provide a false sense of safety and place those behind them at further risk (Cooper & Pile, 2014, pp. 90–98). Recent EU and government policies provide for a more flexible approach to coastal adaptation. While 'grey infrastructure' solutions can continue to be used, it is recommended that more ecosystem-based approaches to adaptation (or green measures) are applied in addition to managerial, legal and policy approaches (soft measures) (EC, 2015, p. 8).

Ecosystem-based adaptations are considered to be part of a suite of Nature-based Solutions (NbS) which is an umbrella term for the nature-based concepts that include

ecosystem-based adaptation (EbA), green infrastructure (GI) and ecosystem services (ESS) (Kabisch et al., 2017, p. 41). Nature-based Solutions have numerous commonalities and they all attempt to use nature as a means of complementing, improving or even replacing traditional engineering approaches (Kabisch et al. (2017), p. 39). The recommendation to use Nature-based Solutions is included in a range of key EU policies such as Biodiversity and Climate Change (EEA, 2015, p. 2) as they are considered to be less expensive, more robust and sustainable and they can also be applied to a range of spatial scales from national to local level. The popularity of Nature-based Solutions at EU level has also led to member states including them as adaptation options. In the Republic of Ireland, commitments are included in key national level plans and strategies such as the National Planning Framework, the National Adaptation Framework and the Climate Action Plan to use Nature-based Solutions to enhance the resilience of human and natural systems. The aim of this study is to assess how a Nature-based Solution was designed and implemented in response to significant beach and dune erosion arising from climate change in a coastal area in Ireland. The capacity of the Nature-based Solution to achieve the regeneration of the beach and dune system is considered along with its potential and suitability for more widespread application.

## 2 Case Study Profile

The small coastal village of Maghera (An Machaire) is located in County Donegal on the north west Atlantic coast of Ireland. The village is located inside Maghera bay which comprises a primary beach and an established dune system in addition to a smaller beach which is located to the south (Fig. 32.1). The main beach is surrounded by local roads, a sports pitch and a community centre. The coastline and adjacent marine areas in Maghera have a range of significant socio-ecological functions. The area forms part of Termon Strand which comprises 85 ha and includes a coastal lagoon as well as the beach and dunes at Maghera Bay. The ecological importance of this coastal area is reflected in its designation as a Special Area of Conservation (SAC) under the Habitats Directive. The beach and dunes at Maghera also provide a valuable amenity as the main beach is particularly popular with visitors during the summer months and residents who use the beach for walking and other recreational purposes all year round.

The high-energy coastline around Maghera means that the beach and dune system are regularly moving in and out of erosional and accretional phases which are driven by storm activity and sediment supply to the system (Jackson et al., 2022). Shoreline analysis reveals that continuous coastal change is taking place with the shoreline advancing seaward by 120 m seaward between 1841 and 1913 (Jackson, 2015, p.10). Post-1913, the shoreline began to retreat and by 2000, it had receded approximately 100 m by which time the location of the shoreline was similar to its position in 1841. A process of shoreline recovery began in 2000 and by 2005, it had advanced between 20 and 30 m. The coastal advance accelerated between 2006 and



**Fig. 32.1** Location map and aerial view of Maghery beach in NW Ireland. (Source; Google Earth, 2021)

2011 following the implementation of the Nature-based adaptation Solution (comprising of a sand trapping scheme). The shoreline is believed to have entered an erosional phase between 2011 and 2015 due to a lack of maintenance of the sand trapping scheme combined with the impacts of a series of severe marine storms at the site.

This pattern of movement is consistent with the accounts given by local residents. The beach and dunes were monitored by the coastal community over the period in question and significant variations in the appearance of the beach and sand dunes were apparent in 1994 with pronounced erosion visible. Concerned at these changes, the coastal community made contact with the Office of Public Works (OPW) to make them aware of the erosion of the beach and dunes and these representations led to a proposal to construct coastal protection structures comprising of rock armour at the southern and the northern end of the main beach which were implemented in 1997. It was made clear at this time that coastal protection works were to be limited to the northern and southern parts of the beach and that soft engineering measures would be more suitable for protecting the beach and dunes.

