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# A conceptual framework for governing and managing key flows in a source-to-sea continuum

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**Abstract**

Current approaches to environmental protection and development on land, along rivers and coastal zones, and in marine environments are struggling to effectively promote sustainability. This is partly due to limited understanding of how ecosystems are linked, and partly due to fragmented governance and management arrangements in the continuum from source to sea that hinders cooperation and strategic overview across connected systems. Meanwhile, the key flows that link ecosystems are being altered by climate change and by an intensification of human activities, which are also expanding offshore where management regimes are typically weak or non-existent. This paper presents a conceptual framework to guide the design of future initiatives aimed at supporting green and blue growth in source-to-sea systems. It includes a taxonomy of key flows, elements to guide analysis and planning and a common framework for elaborating a theory of change. Assembling a governance baseline and engaging stakeholders are critical elements in the approach. The conceptual framework builds on recent experiences of pro-sustainability action in source-to-sea systems around the world, and the paper applies the theory of change framework to selected case studies in order to develop further insights.

*Keywords:* Governance; Integrated management; Marine; River basin; Sustainable development; System linkages



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## Introduction

### *The degradation of ecosystems in a continuum from source to sea*

Since the 1950s, the world has experienced a period of rapid intensification in human enterprise, during which global population, gross domestic product and urban populations have increased exponentially (Steffen *et al*., 2015). Ecosystems have largely been able to meet the growing demands for food, thanks to advances in irrigation and fertilizer use, and human well-being has improved through the management of water use, flood control, irrigation, hydropower and pollution control (Millennium Assessment [MA], 2005). Many natural resources are, however, over-exploited or on the verge of over-exploitation and projections suggest that the human demand for water (Organisation for Economic Co-operation and Development [OECD], 2012), food (World Bank, 2007), energy (OECD/International Energy Agency [IEA], 2014) and space (United Nations, Department of Economic and Social Affairs [UNDESA], 2015) will continue to grow in coming decades. Meanwhile, projected impacts of climate change are likely to affect supply and demand of water resources and all aspects of food security (Intergovernmental Panel on Climate Change [IPCC], 2014).

The World Wildlife Foundation (WWF) (2014) reports that freshwater biodiversity has declined by 76% globally over the past 40 years. Over the same period, 64–71% of the world's wetlands have disappeared (Davidson, 2014). Hydraulic infrastructure has, according to Nilsson *et al*. (2005), resulted in over half of the world's major rivers being severely affected by the alteration and fragmentation of their flow regimes. Similarly, 20% of the world's groundwater aquifers are reportedly over-exploited (Gleeson *et al*., 2012). The world's deltas are increasingly vulnerable to flooding and submergence through the combined effects of the trapping of sediment behind dams and sea-level rise due to climate change (Syvitski *et al*., 2009) and in some cases over-abstraction of groundwater (Erban *et al*., 2014).

Halpern *et al*. (2008) assert that virtually none of the world's marine areas are today unaffected by human influence and that the largest impacts are felt in those areas subject to both land-based and marine-based human pressures. The excessive loading of nutrients in marine and coastal areas is a major pollution problem globally (Howarth *et al*., 2002) and the resulting eutrophication is one of the leading causes of degradation of marine waters. Increasing carbon dioxide emissions and the global spread of industrial pollutants such as mercury and persistent organic pollutants (POPs) are contributing to changes in the chemistry of the ocean (Doney, 2010). The increasing abundance of microplastics and other marine litter puts severe stress on open ocean ecosystems (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection [GESAMP], 2015).

There is a growing understanding that 'the Earth behaves as a system in which oceans, atmosphere and land, and the living and non-living parts therein, are all connected,' (Steffen *et al*., 2004). The continuous circulation of water ties together the Earth's lands, oceans and atmosphere into an integrated system crossing political jurisdictions.

### *Societal response*

Even as human activities put increasing pressure on natural ecosystems and resources, there has been significant progress in understanding both the value and the vulnerability of natural ecosystems. With Agenda 21, the 1992 United Nations Conference on Environment and Development (UNCED) established sustainable development as a common global priority and identified integrated approaches to the management of natural resources as a means to achieve it (UNCED, 1992). Similarly, an integral part of the 2030 Agenda for Sustainable Development (United Nations General Assembly [UNGA], 2015) addresses sustainable management of the planet's natural resources.

Global commitments underline the important links between upstream and downstream systems from different perspectives. The UN Environment Programme Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA), adopted in 1995, calls for the application of integrated approaches in coastal areas and river basins, 'such as the "ridge-to-reef concept"' (United Nations Environment Programme [UNEP]/GPA, 2012). The Convention on Biological Diversity (CBD) adopted the ecosystem approach as its primary framework of action: 'a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way' (CBD, 2000). The Aichi biodiversity targets (CBD, 2010) include measures to safeguard both terrestrial and inland waters and coastal and marine areas. Further, the goal to achieve 'a land-degradation neutral world in the context of sustainable development' was approved in 2012 (United Nations Convention to Combat Desertification [UNCCD], 2012; United Nations Conference on Sustainable Development [UNCSD], 2012b). In 2015, commitments were also reached to address climate change and its impacts on ecosystems and livelihoods (United Nations Framework Convention on Climate Change [UNFCCC], 2015).

