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Comparative analysis of adaptation strategies for coastal climate change in North West Europe

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ABSTRACT

Adaptation to climate change has experienced a recent rapid increase in guides, manuals and strategies, including the EU adaptation strategy of 2013. However, minimal critical review or evaluation has been done on the process and outcomes of adaptation strategies. This work presents a comparative analysis of progress towards adaptation strategies in nine coastal areas in NW Europe (from Belgium, France, Ireland and UK) where the INTERREG IVb IMCORE project was implemented. Adaptation progress was evaluated using a suite of indicators in six categories: Relevance, Effectiveness, Efficiency, Results & Impact, Sustainability and Management. Data were obtained through a combination of questionnaires and interviews. Although a similar IMCORE adaptation process was implemented there were notable differences between areas. Two alternate modes of implementation were identified: one focused more on impact and results and one on institutionalisation and future security of the adaptation process. The length of history of collaborative working was positively associated with progress in adaptation planning. The results thus recommend creation of a base for collaborative working prior to undertaking an adaptation initiative. However, this contrasts with the EU approach for developing adaptation strategies in which seeking agreement with stakeholders responsible for implementation is the penultimate stage.

1. Introduction

1.1. The need for adaptation

Climate change is cited as arguably the most persistent threat to global stability in the coming century (e.g. Adger et al. [1]). With climate change becoming more of an issue globally, communities and institutions need capacity to adapt to predicted impacts to ensure wellbeing and long-term sustainability. Institutions are the prime modality within which the processes of adaptation will take place; these will be drawn from international, governmental, private-sector and community-based levels. There is interplay between these institutions with their vulnerability and adaptive capacity being profoundly influenced by the market and regulatory contexts within which they operate which are determined by governmental policies [2].

Many reports and adaptation guides have been produced to support adaptation initiatives since it is a new and developing theme across the globe, for example, NOAA (National Oceanic and Atmospheric Administration) has produced a planning guide on adapting to climate change for coastal managers [3]. UNFCCC climate negotiations in Doha (Conference of Parties, COP 18) discussed key issues which included National Adaptation Plans (NAPs), and in Warsaw (COP19) negotiations saw the capitalisation of the Green Climate Fund which has a ring-fence around adaptation-orientated investments. The key message which can be drawn from this is that adaptation is the way forward in an era of a changing climate, and this is evidenced by large organisations, such as the European Union and World Bank, introducing climate change adaptation and mainstreaming it though their operations.

1.2. Defining adaptation

In a climatic sense, adaptation is defined by IPCC [4] as *the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.* Adaptation is said to comprise two related challenges: adaptation to current climate change, and to future climate change [5]. Adaptation does not solely encompass physical aspects such as defence against rising sea levels. Both "hard" and "soft" adaptation methods need to be considered; from engineering and infrastructure, to social, economic, political and

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institutional. It follows that adaptation strategies should be flexible enough to take on board social infrastructure investments and new knowledge as it is generated, rather than inflexible large-scale hardware [6].

1.3. International and EU developments in adaptation

Sustainable development can both contribute to climate change and reduce vulnerabilities to its impacts. The UNDP (United Nations Development Programme) is supporting countries in achieving sustainable development through strengthening adaptive capacity and enabling environments to create robust and responsive state institutions, capable public and private sector management, and skilled human resources to innovate, adapt and deliver to the changing conditions [7]. More and more, climate change and adaptation are becoming incorporated into daily thinking and an increasing number of developments have come to light over the past few years. A white paper produced in 2009 proposed a two phased approach, with phase 1, which has been largely implemented, laying the ground work for preparing a comprehensive EU adaptation strategy to be implemented during phase 2 [8]. The EU Strategy on adaptation to climate change (COM(2013) 216) was produced in 2013 in order to "*contribute to a more climate-resilient Europe. This means enhancing the preparedness and capacity to respond to the impacts of climate change at local, regional, national and EU levels, developing a coherent approach and improving coordination*" [9].

Since major developments are constantly being made with regards to climate change and adaptation, this ties in with a lot of research, particularly by the European Commission, which has published material on reducing emissions, creating plans, analysing options for future management, looking and evaluating adaptation options.[1] Much work has been done by DG-CLIMA (Directorate General for Climate Action) and increasingly academia is producing a wealth of climate related research, however, little critical review or comparative evaluation has been done on adaptation strategies.

1.4. Difficulties of adaptation in the coastal zone

The complex and interdependent nature of the coastal zone is highlighted by Levina et al. [10]. "*The coastal zone is an area at the interface between the ocean and land of important ecological significance where many economic, cultural and recreational activities take place*". In addition to coastal complexity, the conceptual complexity of climate change adaptation and its management causes confusion among scholars. For example, adaptation and resilience are often used interchangeably and inappropriately so [11,12]. Resilience is defined as the degree to which a system can absorb a disturbance and return to its pre-disturbance steady state, whereas adaptation refers to the ability to modify behaviour or respond to the disturbance [12]. Climate change adaptation began to be recognised as a key part of coastal planning in 1999 [13] particularly due to the growing additional pressures faced by the fisheries and aquaculture industries for example. These pressures introduce potentially severe impacts on coasts and the wider marine ecosystem, limiting their ability to cope with further stressors [14]. Adaptation does not solely encompass physical aspects of adaptation such as defence against rising sea levels. Both hard and soft adaptation methods need to be considered for all factors included; from ecological and engineering, to social, economic, political and institutional.