Following the placement of the rock armour (Fig. 32.2), Donegal County Council (DCC hereafter) commissioned a team from Ulster University led by Professor Derek Jackson (a Coastal Geomorphologist) to complete a study of Maghery



**Fig. 32.2** Rock Armour on the northern and southern sides of the beach. (Photo: Paul Lawlor, 2019)

beach and coastline. This study, which included consultations with local stakeholders such as residents groups and Non-Governmental Organisations, considered the natural dynamics of the site and how to manage the erosion of the main dune frontage and other associated issues (Jackson, 2015, p. 1). The final report presents a

range of management options for the beach and dune system which include ‘grey’ measures (hard engineering approaches such as a sea wall) and ‘green’ measures (such as nature-based approaches). From the outset, grey measures were ruled out as an effective means of addressing the erosion of the beach and dunes. The report stated that; *‘rock armouring will be counterproductive to the beach dynamics and would set up an instability in the sediment system whereby strong wave action will reflect off hard defences (even porous structures) and strip the beach sand lower than present levels’* (Jackson, 2015, p. 14). The study concluded that the preferred management option was to regenerate the frontal foredune area using a Nature-based Solution comprising of a sand trapping fencing scheme and by revegetation of the restored dunes. This approach was followed in 2005 and it was repeated again in 2015.

### 3 Methods

The sand trapping system was designed to be consistent with the natural sand transport dynamics of the site and to maintain the stability of the sediment deposition and removal processes that were taking place. Wind-blown (aeolian) sand being transported by onshore winds (especially at low tide) moves up to the back beach area and is forced into deposition by the retardation of airflow through the presence of new dune fences that were placed in front of the dunes at the back of the current beach. The dune fencing (as shown on Fig. 32.3) was made up of circular wooden



**Fig. 32.3** The sand trapping scheme in Maghery in 2006 which was comprised of a lattice network of fencing. (Photo: Prof. Derek Jackson)

support poles (150 mm in diameter) placed in rows spaced 2 m apart. Each fence pole was firmly anchored into the sand and protruded a minimum of 0.8 m above the surface. The fence poles within each row were spaced 1 m apart with a series of vertical chestnut palings in between. The poles and the chestnut palings were knitted together using stainless steel wiring (to ensure no degrading or rusting) thus creating a lattice network of fencing. Each row of dune fencing extended 11 m from the face of the dune system onto the beach. The sand trapping system, based on those used elsewhere (Scottish Natural Heritage, 2000; Eichmanns & Schüttrumpf, 2020), was relatively extensive, stretching circa 500 m along the beach (between the rock armour to the north of the beach and the vehicular entrance to the south).

Following sand build up, revegetation of the foredunes with local marram grass (only) was also considered necessary to enhance the durability of the regenerated dunes. While natural revegetation was anticipated, it was recommended that this process should be accelerated by planting marram grass stock that was sourced from vigorous clumps in sheltered conditions from as near to the site as possible (e.g. to the rear of the existing foredunes). The use of marram grass stock from inland mature dunes was discouraged as it was less likely to thrive in a vigorous foredune environment. Clear directions were also given on the timing of the marram grass planting (between February and early April), the required root depth and its spacing. In addition, management measures were put in place (such as appropriate fencing and signage) to advise the public that revegetation was taking place along dune sections and that access was restricted. It was also necessary to leave a 'dynamic unvegetated (horizontal) zone' of approximately 5 m at the toe of each profiled dune to allow for a continuation of the natural process of sediment transfer to and from the beach.

The Community of Maghery played a key role in the implementation of the project. While DCC installed the lattice network of dune fencing, the local Community engaged in marram grass planting (in 2015) and the maintenance of the protective fencing and signage. Continuous monitoring and assessment of the dune fencing (especially along the front edge) was considered necessary to ensure that the sand trapping system remained in position and in good condition. According to the 2015 report, the coastal community were assigned the task of monitoring the condition of the fencing (especially following storms and extreme weather) and to report any visible defects. It was emphasised to all parties at the time that a lack of maintenance of the sand trapping system would reduce its effectiveness and potentially lead to a failure to regenerate the dunes.