Meanwhile, management approaches to enable more sustainable use of natural resources have been developed and tested throughout the source-to-sea continuum. These include sustainable forest management that addresses forest degradation and deforestation, while sustainable land management (SLM) strives more broadly to enable land users to maximize economic and social benefits from land resources without jeopardizing their ecological support functions. Integrated water resources management (IWRM) takes a river basins approach in the process of allocating water for multiple use, while integrated coastal management (ICM) deals with multiple-resource and multiple-use management based on physical planning approaches. Fisheries management typically strives to adopt an ecosystem approach to management.

In coastal and marine areas, the practices of ICM are now becoming increasingly adapted to marine spatial planning (CBD & Global Environment Facility [GEF]/Scientific and Advisory Panel [STAP], 2012; Granit *et al*., 2014). It has been put forward as one of the most pragmatic tools to advance ecosystem-based management in coastal and marine areas (CBD & GEF/STAP, 2012). Spatial planning on land, however, and particularly in urban settings, has been more focused on economic and social development than on environmental protection (Granit *et al*., 2014). Integrated coastal area and river basin management has further been introduced to better connect IWRM and ICM (UNEP *et al*., 1999) and approaches recognizing the connection between terrestrial water resources' flows and the downstream environments (Brisbane Declaration, 2007) are being increasingly applied.

In parallel, the importance of providing incentives for sustainable livelihoods has evolved in which economic growth and environmental sustainability are seen as mutually reinforcing factors. UNEP (2011) defines the 'green economy' as an economy that 'results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities'. The concept of the blue economy has developed alongside the green economy to consider the economic benefits generated by coasts and oceans in all aspects of economic activity (UNCSD, 2012a).

A common objective of these different management approaches and development principles is coordination across sectors. In each case one sector acts as the focal point, typically within a defined spatial unit, not necessarily addressing larger system linkages. Different zones of the same water body on land and in coastal zones can be subject to a multitude of rules, governing entities and enforcement authorities related to differences between the borders of natural systems (e.g. river basins and coastal areas) and administrative units (e.g. national and municipal borders and exclusive economic zones). This creates challenges when multiple political jurisdictions are involved. The biggest challenge lies in fitting such practices into a nested governance system in which the multiple levels of governance interact to establish management frameworks that provide synergies and are able to address the well-being of the source-to-sea system as a whole.

### *Purpose*

Challenges exist in addressing linkages and in preventing unintended negative outcomes from interventions in the source-to-sea continuum. In many instances current governance and management arrangements are poorly suited to balancing diverse and often conflicting management objectives. Instead, issues tend to be dealt with segment by segment or sector by sector, aiming for outcomes that may or may not be optimal for the system as a whole.

This paper proposes a conceptual framework that offers an approach to tackle the development aspirations defined in the 2030 Agenda for Sustainable Development (UNGA, 2015) at a source-to-sea system scale, recognizing the need to treat sustainable development in an integrated manner balancing complex economic, social and environmental dimensions. The paper is intended to provide a framework for analysis and dialogue as well as a theory of change that can inform action by different stakeholders such as multilateral agencies, national governments and other concerned actors to better govern and manage interconnected source-to-sea systems.

A source-to-sea system, as defined in this paper, includes the land area that is drained by a river system, its lakes and tributaries (the river basin), connected aquifers and downstream recipients including deltas and estuaries, coastlines and near-shore waters, the adjoining sea and continental shelf as well as the open ocean in which these drivers and pressures are clearly visible.

## Methods

We use a combination of analytical methods. A literature review helped to identify the challenges that have emerged in source-to-sea systems and illustrate the pressures and impacts that human activities can generate in different geographical segments of a system and their consequences for the system as a whole. Theories of 'green' and 'blue' economic development are used to demonstrate opportunities for sustainable economic growth.

The Orders of Outcomes framework (Olsen *et al.*, 1999; Olsen, 2003; UNEP/GPA, 2006) (Table 1) provides the analytical underpinning of a proposed theory of change to achieve sustainable outcomes in source-to-sea systems. Central to this theory of change is the distinction drawn between governance and management whereby governance concerns the fundamental goals, institutional processes and structures that are the basis for planning and decision-making, while management is the process by which human and material resources are harnessed to achieve a defined goal within a defined institutional structure.

To test the early results and findings, consultations were undertaken including a peer review process involving a wide range of actors with large collective experience from the science, governance and management of source-to-sea systems globally. To support the conclusions, an in-depth analysis of a selection of major source-to-sea initiatives was conducted by applying the theory of change as an analytical tool. The summary of those findings is found in the Discussion[1].

## Results – defining an outcome-driven conceptual framework

Achieving positive outcomes in source-to-sea systems requires an approach to analysis, planning, policy-making and decision-making that considers the entire social, ecological and economic system, from the source of a river to the coastal area and even to the sea or open ocean it flows into. We introduce a conceptual framework to help analyse priority issues and identify governance and management responses at the appropriate scale that can support the design of future initiatives promoting green and blue growth in source-to-sea systems. The framework combines a set of elements that can help to identify appropriate courses of action in a given source-to-sea system. The following sections introduce each element of the proposed conceptual framework.