It follows that adaptation strategies should be flexible enough to take on board social infrastructure investments and new knowledge as it is generated, rather than large scale hardware [6]. However, there is concern about "doing adaptation wrong". For example, Thomsen et al. [15] suggest that manipulative behaviours may masqueraded as adaptation with fundamentally different intentions and outcomes which may turn out to be maladaptation over time.

1.5. Innovative Management for Europe's Changing Coastal Resource – IMCORE

The IMCORE project – Innovative Management for Europe's Changing Coastal Resource (www.imcore.eu), supported by EU ERDF INTERREG IVb funding, aimed "*to promote a transnational, innovative and sustainable approach to reducing the ecological, social and economic impacts of climate change on the coastal resources of North West Europe*". Through 17 North West European partners, a series of five Work Packages were designed to achieve this overall aim. The aim of the fourth Work Package was "*to produce nine local adaptation management strategies*". Adaptation strategies were produced by the 17 partners working in nine small local clusters termed ECNs (Expert Couplet Nodes) (Table 1). To fully understand, determine similarities and form comparisons between different areas to facilitate development of future adaptation strategies in different localities, an evaluation must be completed as the final stage in the process.

There were a number of limitations of the study, these included:

- Questionnaires only offered a brief snapshot in time rather than a longitudinal view of the progression.
- The authors determined whether indicator criteria were satisfied based on responses, which could potentially introduce an element of bias.
- Due to the nature of the work process, not every ECN was in the same stage, all were working to different targets and timeframes based on local agreements, however all had the final goal of better climate change adaptation.
- The number and type of adaptation indicators were selected by the authors from literature review and perceived as commonly appropriate across the sites being studied thus, some subjective bias is likely.

1.6. The evaluation of adaptation initiatives

This work is concerned with the evaluation and comparison of these adaptation strategies, comparing different social, economic and institutional aspects. Through evaluation of these adaptation strategies, best practise measures and suggestions can be put into place and further guidelines drawn up. Few studies have been executed looking at comparisons of adaptation strategies (e.g. [16,17]), but none performed in the same manner as this work using existing international best practise of evaluation in the form of the adaptation indicators.

Evaluation is taken here as the "*systematic and objective assessment of an on-going or completed project, programme or policy, its design, implementation and results*" [18]. The nine local adaptation strategies were evaluated and comparisons drawn between the nine local ECNs upon which these are based. To achieve this, it was necessary to assess different criteria which have already proved successful in other projects, also drawing upon those identified from review of the peer-reviewed literature. Swart et al. [16] recommend that for effective evaluation, clear and precise objectives are required relating to meaningful indicators, which allow for a pragmatic approach to environmental management based on actual consequences of real decisions.

[1] http://ec.europa.eu/clima/.

Table 1
ECN scenario type chosen, reasoning for this choice, and final output type.

Expert couplet node	Scenario type chosen	Reason for scenario choice	Final output
Aberdeen	Normative	Flooding should be the main impact of climate change in the area.	Adaptation strategy
Belgian Coast	Exploratory	Enable open discussions and make sure all drivers are taken into account.	Adaptation strategy
Cork Harbour	Normative and Exploratory	Cork opted to use an exploratory scenario process in order to establish how the future of flood management could unfold in the harbour over the next 20 years.	Adaptation strategy
East of England	Exploratory	Governance is a key factor for adaptation. Exploratory approach allows stakeholders to test existing arrangements to understand how they would perform in different circumstances.	Community adaptation strategy (Action Plan)
Golfe Du Morbihan	Exploratory	Large numbers of stakeholders concerned by the subject and it was anticipated that points of view may be different. It was therefore impossible for the Golfe Du Morbihan to define and agreed target to reach as a first step. The exploratory approach seemed to be more relevant than the normative.	Adaptation strategy based on three scenarios which couldn't be agreed upon -decision support tool not a report
Lough Swilly	Exploratory moving to Normative	No previous stakeholder engagement.	Adaptation strategy
North East England	Exploratory and Normative	Exploratory – a list of issues was already available and determining how these issues will affect the area in the future. Normative - with a group of people it proves beneficial to do a normative scenario as it is a participatory process and allows all members of the group to voice opinion whilst also providing a more detailed picture of the single selected scenario and thus required an active choice or preference to be made by the stakeholders and permitted actions to be identified.	Adaptation strategy
Sefton	Normative	Large data sets are available for the coast. With this, there is a good understanding of processes. This enables Sefton to pursue the Normative approach. Also, many of the Partners are from a scientific background and so are comfortable with this approach.	Adaptation study
Severn Estuary	Exploratory	Highly differentiated and numerous discrete stakeholder groups likely to benefit from capacity building and strategic conversation provided as by-products by the exploratory method. Also highlighted as best approach in the issues and challenges derived from IMCORE Severn Planning Review (Phases 1 & 2).	Adaptation strategy

2. Methodology

The data used in this analysis were derived from nine coastal areas in NW Europe where the IMCORE project developed ECNs to work towards creation of adaptation strategies. The ECN case study sites, from north to south, were: Aberdeen (UK), North East England (UK), Lough Swilly (Ireland), Sefton (UK), Cork Harbour (Ireland), Severn Estuary (UK), East of England (UK), Belgium Coast (Belgium) and Golfe Du Morbihan (France). The sites ranged in spatial scale from local areas of 10's of km (e.g. Golfe of Morbihan, Sefton), to over 100 km's (Severn Estuary, North East England), as well as in administration from local authorities (e.g. Cork Harbour), to regional entities (e.g. North East of England) to national governments (the whole of the Belgium Coast).[2] The respondents used in this study were project partners who were closely involved in the adaptation work; they were drawn from both the academic and the local administrative or management bodies.