The above method was followed when constructing the original sand trapping scheme in 2006. In 2015, the process was repeated in order to re-establish the lattice network of fencing based on the overprint of the original scheme and two rows of net fences (parallel to the beach line) were added to address the problem of sand blow from the beach and dunes that was causing significant sediment removal and causing difficulties for surrounding structures such as the community centre and car park. Both net fences were erected by the local community with one line of fencing (1 m in height) positioned on the seaward side and a second line of fencing (2 m high) located on the landward side, 1–2 m down from the crest of the dune. The net fences

extended along a 150 m stretch of the beach and dunes immediately adjacent to the community centre and pitch.

## 4 Results

The results of the original sand trapping scheme in 2006 and the later scheme in 2015 are discussed in sequence. The 2006 scheme was successful as it initiated a significant build-up of sand at the foredunes between 2006 and 2011 with continuous deposits of sand made throughout the 5-year period and a noticeable acceleration in the rate of accumulation between 2010 and 2011. This process led to fully regenerated foredunes in 2011 (Fig. 32.4).

However, noticeable erosion was visible on the lower sections of the dunes and beach (below 2 m in height) by 2015. A survey (taken from representative cross sections) compared sand levels on the beach in 2005 and 2015 and it demonstrated a decline of 0.8 m over the 10-year period and sand levels that were below the levels seen before the original sand trapping scheme was installed (Fig. 32.5). It is understood that the accelerated pace of erosion was caused by the coastal system entering an erosional phase between 2011–2015 combined with a lack of maintenance of the sand trapping scheme and the impacts of a series of severe storms. Despite the erosion, the 2015 back beach and dune levels still retained heights of around 2 m above 2005 levels – confirming that the rebuilt dunes remained intact. However, the experience demonstrates that the Nature-based Solution emplaced here requires continuous monitoring and proactive repair to ensure that it remains fully effective.

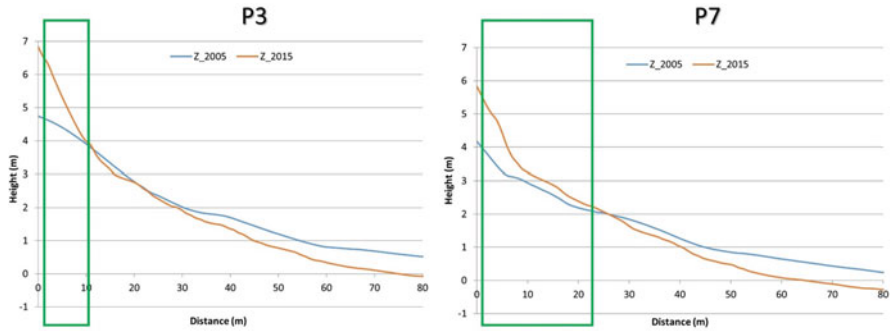
In February 2015, the sand trapping scheme was re-established, dune replanting took place and this led once again to the successful regeneration of the lower sections of the dunes and the beach. A survey in November 2015 demonstrated the extent and the speed of the recovery with the lower dune and beach sand levels increasing by 0.8 m in 9 months. This recovery enabled the dunes and beach return to the same sand levels that were recorded in 2005 (Fig. 32.6).

## 5 Discussion

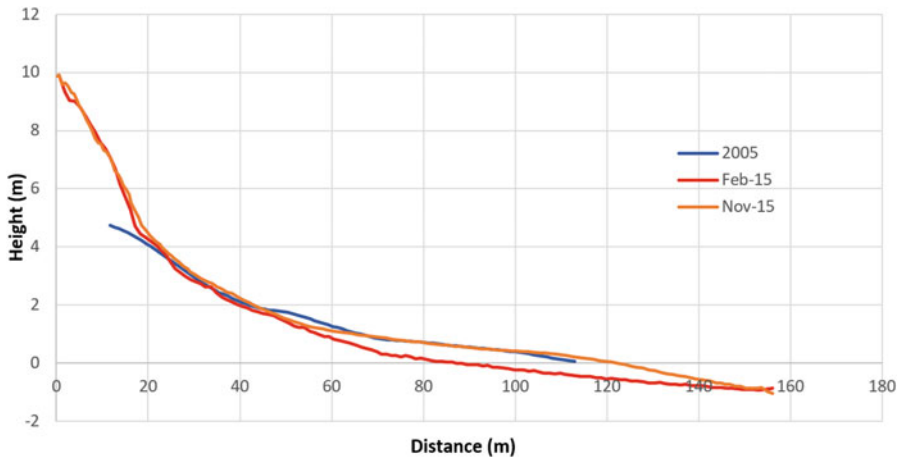
The case study revealed that the decision to undertake a Nature-based Solution to help manage the beach and dune erosion issues at Maghery was influenced by a number of features of the coastline with the natural dynamics of the site and its socio-ecological importance proving significant. The initial study revealed that using grey infrastructural measures to manage the erosion would be counterproductive as they would risk destabilising the sediment system by causing sand to be stripped from the beach by wave reflection off hard defence structures. The inclusion of the beach and dunes in the Termon Strand Special Area of Conservation also meant that a hard