### *Understanding source-to-sea systems through key flows*

Flows – of water, sediment, pollutants, materials, biota and ecosystem services – connect geographical segments from source to sea (see Figure 1). The state of each segment can be affected by activities taking place in the others.

*Water flows.* Water flow patterns are essential to the ecological health of river, floodplain and estuarine ecosystems (Bunn & Arthington, 2002). Reduction of freshwater flows into deltas can lower their

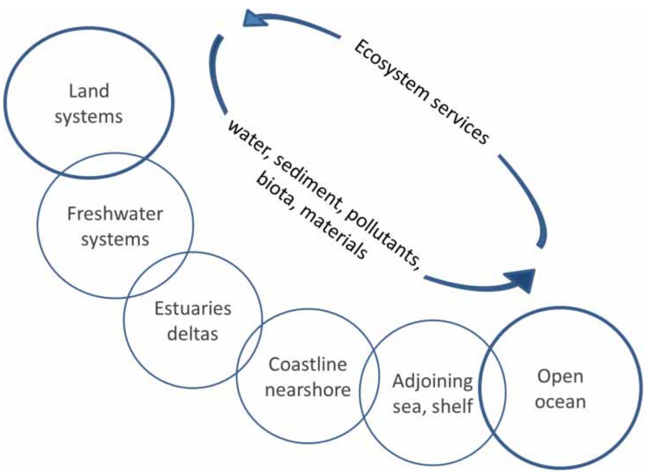


Fig. 1. Key flows connecting geographies from source to sea: water, sediment, pollutants, biota, materials and ecosystem services flows.

[1] The full analysis of the case studies of source-to-sea initiatives can be found in the supplemental material to this paper.

productivity and biodiversity, and result in over-salinization. On the other hand, changes in climate, land use and ecology may lead to soil erosion and contribute to flood risk or flood severity along rivers and deltas.

*Sediment flows*. Activities causing soil degradation and erosion in a river basin can increase the sediment load downstream, with potential impacts including smothering coral reefs and seagrass beds (Orth *et al*., 2006; Wilkinson, 2008). Globally, however, reservoir construction is probably the most important factor influencing land–ocean sediment flows (Walling, 2006). Reduced sediment delivery contributes more to the submergence of numerous deltas than does global sea level rise (Syvitski *et al*., 2009).

*Pollutant flows*. A range of pollutants can enter source-to-sea systems from a variety of sources. Their properties affect how they are transported through source-to-sea systems and their potential impacts on organisms and ecosystems along the way. Projections suggest that there will be increases in nutrient inputs to coastal areas in most regions by 2050, along with more eutrophic coastal systems and exacerbated effects of eutrophication due to climate change (Rabalais *et al*., 2009).

POPs, heavy metals and pharmaceuticals have been linked to reproductive, developmental, behavioural, neurological, endocrine and immunological adverse health effects in both humans and wildlife (Ross & Birnbaum, 2003; Williams & Cook, 2007). The cumulative effects of these various substances have been identified as a major future global environmental challenge in both fresh and marine waters (STAP, 2012).

Marine litter and microplastics in marine environments are increasing global environmental problems (STAP, 2011; GESAMP, 2015). Marine litter impacts biodiversity when wildlife ingest or become entangled in litter. If ingested by marine organisms, plastic can also transfer toxic substances into the food chain and has been shown to accumulate and concentrate POPs from other sources (Thompson *et al*., 2009).

*Biota flows*. A number of fish species depend on the 'ecological highways' provided by rivers to migrate between habitats (Gough *et al*., 2012) during different phases of their life cycles. Dams and other impediments risk disrupting these biota flows of fish by reducing connectivity in the river system, unless structures or other modifications are used to allow fish to pass around or through them. This, in combination with flow obstructions and other river modifications, has caused the disappearance or fragmentation of habitats and substantial declines in the populations of many fish species around the world (Gough *et al*., 2012).

*Material flows*. Construction and other development activities to respond to needs for housing, river and marine transport, renewable energy and natural-disaster defence can bring major flows of solid material into the source-to-sea continuum, as well as flows of material out of the system through, for example, dredging, clearing rocks, and deliberate modifications to channels or coastline. Coastal landscapes in particular are being transformed. Where land is limited and demand for it is high, land reclamation is becoming increasingly economically viable compared to developing expensive seafront land (Gatto, 2015).

*Ecosystem service flows*. Ecosystem services – 'the ecosystem conditions or processes utilized, actively or passively, to produce human well-being' (MA, 2005) – represent part of the total economic value of the planet (Costanza *et al*., 1997). In source-to-sea systems, the other key flows described in this section are important transport agents for ecosystem services. For example, the Millennium Ecosystem Assessment identifies four categories of ecosystem service related to water in a source-to-sea framework: (i) provisioning services such as ensuring water supply for different uses; (ii) water-regulating services including navigation; (iii) cultural services such as spiritual and religious values; and (iv) support services, for example, providing a habitat for ecosystems, nutrient dispersal and recycling (MA, 2005).