2.1. Questionnaires

A review of the literature on the current best practise with regards to development initiatives and climate change adaptation identified a number of desirable aspects for development of adaptation strategies. In particular, three key documents were identified for their comprehensive coverage and suitability for this work and from which desirable assessors were derived [16,18,19]. These assessors formed the basis of the interrogative aspects of the methodology.

Six OECD (Organisation for Economic Co-operation and Development) evaluation headings (Relevance, Effectiveness, Efficiency, Results & Impact, Sustainability and Management) were used as the structure for the main criteria; these are the standard headings for evaluation of development projects. Within each of these six main criteria three sub-questions, relating to adaptation, were included in order to gather the information required for detailed analysis. The sub-questions were also used to triangulate responses to provide a level of verification in the process. Between two and eight indicators, derived from the adaptation literature, were identified for each sub-question. If this indicator was present in the answers, then it was recorded as evidence of adaptation progress. The multiple-indicators within sub-questions allow results to be cumulated to look at progress in the six main criteria. The main criteria, sub-questions and indicators are presented in Table A1.

It was estimated that completion of the questionnaire would take around two hours due to the complex nature of the questions. This was confirmed after the questionnaire was piloted by a project representative in the local area. Ordinarily this process may seem long, but the in-depth approach was facilitated as the evaluation was an integral part of the overall project. The pilot questionnaire suggested that offering guidance on the indicators would provide more comprehensive responses. Due to differing policy and governmental structures throughout North West Europe, a few indicators were not applicable to a handful of ECNs. Appropriate corrections (through the omission of questions which were irrelevant and adjustment of totals and percentages) were made in these instances to ensure valid comparative analysis throughout.

2.2. Data collection

Data were gathered by a number of different methods throughout the months of spring and summer 2011; this was the final full year of the IMCORE project during which progress in all adaptation strategies was still on-going but near-complete. The primary survey instrument was a questionnaire but to increase the scope and depth of

[2] Further details of the study sites can be found at http://www.coastaladaptation.eu/index.php/en/9-experiences.

received responses, additional information was collected based on the gaps and questions apparent from the questionnaire responses. Additional information was collected through face-to-face interviews with each partner (at a project progress meeting) to clarify particular points which emerge from the questionnaire response. Further email and telephone correspondence were performed as required to ensure a comprehensive suite of information for each target area.

Additional literature material, in the form of ECN case study materials and summary tables, was available through the IMCORE project. These were used to improve the analytical depth and understanding of the adaptation process at each site and to cross-check the assertions of some respondents; overall, this allowed a more comprehensive evaluation of each ECN.

2.3. Data analysis

A number of standard statistical analysis routines were carried out as well as a mathematical ordination approach (Principal Components Analysis); all were performed in Minitab (v16).

3. Results

3.1. Differences between adaptation indicators by site

A non-parametric Friedman's test (based on ranks and not count data) was used to compare the number of indicators and distribution of indicators between criteria for the six study areas. Results showed differences between the ECNs sites and between the criteria (Friedman's test, $P < 0.05$) (Fig. 1). The East of England couplet exhibited the lowest number of indicators and had fewest indicators present in the Results and Impact, and Efficiency sections, whereas Sefton demonstrated the highest number of indicators and strong Results and Impact.

To permit further interpretation data was presented in terms of the proportion contribution of each adaptation indicator to the site total, broken down into the six main evaluation criteria (Fig. 2) demonstrating the proportional compliment of adaptation indicators which supports progress in the adaptation process.

3.2. Comparison of the composition of adaptation indicators

The Friedman's test shows that there were differences in the number of adaptation indicators between sites and between the main adaptation criteria. To explore the composition of indicators between sites in more detail a Principal Components Analysis (PCA) was used. PCA is a multivariate ordination routine which can identify differences in indicators between ECNs in low multi-dimensional space. PCA provides a plot of the distribution of sites based on their constituent adaptation indicators as well as bi-plots showing the contribution of each of the main adaptation criteria. The PCA plot illustrated the similarity between the six sites and the contribution of the main criteria to that distribution (Fig. 3).