**Fig. 32.4** Stages of dune restoration using a Nature-based Solution from sand accumulation (2006–2010) to revegetation and full regeneration (2011). (Photos: Prof. Derek Jackson)



**Fig. 32.5** A comparison of beach profile sand levels in 2005 (pre-installation) and 2015 (before second phase of fencing/repair) taken from cross sections. Graphs are based on GPS profile data in Jackson (2015). Note green boxed areas are foredune/back beach areas showing elevated surface levels in new dune heights still intact despite lowered frontal beach levels over the 10 year period



**Fig. 32.6** A comparison of beach sand Levels in February 2015 and November 2015 taken from a cross section (Based on data in Jackson, 2015)

engineering solution (such as a sea wall) would not be permissible. Therefore, the options for dealing with ongoing erosion were limited to softer interventions such as a Nature-based Solution to regenerate the foredunes that provide a natural buffer to coastal change.

The preferred Nature-based Solution for regenerating the Maghery dune system involved the construction of a sand trapping system which was designed to harness the natural wind-blown dynamics of the site and accelerate a build-up of sand in the foredunes. The strength of the regenerated dunes was to be supplemented by natural marram grass growth. Following consultation with the principal stakeholders in the area (DCC and the coastal community), it was agreed to proceed with the sand trapping system and associated measures. However, and notwithstanding the

constraints pertaining to the site (i.e. its unsuitability to an engineered solution and its SAC designation), some members of the local community retained a preference for a sea wall as it was perceived to be a more permanent and durable solution.

The evidence presented in the case study demonstrates that the Nature-based Solution adopted at Maghery led to the successful regeneration of the dune system and an increase in sand levels on the beach between 2006 and 2011. It is also understood that the costs of building (and maintaining) the sand trapping system were significantly lower than the costs of alternative grey infrastructure coastal protection methods. Furthermore, the study indicates that a series of severe winter storms combined with a failure to maintain the sand trapping system led directly to higher rates of erosion of the beach and dunes after 2011 and this necessitated a reinstatement of the sand trapping system in 2015. While the decline of the sand trapping system in 2011 was not anticipated, it demonstrated the dynamic nature of the adaptation solution in Maghery and the need to continuously monitor and maintain it as a means of ensuring its longer term resilience and effectiveness.

The decline of the sand trapping system after 2011 also highlighted the need for all stakeholders in the process (particularly DCC and the coastal community) to fully understand their roles in the adaptation project. The research revealed that the role of the community was either not made clear or was not fully understood, particularly with respect to the ongoing maintenance and management of the sand trapping scheme and dune revegetation programme. A clear view emerged during the research that the community expected DCC to have a larger role in maintaining the Nature-based Solution following its implementation. The absence of a formal management committee to deal with ongoing issues was seen as a further weakness as it hindered communication between all parties and it reduced opportunities for reflective learning by all stakeholders throughout the process.

## 6 Conclusion

This example from County Donegal in Ireland reveals that Nature-based Solutions can play a significant role in responding to challenges from climate change in coastal areas and that they can provide workable alternatives to 'grey' infrastructure solutions – particularly in areas designated under the Habitats Directive. The case study also demonstrates that Nature-based Solutions are often dynamic and subject to change by the environment in which they are located and while this is often seen as a significant advantage of these approaches, it also means that they require continuous monitoring and maintenance to ensure their effectiveness. These maintenance requirements mean that Nature-based Solutions can lend themselves to partnership arrangements between Local Authorities and local communities or other interests who are interested in a management or stewardship role in coastal areas. However, the case study also reveals that in order for these partnerships to operate effectively, all parties must clearly understand their roles in maintaining the

Nature-based Solution and that continuous communication (through existing governance structures) among stakeholders is crucial.

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