*Characterizing the source-to-sea system*

Characterizing a source-to-sea system should start with identifying the issues that need to be addressed segment by segment, and for the system as a whole. This includes analysing the drivers and pressures for alteration of the connecting flows in the source-to-sea system and related ecosystem impacts, and the governance and management decisions taken to date. The key source-to-sea flows can be used to guide the analysis of linkages between the different geographical segments by applying methodologies such as the driving forces, pressures, stress, impact and response (DPSIR) framework (European Environment Agency [EEA], 2003a, 2003b) or the transboundary diagnostic analysis applied by GEF International Waters projects to identify, quantify and set priorities for environmental problems that are transboundary in nature (GEF, 2013).

*Defining the appropriate scale*

Once the issues and the characteristics of the key flows, the individual ecosystems and the system as a whole have been identified, the scale determines at what levels the governance and management arrangements would need to be strengthened in order to respond to source-to-sea linkages (Figure 2). The appropriate scale could vary from one or more closely connected segments to a river basin and downstream recipient, a sea and its drainage area or all the way to global system linkages illustrated by climate change drivers. Scale can be identified from a geographical perspective, with the river basin or the recipient water body as the starting point for tracing different key flows, or using a single issue, such as marine litter, as the starting point.

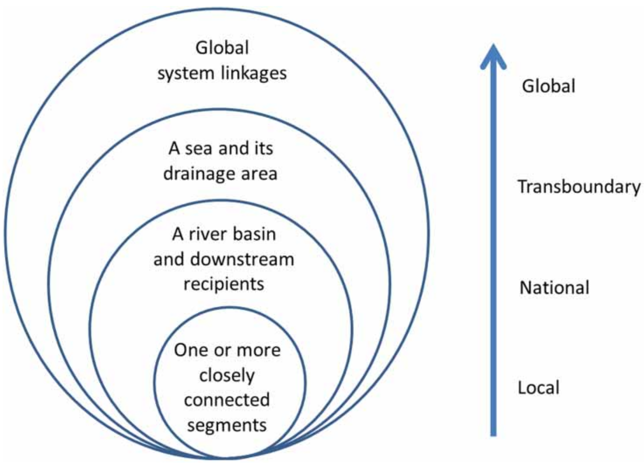


Fig. 2. Source-to-sea linkages and the need for governance and management responses at different scales.

Defining the appropriate scale can be difficult, as alterations to key flows in a source-to-sea system can have impacts at local, national, transboundary and even global levels. Although one scale should be identified as a starting point for analysis and action, adaptation will most likely be necessary at multiple scales.

*Assembling a governance baseline*

The often complex governance arrangements in source-to-sea systems call for a deep understanding of their strengths and weaknesses when designing an appropriate course of action. Governance baselines (Juda & Hennessey, 2001; UNEP/GPA, 2006; Olsen *et al*., 2009, 2011) provide an analysis of the ecosystem governance processes and outcomes in a geographically defined area. Preparation of a governance baseline can reveal where the management of linkages among segments in a source-to-sea system is weak or absent, and identify the consequences of actions that did not take into account the functioning of the system as a whole. In all but a few small-scale instances, source-to-sea systems have a history of management and examples of successes and failures in addressing issues raised by change in segments of the system.

*Engaging key stakeholders*

The design of a course of action requires a thorough understanding of both social and sectoral dynamics in a source-to-sea system. This calls for identifying who the affected stakeholders are and how they are organized with respect to the use and management of resources in the system. Stakeholders might be defined by economic sectors (like agriculture and industry), environmental interests, and cultural or indigenous groups that rely on ecosystem services provided by the system. To secure their engagement in the design and implementation of actions that benefit the system as a whole, it is important to identify their respective priorities with regard to resource management; how current management arrangements reflect those priorities; and to what extent different stakeholders participate in operational and policy decisions at local, national or regional levels.

*Defining a theory of change*

As human activity intensifies, and as climate change alters the dynamics of ecosystem behaviour, governance that can address entire source-to-sea systems demands adaptation and learning. The combination of forces acting on source-to-sea systems calls for a theory of change that can guide governance and management responses. A theory of change describes the building blocks that it is hoped will lead to a particular desired long-term outcome (Davies, 2012). Our proposed theory of change framework applies the Orders of Outcomes framework (Olsen *et al*., 1999; Olsen, 2003; UNEP/GPA, 2006). It sets out four ‘orders’ of outcomes in a source-to-sea programme’s responses to changing societal, economic and environmental conditions, leading to the ultimate long-term goal of sustainable forms of development. These four orders are described in Table 1.

The outcomes associated with each order do not accumulate in a strictly sequential manner. In complex source-to-sea systems, evidence of Second and Third Order outcomes may be seen at the smaller geographic scales addressed by pilot projects or within segments or sectors that are amenable to new approaches to issues of concern.

Table 1. A theory of change framework for the governance of source-to-sea systems – measurable outcomes disaggregated into four 'orders'.

| Order of outcomes | Description |
|---|---|
| First | Creation of the enabling conditions for a source-to-sea governance initiative. |
| Second | Changed behaviour of resource users and key institutions. |
| Third | Achievement of desired changes in societal and environmental conditions. |
| Fourth | A more sustainable and resilient source-to-sea system. Blue and green growth opportunities materialize. |

The First Order of outcomes concerns four enabling conditions for the implementation of a programme (Olsen *et al.*, 1999; Olsen, 2003; National Research Council [NRC], 2008):

1) Clear long-term goals addressing the social, economic and environmental dimensions of a source-to-sea initiative.
2) Commitment from responsible government agencies, indicating that the necessary authority, resources and political will are available.
3) Constituencies among the stakeholders that understand and actively support the goals and strategy of the source-to-sea initiative.
4) Sufficient capacity among key stakeholder groups and institutions to practise an ecosystem approach to carry the initiative forward to achieve its Third Order outcomes.