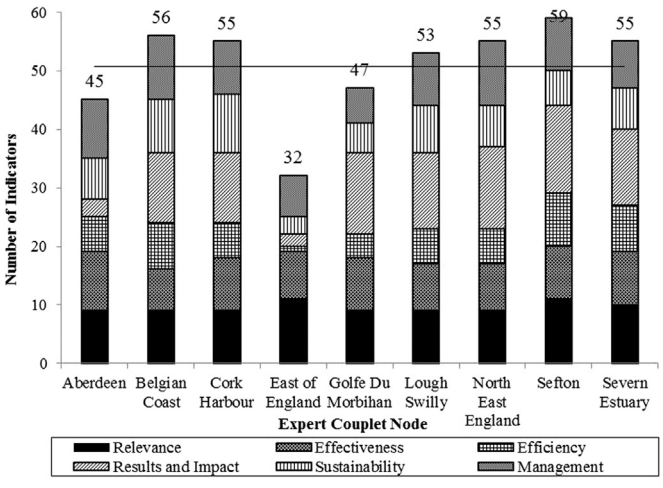

Fig. 1. Distribution of adaptation indicators across six Expert Couplet Node study sites in NW Europe: total number of indicators for each site is written above the bar, each bar is divided into the six main criteria categories; the single horizontal line indicates the mean number of indicators per site.

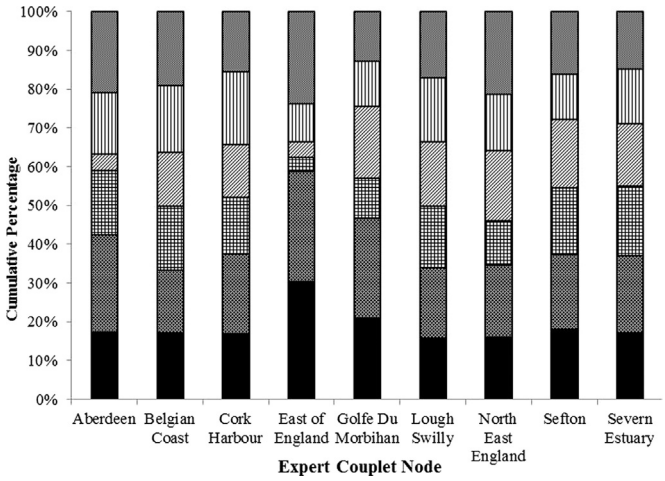

Fig. 2. Comparison of percentages of adaptation indicators in the six evaluation criteria (shading as per Fig. 1) for the 9 study areas.

The PCA displayed one main cluster containing Aberdeen, Lough Swilly, Cork Harbour, North East England, Cork Harbour and Belgium Coast (central - right, Fig. 3), one further loose cluster of ECNs could also be seen with Golfe Du Morbihan, Severn and Sefton (top right, Fig. 3), although it may be perceived that Sefton and Severn are also outliers. This shows all ECNs to be at least 15.02% similar, which appears to be intuitively correct reviewing all outputs. The highest level of overall similarity is exhibited by Cork Harbour and Lough Swilly (33.34%), followed closely by Sefton and Severn Estuary (29.29%). The Golfe Du Morbihan shows little overall similarity to other ECNs and is represented as a clear outlier. Visually, the East of England appears to be an obvious outlier in comparison to the other sites; it was previously noted to have the lowest complement of adaptation indicators (see Fig. 1).

The bi-plots of criteria show increasing Relevance and Effectiveness both associated with the positive area of the x-axis and

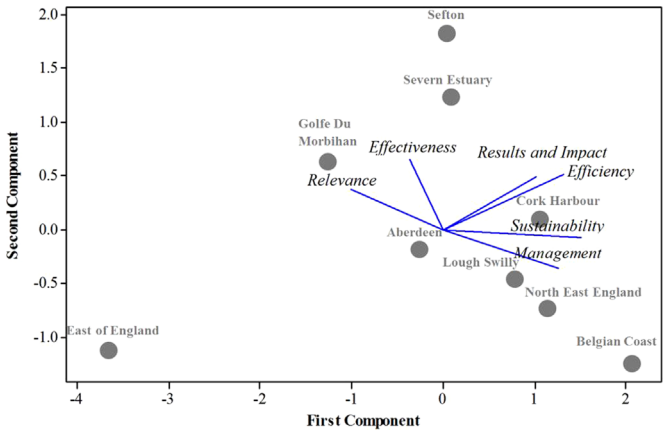

Fig. 3. Principal Components Analysis (PCA) plot of the six study sites defined by adaptation indicators (grey points labelled by site) with the bi-plots of the criteria (straight lines labelled by criteria).

Sustainability and Management in the opposite direction (Fig. 3). The divergence between criteria bi-plots demonstrates that there are a number of different dimensions in the adaptation initiatives under study, rather than a singular linear progression towards adaptation. This may also be explained due to the progression of individual adaptation strategies with different ECNs being at different stages of the strategy development.

This visual interpretation was confirmed by statistical analyses using stepwise multiple regression which concluded that PCA-1 was most related to positive Management, whereas PCA-2 was related to Effectiveness.

4. Discussion

4.1. Assumptions of the study

Throughout this work, a number of assumptions have been made and results are therefore subject to certain limitations. The main assumptions were that:

- All indicators were of the same value in terms of their significance towards adaptation.
- All ECNs took the same amount of time in answering the questions and provided the same level and quality of results.

Although it was not possible for all ECNs to provide comprehensive answers for every question, expert estimates were given in some instances and the answers were taken as a given, assuming that all responses were correct.

There is additionally considerable diversity among the ECN sites over and above the spatial scale and administrative differences previously noted. Not all ECNs were aiming to create a coastal adaptation strategy per se, some ECNs were more focussed on development of stakeholder engagement and working towards an adaptation approach rather than a formal and ratified adaptation strategy. Internal structural and budgetary changes which occurred within the IMCORE project led to various restructuring and revision in some ECN plans. Finally, it should be remembered that all ECNs attempted to consider all sectors (including ecological, institutional social and economic); however, some ECNs tended to prioritise certain aspects, for example physical geomorphological change (Sefton) or institutional structure and engagement (NE England). Each ECN is moulded in structure and function to local circumstances and therefore applicability of outcomes to other areas undergoing adaptation initiatives needs consideration.

4.2. Progression in the adaptation response

The generic approach for creation of an adaptation strategy was developed within the IMCORE project and followed in the ECN areas. However, the results from the work presented here showed that there were differences with respect to the adaptation indicators in the nine target areas. This shows that similar generic approaches produce different adaptation results in different areas. However, of more significance is a consideration of how the differences are manifested in the portfolio of adaptation indicator values and how the adaptation indicators interact or are associated. This provides not only an understanding of the adaptation process but of differences, or similarities, between local circumstances and thus potential “good practise” to use in other coastal areas undertaking development of an adaptation strategy.

The analysis provided an indication of the proportional focus on each OECD indicator category for each ECN, and permitted a broad overview of the relatively stronger and weaker criteria within each ECN, irrespective of differences in total indicators (Fig. 2). This did not reflect exactly which indicators were satisfied; two ECNs could have had the same number of indicators satisfied within each criterion, yet these could be completely different individual answers. Interestingly, the ECNs which appear to have the most solid plans and management techniques (the Belgian Coast, Cork Harbour, Lough Swilly, Sefton and the Severn Estuary) have consistent relative percentages across each criterion, inferring that equal proportions of all criteria produce a better rounded strategy and future management options. This is qualitatively supported, for example, Lough Swilly already has elements in place for different management functions at appropriate levels, an important consideration for the future.

The significant p-value produced by the Friedman's Test ($p=0.001$, $p<0.05$) indicates that ECN means are significantly different from each other (Fig. 1). This is as expected since ECNs are not only situated in very different geographical locations, but are at different stages in the process and operate within different governmental structures and local policy environments. Each of these factors could either facilitate or hinder the ECN in the production of an effective strategy and thus the adaptation process has to be “negotiated” around local specificities.

4.3. Interplay between adaptation criteria

The indicators for Sustainability and Management closely map onto the PCA scatter plot (Fig. 3). From the answers provided, it was apparent Belgium and North East England had more resources than other ECNs, and they had groups that were already established in order to formulate institutional processes and designations to take things forward. In resource terms, the Flemish adaptation strategy is independent of project funding and will be paid for by tax payers, potentially giving it a measure of longer term security and stability.

Conversely, other ECNs were less institutionally aligned and lacking firm options for the future of the adaptation initiative. The East of England stated in the questionnaire “*The regional coastal group of operating authorities for coastal protection and flood defence works have the potential to take forward the messages from the programme at regional level*” but nothing was firm and this assertion was only speculative. This is visualised in the PCA plot since the Belgian Coast ECN lies furthest right along the PCA-1 axis, and sit closest to the Management sub-axis, whereas the East of England lie the furthest left on the PCA-1 axis (Fig. 3): closest to Results and Impact and Efficiency sub-axis, implying, however, that there was an efficient adaptation strategy development which made an impact. The East of England concentrated more on stakeholder involvement and engagement than producing an adaptation strategy in the earlier stages which proved very relevant in their designated area since the community involved are from the UK's most deprived town (at the time of this study) – Jaywick. The East of England invested effort creating a legacy by charging a standing network with championing the issues and solutions around adaptation on the coast although future resourcing and sustainability could undermine such efforts.

Where the East of England scores poorly, the highest positioning on the Relevance and Effectiveness dimensions (Fig. 3) is Sefton who don't have an adaptation strategy per se; they produced an adaptation study, since issues were already identified in prior work. Future considerations indicate the Council will continue with the strategy and process but are actively looking for other people to take responsibility. It was also stated by key members of the ECN that (Pers. Comm. Graham Lymbery, Sefton County Council, 12th May 2011) “*cost was not a problem as the funds were available; any problems arose from lack of willingness to take things forward and commit after the end of the project*”.

4.4. Institutional maturity in adaptation initiatives

The PCA plot illustrates progression in development of the adaptation process, with increasing maturity with increasing first and second axes scores (from bottom left to top right, Fig. 3). Orthogonal divergence from this line of increasing maturity seems to lead to improved Relevance and Effectiveness (more positive PCA 2 scores) or improved Sustainability and Management scores (lower PCA 2 scores) (Fig. 3). Sefton, the Severn Estuary, and increasingly, the Golfe Du Morbihan, feature high on the PCA-2 axis. Conversely the ECNs which have good planning and management, yet have failed in delivering as much as would have been anticipated, feature further to the right on PCA-1 axis (the Belgian Coast, North East England, Cork Harbour, and Lough Swilly).