The Second Order outcomes come during implementation. They take the form of changes in how user groups interact with the environment, and associated changes in the conduct of institutions. These changes are essential to achieving the Third Order outcomes. The strengths and weaknesses of a source-to-sea initiative's design often become apparent during identification and tracking of Second Order outcomes; for example, the extent to which institutions collaborate and amend their practices and the programme (or programmes) demonstrates the capacity to make the practices advocated by a source-to-sea initiative operational.

The Third Order outcomes are defined by goals for sectors or segments within a source-to-sea system. An important First Order outcome of any source-to-sea initiative would be the setting of specific (ideally time-bound and quantitative) societal, economic and environmental targets whose achievement contributes to the greater sustainability and resilience of the system as a whole. In actuality, sector-by-sector management programmes are typically designed, implemented and evaluated discretely.

The Fourth Order outcomes address the overarching aim of any source-to-sea initiative: contribution to greater sustainability and green or blue growth where development 'meets the needs of the present without compromising the ability of future generations to meet their own needs' (United Nations World Commission on Environment and Development [UNWCED], 1987) and contributes to the 2030 Agenda for Sustainable Development (UNGA, 2015).

### *A source-to-sea conceptual framework*

The conceptual framework is built of a set of analytical approaches to guide issue prioritization and design of future initiatives aiming to support green and blue growth in source-to-sea systems moving towards sustainability. The way these elements are linked is visualized in Figure 3.

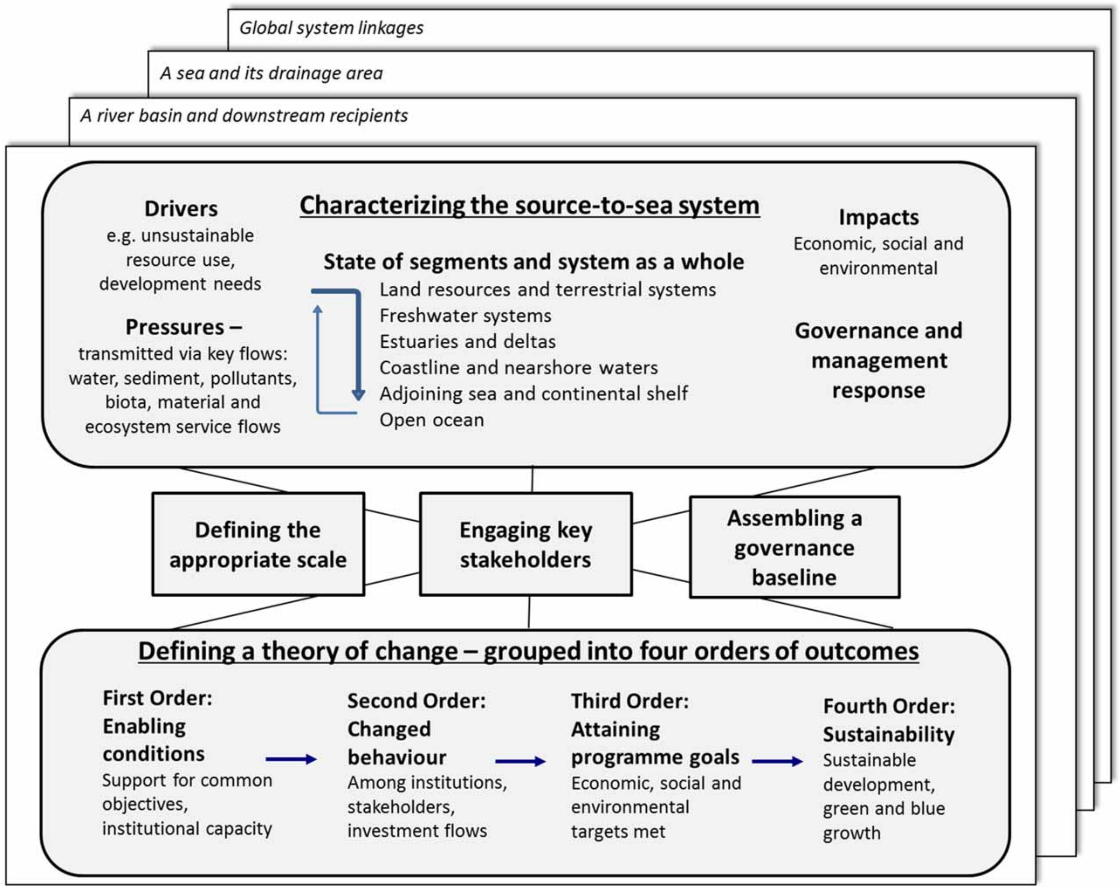


Fig. 3. A conceptual framework to support analysis, planning and decision-making for sustainable outcomes in a source-to-sea system.