If this trajectory of adaptation progress is attributed to ECN maturity, it is possible to deduce ECN maturity arises from a combination of both effectiveness and results based achievements, coupled with good ECN management. It is further recommended that both aspects need to be worked on for maturity within an ECN. For example Sefton and the Severn Estuary should focus their efforts on management, whereas North East England and the Belgian Coast need to become more delivery orientated.

Whilst the IMCORE project lasted four years, some of the ECNs have been working together for longer. Thus, ECN maturity ranges from less than four years to in excess of eight years. The maturity of the involved ECNs is summarised in diagrammatic form in Fig. 4.

A pattern emerges, as the ECNs with lowest number of indicators (Fig. 1) (East of England and Aberdeen) are lowest in ECN maturity, whereas Sefton, Severn Estuary have high number of indicators (1st and 3rd, respectively). East of England lost their partner with the demise of government offices and Regional Development Agencies so CoastNet was left as the sole regional partner in this ECN on the project. It can be concluded that ECN maturity is a significant factor associated with adaptation strategy progression.

The long history of collaborative work in the Severn Estuary and good level of progression in the adaptation process have high value because of the complex jurisdictions of the area. Bordering both Wales and England, the Severn ECN area is affected by different and sometimes inconsistent policies on climate change. These differences understandably made some interactions and decision making very difficult. Such trans-boundary issues are frequently cited in the literature [20–23]. This highlights the need for uniform planning across the UK, although European guidelines are increasingly influential. The EU now has a strong role when the impact of climate change transcends the boundaries of individual countries [8]. As well as addressing issues of transnational co-operation, the Australian Government [24] emphasise adaptation as a shared responsibility between governments, businesses and the community, all of whom have a stake and a role in responding to climate change impacts. It is therefore acknowledged that a more strategic approach is needed to ensure timely and effective adaptation measures are taken. A wider, trans-boundary approach needs to be adopted to ensure the greatest benefits can be seen in adapting to climate change [16].

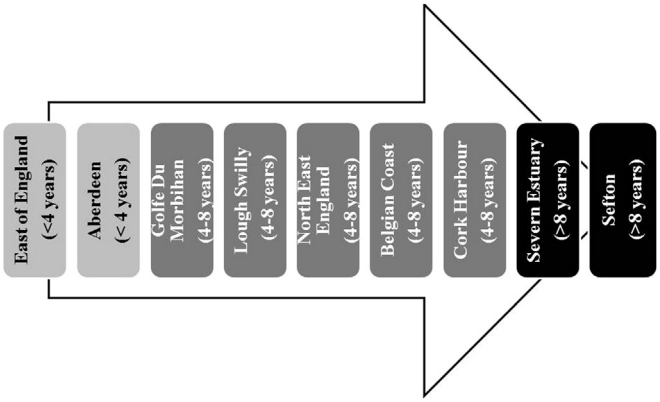

Fig. 4. Diagrammatic representation of ECN Maturity (with years of ECN existence), going from least mature which developed specifically for the IMCORE project (light grey on the left) to the most mature which has been working together for 8+ years prior to the IMCORE project (black shading on the right).

4.5. Issues for consideration in coastal adaptation planning

This comparative analysis has identified several interesting issues; particularly the need for full and long lasting stakeholder engagement, with adequate provision for the future. It was also concluded by Lough Swilly that the potential for learning and the transfer of expertise experienced through the process of ECN working, was invaluable. Even though it would be mostly the councils and policy makers who would be implementing the IMCORE process and adaptation strategy as a whole, working with a diverse range of stakeholders, interdisciplinary teams, and receiving input from diverse organisations made a valuable contribution to the development of the strategy. A 'successful' adaptation strategy seems to come from not only the number of indicators satisfied, but a balanced spread across all criteria categories.

This work did not seek to rank or produce an IMCORE league table, but more seeks to emphasise the unique nature of each ECN; each is in a different situation, they have advanced at different rates due to policies, governmental structure and design, and especially locality. Within this project, both top-down and bottom-up governance influences were identified, however a mixture of the two seems to produce better results, keeping both policy makers and stakeholders engaged with the process – an important factor if adaptation is to succeed [25,26]. Minamikawa [27] also suggests that to increase adaptation effectiveness, it is important to consider the prevailing understanding of the current situation, prediction of impacts, policy formulation, implementation and evaluation. Within some ECNs, some partners were not as well engaged as others, and the work was left to one partner. This eroded many of the highly valued potential benefits, such as inter-organisational learning, and left partners less satisfied with the process. In the most severe case, the East of England couplet was left consisting solely of one partner. However, its bottom-up approach has demonstrated some success, the community adaptation strategy produced seems manageable and, by initiating community engagement early on, the ECN has raised awareness and willingness to change in the communities with which it works.

Comparison of adaptation strategies has provided a varied overview based on nine different situations in NW Europe – as stated in Cork Harbour ECN's questionnaire, it may be "*about adjusting the process to suit the application*". Rosenzweig et al. [28] recommend bearing in mind that we should not only monitor climate change and associated impacts, but also advances in scientific understanding, technology and strategic thinking of relevance to adaptation. Furthermore, consideration of who should be making decisions about the coast, how, and who bears the potentially high cost of adaptations to climate change [29], remain essential. Encouragingly high levels of stakeholder engagement in the IMCORE process should at least ensure that a broad range of interested parties address these questions.

Data collected for this work was gathered over a relatively short timeframe, providing only a snap shot at one point in the process. It is therefore recommended that the tracking of adaptation progress is carried out periodically (e.g. annually or every two years). This should allow changes and success or failures to be documented, and underlying causes explored. It would also permit the charting of the development of ECNs as organisations, as they pass through different stages of the process, so that regardless of

their starting state, their progress can be tracked up to the same point - attainment of a fully developed adaptation strategy. The monitoring and evaluation of adaptation initiatives and the climate change response is an important and growing requirement as more initiatives and resources are aligned to this area.

5. Conclusions and recommendations

This study has shown that:

- Adaptation progression was greater in areas which had a balanced score in all evaluation criteria areas: Relevance, Effectiveness, Efficiency, Results and Impact, Suitability and Management.
- There seemed to be two alternate thematic modes which the areas displayed, one focused on impact and results and one about institutionalisation and future security of the adaptation process.
- Of major significance were institutional maturity and the length of history of collaborative working which are strongly associated with progress in adaptation planning.

Recommendations can be drawn from this suggesting that a balanced progression across all the evaluation criteria would be an important consideration to build into a plan for an adaptation initiative. However the strongest recommendation is to promote collective working and stakeholder engagement at the earliest stage, ideally many years before the commencement of an adaptation initiative.

This recommendation for creation of a base for collaborative working prior to undertaking an adaptation initiative contrasts with the EU approach for developing adaptation strategies. The EU proposes that the penultimate step of developing an adaptation strategy is to "*seek agreement with stakeholders responsible for implementation*" (Climate-ADAPT, step 5b; [30]) after preparatory actions, assessing risks and vulnerabilities, identifying adaptation options and assessing adaptation options (steps 1–4 respectively). The results of the work presented based on empirical studies across NW Europe, point to the opposite approach and suggest that there is a need to build in stakeholder engagement at the earliest stage or even before adaptation planning is initiated.

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Appendix A

See Appendix Table A1

Table A1
The six main criteria, the sub-questions used to elicit respondents responses and then indicators reflecting progress in coastal adaptation.

Main criteria	*Sub-question*	*Adaptation indicators*
Relevance – the extent to which the adaptation strategy is suited to the priorities and policies of the target group, recipient and donor.	A. To what extent is the adaptation strategy aligned with priorities and policies within the Local Authority? Has the adaptation strategy aided in your ECN climate change management needs?	1. Are scenarios available to wider local audience? 2. Strength of the link between the predicted and actual results, and local and national needs. 3. Coherence within the ECN and nationally. How the strategy fits into the ECN country's climate change future – e.g. UK Climate Change Act/ National Climate Change Strategies and Plans. 4. Is the ECN within an area where the council has signed the Nottingham Declaration? 5. Contribution to build adaptive capacity within the wider area. 6. Validity of adaptation strategy for future use.
	B. Has the strategy formed a platform to enhance the robustness of long-term investments and/or improved societal awareness and preparedness, and/or increased the adaptability of vulnerable marine activities.	1. Have all relevant sectors been considered (environmental, social, economic and institutional)? 2. Are beneficiaries identified? 3. Evidence of stakeholder involvement and relevance to adaptation strategy. 4. Strength of the link between the expected results and local and national needs. Are these related to the adaptation strategy?
	C. Does the adaptation strategy consider the existing institutional context of the region and adaptation planning processes of the country? Has your adaptation strategy helped to contribute towards National Climate Change Policies?	1. Information on existing institutional context. 2. Coherence within the ECN and nationally. How the strategy fits into the ECN country's climate change future – e.g. UK Climate Change Act/ National Climate Change Strategy/ Plan. 3. Is the ECN within an area where the council has signed the Nottingham Declaration? With National Climate Change Indicators Listed.
Effectiveness - a measure of the extent to which the adaptation strategy attains its objectives.	A. To what extent has your ECN achieved the original adaptation strategy objectives as set out by the ECN in the early stages of the project? Where does this fit into the future?	1. Full or part achievement of objectives. 2. Adaptation strategy covers various sectors and resulted in: change in capacity for awareness raising, information management, future implementation of adaptation strategies, perceptions to climate change adaptation, change in level of support from local to regional etc. 3. Full use of the adaptation strategy process and ensuring future effective use. 4. Gaining stakeholder involvement and interest in future plans.