The conceptual framework includes a taxonomy of key flows in the source-to-sea system to help analyse ways of addressing negative aspects or enhancing positive aspects of flow alterations. These include biophysical flows of water, sediments, pollutants, biota and material. Return flows are defined as ecosystem service flows such as clean water, food and navigation.

The next analytical step includes characterizing the source-to-sea system by identifying environmental and development priorities and existing governance capacity in the different segments and for the system as a whole at the appropriate scale. Stakeholder engagement is necessary in all steps of the process to ensure a comprehensive analysis considering that source-to-sea systems are not static and the political and economic contexts change constantly.

The adoption of a unifying theory of change could facilitate integration across segments, setting common goals, and recognizing and documenting achievements. The Orders of Outcomes framework is therefore chosen as the theory of change connecting the different analytical building blocks of the conceptual framework to support analysis, planning and decision-making for sustainable outcomes in a source-to-sea system.

In the discussion below, we apply the selected theory of change of the conceptual framework to six major source-to-sea initiatives to analyse the extent to which outcomes addressing source-to-sea priorities were achieved, to identify common challenges, and to provide guidance for future initiatives.

## Discussion – how to achieve positive outcomes in source-to-sea initatives

### *Case studies*

There have been several long-term initiatives to remedy downstream impacts of large-scale water diversion, to reduce pollutant loads, and to improve the planning of multiple activities. Six case studies of multi-country initiatives from different regions have been reviewed to learn from these processes and to identify common challenges and successes. Table 2 provides an overview of these initiatives.

### *Establishing enabling conditions: first order outcomes*

The case studies demonstrate that establishing a critical mass of First Order enabling conditions for better governance remains a central but unmet challenge in many source-to-sea systems, even after decades of collaboration. Problems are associated with limited coordination or disagreement between the institutions responsible for different segments of a source-to-sea system; and challenges to win the support of resource-using sectors and other key stakeholders. Progress towards desired Second and Third Order outcomes demands long-term commitment and acceptance that advances will be incremental. This calls for identifying strategic priorities to strengthen the weaker links in enabling conditions, building on existing strengths and showcasing the benefits of collaborative action.

Over its more than 20 years of implementation, *PEMSEA* in East Asia has strengthened enabling conditions incrementally, promoting inter-agency and inter-sectoral coordination and contributing to notable rates of development and implementation of national policies, strategies, action plans and programmes in coastal and ocean management and river basin management. However, many of the PEMSEA sites face the classic upstream/downstream dilemma when it comes to scaling up ICM: inland local governments need to invest in activities that will largely benefit local governments in coastal areas (GEF, 2012).

The first-phase *Caribbean IWCAM* project has created the foundations for an IWCAM approach in the participating SIDS. However, Caribbean SIDS face major institutional and governance barriers. Planning processes are sectorally driven and do not take into consideration principles of ecosystem services flows. There are gaps in institutional mandates and in legislative and regulatory instruments that do not adequately address coordinated planning for IWRM, SLM and biodiversity management.

The *BOBLME* project has in its first phase developed reasonable formal and informal collaboration among the eight littoral countries. Formal commitments have been made to address the priorities of the adopted strategic action plan, including some critical source-to-sea flows. However, upstream linkages beyond the coastal zone in relevant river basins have not been identified, including how to link different but related management approaches, such as habitat management and ICM. In addition, the BOBLME project has struggled to involve key sectors concerned.

The *Danube River and Black Sea collaboration* formalized joint goals for the International Commission for the Protection of the Danube River (ICPDR) and the Black Sea Commission (BSC) to reduce

Table 2. Case study overview.

| | |
|---|---|
| **Asia and the Pacific** | |
| Partnerships in Environmental Management of the Seas of East Asia (PEMSEA) | The East Asian Seas region contains a number of large marine ecosystems (LMEs), sub-regional seas and their coastal areas. The GEF has invested for more than 20 years in assessing and improving the status of these LMEs. Work has included developing and implementing the Sustainable Development Strategy for the Seas of East Asia, which identifies ICM as a practical framework for sustainable development and provides an overarching framework for management of the region's LMEs. |
| Bay of Bengal Large Marine Ecosystem | The Bay of Bengal large marine ecosystem (BOBLME) is one of the largest LMEs globally. A GEF-supported project in the BOBLME has started to establish enabling conditions for ecosystem-based management through developing collaboration among the participating countries. |
| **Europe and Central Asia** | |
| Danube River and Black Sea Collaboration | In the 1970s and 1980s, the ecosystems of the western Black Sea collapsed as a combined effect of pollution and unregulated fishing. The link between Black Sea eutrophication and Danube river inflow was recognized in both the 1994 Bucharest Convention and the 1998 Danube River Protection Convention. Major improvements have since been documented in the status of the Black Sea. |
| Baltic Sea Collaboration | Efforts to protect the semi-enclosed and brackish Baltic Sea through regional collaboration date back to 1960s. Decades of pollution control have resulted in cleaner beaches and healthier seafood, but the Baltic Sea remains the most eutrophic marine area in the world. Enabling conditions for better governance of the Baltic Sea have emerged over a long period. |
| **North and Latin America** | |
| Caribbean Small Island Developing States and Sea Basin – Integrated Watershed and Coastal Area Management (IWCAM) | Water resources, coastal areas and ecosystems in the 13 Small Island Developing States (SIDS) of the Caribbean and in the larger Caribbean basin are exposed to a number of stressors. The GEF has supported a series of projects on integrated water and natural resources management in the Caribbean. |
| Colorado Basin and Delta, and Upper Gulf of California | Early agreements to allocate the water of the Colorado River and its tributaries did not reserve water for ecosystems and did not include any water quality standards. As a result, the salinity in the Colorado River basin increased dramatically and the amount of water flowing into the sea was drastically reduced. Efforts to address some of the key environmental pressures include salinity control in the Colorado basin, ensuring environmental flows to the delta, regulating fisheries and strengthening marine area protection in the Gulf of California. |