Table A1 (*continued*)

Main criteria	*Sub-question*	*Adaptation indicators*
B. What were the main features influencing the achievement or non- achievement of these objectives?	1. Risks and assumptions identified throughout planning and adaptation strategy creation. 2. Uncertainties highlighted through scenario building.	
C. To what extent has the approach used to develop the adaptation strategy been coherent and robust, or to what extent would alternative pathways or approaches have been used in retrospect?	1. Full use of the adaptation strategy process and ensuring future effective use. 2. Gaining stakeholder involvement and interest in future plans. 3. Building of institutional capacity for further adaptation to climate change. 4. Is the ECN within an area where the council has signed the Nottingham Declaration? With National Climate Change Indicators Listed.	
Efficiency – a measure of the outputs of the adaptation strategy (qualitative and quantitative) relative to the inputs of the adaptation strategy.	A. Is the creation of the adaptation strategy cost and time efficient to users and strategy development?	1. Were the benefits seen proportional to time and spend? 2. Did the process lead to establishment of objectives, goals and priorities for adaptation. 3. Adaptation strategy easy to understand, and provides best results.
	B. Did activities overlap or duplicate other similar interventions? Was the adaptation strategy implemented in the most efficient way compared to alternatives?	1. Adequacy of project choices in view of existing context, infrastructure and cost. 2. Adaptation strategy easy to understand. 3. Awareness of other similar interventions. 4. Knowledge the IMCORE approach provided best results and proved to be the most efficient.
	C. To what degree was the formation of the adaptation strategy hindered through lack of awareness, capacity and incentives? Did dealing with these constraints lead to unexpected resource requirements?	1. Were changes in strategy design apparent for improvement of efficiency? 2. Was there a lack of awareness, capacity or incentives? 3. Indication of actual results and how they compare to expected results.
Results and impact- the long term positive and negative, direct or indirect, intended or unintended changes produced by the adaptation strategy for enhancing and climate proofing the local area.	A. Which vulnerable sectors specifically were highlighted and which sectors did the adaptation strategy focus on?	1. Identification of vulnerable sectors. 2. Effective communication and dissemination of results to stakeholders for future reference. 3. Communication and collaboration with other organisations for feedback. 4. Adaptation strategy includes provisions for future communication and education. 5. Scenario availability for reference. 6. Usefulness of adaptation strategy. 7. Enhanced resilience and mitigatory capacity. 8. Successful training programmes.
	B. What real difference has the adaptation strategy made to adapting to climate change within your ECN area – is it highly significant, negligible, or somewhere between? What is the impact of these changes? What is the effect of the adaptation strategy on enhancing and climate proofing local areas in the long term?	1. Effective communication and dissemination of results to stakeholders for future reference. 2. Adaptation strategy includes provisions for future communication and education. 3. Usefulness of adaptation strategy. 4. Knowledge, baseline information. 5. Indication of future use.
	C. What points have the adaptation strategy highlighted, or helped to join up, that would have been otherwise missed?	1. Identified areas. 2. Joined up or links created. 3. Scenario availability for reference. 4. Usefulness of adaptation strategy. 5. Successful training programmes.
Sustainability – measuring whether the benefits and outcomes of the adaptation strategy are likely to continue after IMCORE funding has ceased.	What are the strengths and opportunities arising from your IMCORE adaptation strategy? How can you see these influencing future sustainability? Are the current adaptation strategies any use to institutions or in policy making?	1. Have strengths and opportunities been identified and discussed? 2. Are developed/adopted standards/benchmarks in place to assess and improve the quality of the adaptation strategy? 3. Have short, medium and long term sustainability issues been addressed? 4. Indication of thoughts, or evidence of a process in place to adapt adaptation strategies with changing policies and climate?
	To what extent will the benefits of the adaptation strategy continue after IMCORE funding ceases? Are further funding and management considerations to take this forward and fill any identified gaps?	1. Role and responsibilities of managing unit is transparent and agreed upon. 2. Indication of thoughts, or evidence of a process in place to adapt adaptation strategies with changing policies and climate? 3. Are further financing and personnel considerations in place? 4. Has future commitment to adaptation strategy sustainability been considered?
	To what extent have the meetings, discussions and outputs used to create the adaptation strategy been institutionalised or formalised into a responsible authority? Does this institutionalisation help to secure future gains?	1. Expectations for new body or working group, or some organised structure to take things forward in the future. 2. Work plans developed which extend further than IMCORE timeline. 3. Commitment to lead / chair such an initiative by a representative authority.

Table A1 (*continued*)

Main criteria	*Sub-question*	*Adaptation indicators*
Management - is considered to help drive initial views on how the adaptation strategy can help improve accountability of climate change matters and consider how institutional structures, regulations and policy frameworks need to be adapted in the future.	A. Does your ECN have the institutional capacity to implement the adaptation strategy created through IMCORE, but also develop and manage further adaptation strategies?	1. Development of institutional capacity also. 2. Availability of baseline data. 3. Development and contribution to policies. 4. Availability of future project management plans. 5. Engagement of wide variety of stakeholders, and appropriate feedback sought.
	B. What are the different scales of governance (international, national, regional, local and individual) that currently undertake responsibility for implementation (and development) of adaptation strategies? And who will take on such roles in the future? Is there a foreseen national coordination of the climate adaptation work?	1. Acknowledgement of scales. 2. Availability of future project management plans. 3. Elements in place for different management functions at appropriate levels in terms of structures, strategies, systems, skills, incentives, and interrelationships with other key actors. 4. Development and contribution to policies.
	C. Within your ECN, to what extent has the adaptation strategy facilitated stakeholder engagement in the design and implementation of the programme? And how will this be ensured in the future?	1. Engagement of wide variety of stakeholders, and appropriate feedback sought. 2. Stakeholder and policy enforcer support. 3. Indication of future stakeholder involvement.

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