the eutrophication of the Black Sea. European Union (EU) legislation has greatly assisted in garnering political commitment towards nutrient reduction among the majority of the Danube River countries. Among the Black Sea countries, achieving the necessary collaboration among governmental institutions has proved more challenging. For example, no revisions to agricultural policy were instituted to reduce non-point run-off even though this was identified as critical to environmental restoration goals.

The several transnational governance frameworks for the *Baltic Sea and its region* lead to overlap and potential inefficiency. Among the EU members, implementing EU water-related directives, such as the Water Framework Directive and the Marine Strategy Framework Directive, is important to realize their common goal of achieving good environmental status by 2020. The EU Baltic Sea Region Strategy, while not including Russia, provides an innovative approach to stimulate economic growth, collaboration across the riparian states and steps to clean the common sea.

### *Behavioural change: second order outcomes*

Demonstration projects, usually at a small geographic scale or targeting a single activity (such as addressing a specific source of pollution) may produce Second and Third Order outcomes within a few years. However, changing how resources such as water are utilized at the source-to-sea system scale requires several phases of sustained, and adaptive, governance. Particularly difficult is instigating behavioural change in sectors that fall outside the direct sphere of influence of an initiative and stakeholders/resource users located upstream from the targeted area.

The *Caribbean IWCAM* triggered spontaneous replication and catalysed the adoption of new watershed/coastal zone management schemes. A successor project 'Integrating Water, Land and Ecosystem Management in Caribbean Small Island Developing States' (IWEco) is designed to support further scaling up of successful approaches. There are, however, no clear linkages between these projects and the Caribbean LME project, which is being implemented in parallel with the objective to reduce the stress on fisheries. The Caribbean LME project does not address critical source-to-sea flows related to pollution and upstream pressures on coastal habitats, which have been identified as priorities by the IWCAM and IWEco projects.

In the *Danube River and Black Sea collaboration* a key issue raised by the terminal evaluations of both the Danube Regional and the Black Sea Ecosystem Recovery projects concerns the challenge to involve ministries beyond water and environment such as ministries of agriculture, and affect their policies.

In the *Baltic* and in the *Colorado* basin, the riparian countries have invested substantially in behaviour change interventions to achieve common commitments in relation to, for example, controlling salinity in the Colorado basin and reducing nutrient loads from the Baltic Sea countries. In the *Baltic*, all riparian countries have agreed on national nutrient reduction targets, but the vastly different starting points of local actors and stakeholders when it comes to addressing seawater quality and eutrophication lead to slow implementation.

### *Improving environmental and social conditions: third order outcomes*

The case studies show that failure to effectively address source-to-sea key flows due to gaps in First Order enabling conditions or failure to instigate required Second Order behavioural change will prevent or limit the attainment of stated Third Order societal and environmental targets.

The 2012 GEF Impact Evaluation of the South China Sea and Adjacent Areas, which covered not only *PEMSEA* but several other GEF initiatives, concluded that GEF-supported approaches had generally been effective at the specific sites where they have been implemented, but that the results of stress reduction have often been limited because of larger-scale factors that the demonstrations could not address, such as land-based pollution from tourism and agriculture.

Major improvements have been documented in the condition of the *Black Sea*, thanks to reductions in severe eutrophication (ICPDR, 2007). Third Order outcomes have included the virtual elimination of the once expansive hypoxic zone covering the North West Shelf of the Black Sea. These accomplishments were assisted by a dramatic drop in agricultural production after the economic downturn in many lower-Danube countries, but show that early recognition of source-to-sea linkages and concerted effort to achieve policy and regulatory reform among upstream countries and stakeholders can, in combination with targeted investments, contribute to reversing negative environmental trends. The challenge now concerns maintaining the collaboration between the upstream and downstream countries to sustain the positive results and continue nutrient reduction efforts.

Nutrient discharge into the *Baltic Sea* has also been reduced in recent decades, but progress has been slow. To accelerate the pace and achieve Third Order outcomes, identified needs include a broader understanding of the eutrophication challenges among political leaders at national and municipal levels and increased knowledge to enable the identification of a cost-effective combination of measures at the local level.

Despite efforts by the USA and Mexico to resolve some of the major source-to-sea-related pressures on the *Colorado* basin and its downstream segments, problems persist and Third Order outcomes remain elusive. The costs to the USA of salt removal in the basin are likely to increase by 50% by 2030 (Borda, 2004). The results from the environmental flows secured for the Colorado River Delta are yet to be evaluated, but they represent only a tiny fraction of the flows that were once delivered to the delta. In the Gulf of California, conservation efforts have focused on individual sites or on narrowly defined strategies, paying insufficient attention to land–sea connections – important obstacles to the achievement of Third Order outcomes.

### *Towards greater sustainability: fourth order outcomes*

All the initiatives reviewed aim ultimately to contribute to sustainability, the Fourth Order outcome, but even in those cases where some Third Order outcomes have been achieved, it is difficult to make the case that this has led to full triple-bottom-line sustainability. In some cases, considerable advances have been made, such as in the Black Sea, but large systems continue to change as do human uses and pressures acting on them. Other cases show little or no progress towards the achievement of Third Order goals due to unresolved difficulties in achieving the necessary Second Order changes in institutional and resource-user behaviours.

For key actors in a source-to-sea system, sustainability often remains an abstract concept distant from short-term and medium-term concerns and priorities. As the 2030 Agenda for Sustainable Development underlines, the road towards sustainability requires setting goals and implementing strategies on a diversity of issues, most of which come into play at source-to-sea system scales. There are political and economic drivers at higher systems levels influencing the initiatives reviewed in this paper, some of which may offset the gains achieved through strengthened governance and management frameworks developed in the source-to-sea continuum. Nevertheless, all the initiatives reviewed have been sustained over time and in several cases a project approach has been overtaken by changes in the regional political governance context. The case studies demonstrate that the achievement of Third Order outcomes cannot be achieved without the requisite changes in the policies and comportment of key actors. This suggests that greater attention needs to be given to defining and monitoring the Second Order outcomes that are most critical to gaining the Third Order outcomes that contribute to greater sustainability. Experience gained from programmes with an ecosystem focus, including SLM, IWRM and ICM, points to the centrality of collaboration among institutions and cooperative strategies that can generate outcomes that contribute to greater sustainability.

The Orders of Outcomes framework is not static. It provides a theory of change to understand and identify impact pathways in the source-to sea continuum and to establish goals through consultative approaches. Our conceptual framework demonstrates how a theory of change can be embedded in larger social–ecological systems thereby supporting better design of source-to-sea initiatives. A focus on testing of solutions and learning from experience towards Fourth Order outcomes such as green and blue growth are stepping stones towards sustainable societies. The initiatives analysed illustrate the complexity in achieving sustainability in source-to-sea systems but demonstrate promising approaches to achieve Fourth Order outcomes.

## Conclusions – science to policy recommendations

Based on the review of the status of source-to-sea systems and the application of a theoretical framework to a number of case studies, we draw conclusions that could encourage and support governance and management responses at different spatial scales that lead to greater sustainability in source-to-sea systems.

*The source-to-sea conceptual framework offers a guide to the design of future initiatives that work to achieve greater sustainability in source-to-sea systems.*

The conceptual framework presented in this paper provides an aid in developing operational methods and tools to put source-to-sea governance into practice in a changing political and economic context. It offers a way to recognize system linkages in work to achieve development aspirations defined in the 2030 Agenda for Sustainable Development and to tackle the major impacts of climate change on the source-to-sea continuum. The adoption of a unifying theory of change could facilitate integration across segments, setting common goals, and recognizing and documenting achievements. Our conceptual framework outlines a theory of change that frames governance and management options around four orders of outcomes.

*Source-to-sea systems are interconnected by key flows.*

Key flows in the form of water, sediment, pollutants, materials, biota and ecosystem services connect sub-systems at different spatial scales. The scales of an intervention may vary from one or more closely connected segments, to a river basin and downstream recipient, a sea and its drainage area, all the way to global system issues such as climate change drivers.

*Gaps in biophysical knowledge need to be filled.*

While our knowledge of how human intervention influences individual segments of source-to-sea systems is relatively good, there remain great knowledge gaps around the impacts of human activity that span across segments of source-to-sea systems.

*While the pace of change in source-to-sea systems varies widely and interlinkages are complex, learning and adapting to change need to accelerate.*

The review of source-to-sea initiatives in this paper shows that it has taken decades to understand and begin to address source-to-sea system degradation. This is largely a consequence of the complexity and scope of source-to-sea systems and the change in political and economic drivers over time. It takes long periods of sustained effort and investment to achieve changes and then to mainstream practices that operationalize a source-to-sea approach through changes in the behaviour of key actors. Stress-reduction measures need to be implemented in large areas and it takes a long time to assess the responses in the ecosystems. There is an urgent need to better understand how source-to-sea systems respond to management interventions that link across different segments. Such learning would greatly benefit from common sets of indicators and monitoring protocols that allow comparative analysis across source-to-sea systems.

*Coordinated governance arrangements that can address system linkages are needed to address source-to-sea priorities.*

There is a variety of management approaches that recognize the need to support the objectives of an intervention in a particular bio-physical setting and political and economic context. As policy, planning and decision-making by sector and in the different segments of a source-to-sea system will continue to be necessary, so will decentralized, nested governance systems become increasingly important. Source-to-sea systems need governance arrangements that can balance development objectives across segments, taking key flows into account, and are capable of coordinating and integrating across the different management objectives.

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